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EMPLOYEE PERCEPTIONS OF TRANSITIONING TOWARDS INDUSTRY 4.0 IN DISTINCT GLOBAL CONTEXTS

by

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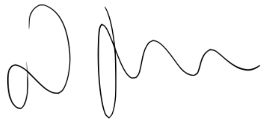

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DEDICATION

In memory of Professor Ronel Rensburg

This thesis is dedicated to Professor Ronel Rensburg, who was the supervisor of my master's dissertation and this thesis. She was the inspiration and driving force that led me to embark on this arduous journey. During the writing of this thesis, she sadly passed away. I will always value her as a mentor and friend. She will forever be missed.

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- To my parents, Sigi and Silvi, who have supported me from the moment I was born, I thank you for supporting me in every way possible and ensuring I never give up.

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- To my partner Selina. I thank you for being the undisputed master of transcribing hours upon hours of German interviews conducted in Berlin accents and for your support throughout.

- I appreciate the cooperation of 'The Company' (that wishes to remain unnamed) and its staff for participating. I thank the 'Industry 4.0' team for their efforts in organising and enabling the interviews. It was a great pleasure to work with you.

- Lastly, I would like to thank all the academics and staff of the 'former' Department of Communication Management at the University of Pretoria for being supportive and a part of this seemingly never-ending journey that started with my bachelor's degree in 2009.

ABSTRACT

Purpose: This study explores the implementation of Industry 4.0 in a large organisation, which operates manufacturing facilities in four distinct regional settings. To explore the implementation of Industry 4.0 from a communication management perspective, staff perceptions were investigated.

Methodology: The study follows a qualitative research approach. Semi-structured interviews were conducted at the respective facilities and were subsequently analysed. Literature on stakeholders, sustainability and communication management formed the conceptual base from which items were developed for the interview guide.

Findings: It was found that the introduction of Industry 4.0 is perceived by many as a source of uncertainty, particularly in Germany. The manner in which such technology is managed and communicated is vital to secure employee support. Cobots are strongly linked to US staffs' perception of Industry 4.0. At other facilities the TicketManager technology is closely related to the perception of Industry 4.0. All interviewees relate the introduction of Industry 4.0 to the quadruple context environment.

Originality: The findings of this study are based on original research conducted through interviews with management and non-management staff on their perception of the introduction of Industry 4.0 in a specific organisation operating in four distinct regions. Findings are presented, expanding existing academic knowledge.

Limitations: Industry 4.0 is a development that is currently ongoing. This research was conducted in a specific organisation in a specific time frame and in specific regions. It is recommended that further research on the perceptions of the implementation of Industry 4.0 is conducted in other organisations and regional contexts.

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List of Relevant Terms

MES (Manufacturing Execution System)	A "Manufacturing Execution System" is a digital management system to supervise and control devices in a manufacturing facility.
QRQC	A specific MES system used at the Hillsboro manufacturing facility.
TicketManager	A control and supervision program, similar to a MES system. It further provides a means for human-machine and machine-human communication through the use of handheld mobile devices and displays at the respective machines.
Camstar / Camline	Camstar and Camline are proprietary systems with MES system properties.
5G Network	A cellular network with ultra-low latency and high data transmission rates.
Cobot	Is the shortened descriptive term for a collaborative robot. Sensors enable the use of industrial robots in close proximity to human workers and may, to varying degrees, possess sensors that allow for cooperative or sequential taskwork with human workers.
Digital twin	A digital twin is a digital simulation that parallels the physical process or good in a manufacturing setting.
Internet of Things	The Internet of Things (often abbreviated as IoT) encompasses all aspects of the internet that enable machine to machine communication without the need of human input. It describes the use of sensors, software and networking to facilitate automated data exchange.

Big Data	Describes a vast quantity of data that is collected through automated means that exceed the quantity and complexity limits of traditional data collection and data analysis technology.
Cloud computing	Cloud computing describes the remote on-demand availability of computing and data storage capacity without traditional physical limitations.
Cyber physical systems	Cyber-physical systems (colloquially also known as intelligent - or smart systems) are systems that control a physical action through computer control or monitoring.
Augmented reality	Augmented reality is an experience that combines physical realities with cyber-based content in parallel.
HoloLens	HoloLens is a mixed reality device for industrial applications produced by Microsoft.
Six- sigma	Six sigma is a system to improve operational efficiency in an organisation. This is often linked to lean manufacturing practices and a drive to remove wastages.
Mix- sigma	Mix sigma describes the utilization of components that do not meet specification in a manner that results in a final product that does meet specification parameters; thusly increasing operational efficiency and reducing resource wastages.

EMPLOYEE PERCEPTIONS OF TRANSITIONING TOWARDS INDUSTRY 4.0 IN DISTINCT GLOBAL CONTEXTS

CHAPTER 1

1 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” (Bennis, 2016).

Since the advent of the internet, people’s interactional abilities have changed substantially. The digitalisation of social interactions through social media has changed the way many people communicate. This has happened not only in private contexts but also in business interactions; several back-office processes are now performed by the customer, such as booking flights. However, it can be argued that the digital networking of physical production activities will result in drastic changes within organisations and lead to substantial changes in society, referred to as the Fourth Industrial Revolution. This is likely to culminate in autonomous factories with minimal human involvement: namely, ‘Industry 4.0’.

At the beginning of the 21st century, industries such as the automotive industry and associated suppliers were undergoing a fundamental change in the type of product that they were producing, with accompanying changes seen in the supply chain. Specifically, the shift towards the electrification of automotive drivetrains was a shift away from the internal combustion engine that had powered vehicles for over 100 years (Geyer, 2016:331).

The electrification of cars has led to the simplification of the production process, reducing the need for a large number of physical components. This simplification of physical supply chains has severely impacted automotive manufacturing suppliers. Suppliers of certain automotive goods will need to reconsider their products and raison d'être if they are to sustain their relevance in the future (Vetter, 2017).

A key issue for the automotive industry and its suppliers is the environmental sustainability of their products and the effect these products have on the environment. One way in which this can be addressed is through the increased energy efficiency of vehicles and the reduced consumption of vehicle components; for example, a shift away from conventional halogen lighting and towards LED lighting (Schoettle, Sivak & Fujiyama, 2008:12).

The period that began in 2019 can, without a doubt, be described as tumultuous: a period of uncertainty in both society and industry. This period saw a pandemic the level of which has not been witnessed since the Spanish Flu, with associated supply limitations caused by breakdowns in supply chains unseen since the dawn of globalisation. This is not to mention the personal and economic hardships that this period has caused. The following chapter provides the reader with an overview of the literature used in this study and introduces the underlying theories used to address the problem statement and research questions formulated in this chapter.

1.1 LITERATURE BACKGROUND

1.1.1 Industry 4.0

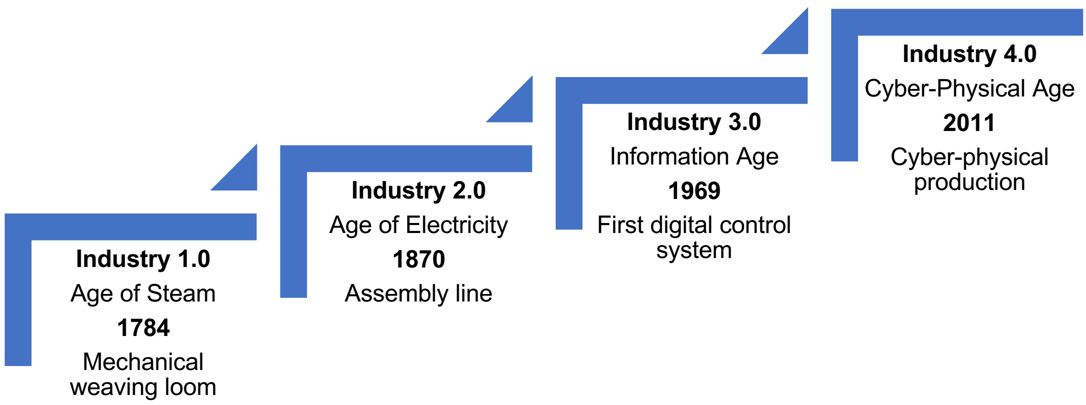
Industry 4.0 is part of a manufacturing evolution that can be traced back to the 1700s, when the first attempts to mechanise manual labour, particularly in the textile industry, were made.

The Second Industrial Revolution, also known as the Technological Revolution, took place between 1870 and 1914, resulting in the development of the internal petrol combustion engine, the motor car and the aeroplane (Mokyr, 2003:1–5). Based on this new machinery, human workers increasingly became part of a rational production or assembly process, the goal of which was to increase efficiency. During this period, management approaches changed from ad-hoc project management to the systematic use of technology and human capital. Two notable actors who shaped this era were F. W. Taylor and H. Ford. Taylor coined the theory of scientific management and Ford, while not inventing it, was one of the pioneers of the automated assembly line (Witzel & Warner, 2015:55–70). The centralisation of production facilities, which provided people with new sources of income, led to waves of urbanisation occurring as part of the industrialisation process in numerous countries.

The digital age began with the invention of the transistor in 1947; since then, mechanical devices have increasingly been replaced by digital devices. This era has been characterised by an ever-increasing ability to communicate through digital means. In terms of production methods, the digital age enabled manufacturers to outsource the warehousing function and offer just-in-time delivery to the facility. However, while interaction between humans and machines has been greatly improved, devices are still largely dependent on human input (Witzel & Warner, 2015:55–70).

Industry 4.0 has been touted as the next paradigm shift in manufacturing, as factories move from computerised automated systems to cyber-physical systems. This technology promises to reduce wastage and manufacturing defects, making zero-waste manufacturing substantially more likely in the future (Arcidiacono & Pieroni, 2018:141).

Figure 1: Evolution of industry



Source: Adapted from Ślusarczyk (2018:236); Xu et al. (2018:2943)

High-tech companies and industrial conglomerates have begun introducing products that make customers' production more and more autonomous, bringing Industry 4.0 close to reality (Vuksanović, Ugarak & Korčok 2016:293). Industry 4.0 offers numerous advantages over conventional production methods, particularly in terms of businesses' commitment to environmental and financial sustainability. Numerous sources have debated the technological aspects of full digitalisation; however, there have been few discussions regarding its effects on future employment. At times, those predictions that do exist mirror aspects of George Orwell's bestseller *Nineteen eighty-four*.

The technologies that are grouped under the umbrella term Industry 4.0 are as follows: mobile connectivity networks such as 5G; the Internet of Things; Big Data; cloud computing;

collaborative robots; augmented reality; machine learning; and additive manufacturing (Bortolini Ferrari, Gamberi, Pilati & Facio, 2017:5703; Parsons, Styma, Fuest & Krys, 2018:20). It is important to note that Industry 4.0 is a novel development and it is being implemented as we speak. Thus, academic literature is often focused on the engineering and technological aspects of Industry 4.0, with the management and communication perspectives yet to be explored.

Industry 4.0 is the introduction of new technologies in the workplace, and as such, there is a need for organisations to communicate effectively to ensure a successful and efficient transition. Ślusarczyk (2018:236) observes that the implementation of Industry 4.0 is a step towards blurring the lines between the physical and the cyber space. At its core, however, this is a change in the work environment that may result in organisational change, as such change communications are a suitable means of facilitating the implementation of Industry 4.0 and the associated transition in the workspace. When exploring the literature, sufficient content on change management and communication can be identified.

Phillips (1983:183) states that failing to adapt a suitable approach to change management (and, therefore, to communication) may put organisations at risk of having to suffer negative consequences and decrease an organisation's ability to adapt to innovation in a timely manner. In a fast-changing business environment, this may force organisations to carefully evaluate short-term changes in such a way that favours the long-term existence of the organisation.

Large organisations are often highly bureaucratic; this is enforced by strict hierarchical structures that, while ensuring efficient operations, do not foster fast change or a creative internal exchange. Smaller organisations do not face such flexibility issues; however, as a consequence of smaller departments and little scalability, they lack the operational efficiency of larger organisations. Kotter (2014:5–7) suggests that a hybrid approach to change is to assign multiple roles to key employees, so that they can act in multiple capacities within the organisation. A mixed setup in an organisation that relies on large hierarchies will ensure the operational stability and efficiency needed to sustain the organisation's existing operations. Small groups that are outside of the formal hierarchy are then formed to implement innovations and communicate the resulting changes within the larger organisational structure, thereby introducing these changes in a timely manner. Using small groups as implementors within large organisations has several advantages. One of these is that the innovation can be implemented in a much timelier fashion, compared to its immediate implementation within larger structures. Additionally, limitations placed on the initial implementation of innovations also safeguard larger structures within the organisation from possible issues or failures that might be caused by the new introduction, restricting any consequences to the small group that is performing the initial implementation.

Communication holds an important role in ensuring that such implementation efforts are successful and executed in a timely manner. Communication from senior management is particularly vital, as it helps to ensure positive morale in the workforce and generate a sense of urgency. A vision of change is a cornerstone upon which success or failure can be measured; it also acts as a motivator for all actors involved in the change. The communication specialist also holds the responsibility for ensuring that the short-term successes are well communicated, as these act as a further impetus that creates motivation for further steps in the implementation process (Kotter, 2014:30).

There are two distinct approaches to two-way communication: two-way asymmetrical communication and two-way symmetrical communication. In two-way communication, organisations engage with their audiences with the explicit desire of receiving feedback from the receivers of the messages. The main difference between asymmetrical and symmetrical two-way communication is the degree of control that the senders and receivers of messages hold during the exchange. An asymmetrical exchange is controlled by the sender, with the receiver given the opportunity to respond and react to the message and actively engage with the original sender of the message. Symmetrical communication takes place between two equal parties, with control of the exchange shared between both parties. The resulting exchange enables all participating communication parties to take both the role of sender and the role of receiver. All these models can be combined as needed in relevant communication situations; such adaptations of one-way and two-way communication are referred to as the mixed-motive model (Falkheimer & Heide, 2018:38).

The vast majority of managers that receive change management training consider this to be an effective approach. Additionally, they view communication as a key means by which insights into and motivations behind the decisions and processes working towards an implementation of change can be shared. Modern business is shaped by the interdependence of organisations, societies and interest groups to ensure a sustainable future. Communication has a critical role in these exchanges and the identification of the various actors.

In an age where the socialist block of the Cold War has largely adopted aspects of the free-market system and where traditional capitalist markets have reached the apex of shareholder focus, the World Economic Forum has been focusing on the stakeholder capitalism system prevalent during the early years of the 21st century (Sundheim & Starr, 2020). Stakeholder capitalism, as described by Klaus Schwab (2021:171–173), may be an approach to addressing the shortcomings of shareholder capitalism – namely, its focus on short-term profitability and disregard for non-shareholder interests – while also avoiding the inflexible and often inefficient option of central state capitalism. Stakeholder capitalism's understanding of an economy echoes stakeholder theory and sustainability by focusing on the maximisation of social, environmental and financial benefits while at the same time minimising negative outcomes and focusing on the long-term prosperity of the environment, society and an organisation's financial position (Schwab, 2021:171–173).

A vital element of including and communicating with stakeholders in an organisation's operation or in the introduction of technical innovation is the identification and classification of stakeholders based on their characteristics. Following Freeman, Harrison & Zyglidopoulos (2018:14–15), 'stakeholders' can be summarised as all parties or individual interest-holders that hold vested interests in the outputs of an organisation. Furthermore, stakeholders and communication with these can be segmented according to their degree of involvement in an entity's operations. Primary stakeholders are those with the most direct ties to the organisation or proposed action. Secondary stakeholders are those that do have an interest in an organisation's actions but are impacted only indirectly and hold no formalised or contractual ties with the organisation (Pesqueux & Damak-Ayadi, 2005:5).

Gehman, Lefsrud and Fast (2017:293–316) emphasise that the sustained existence of an organisation is dependent on a society's acceptance of it and its operations. This is known as a societal licence to operate. When considering the effort required to gain a societal licence to operate, academic discussions often focus on external stakeholders (stakeholders that do not form part of an organisation's formal hierarchy) and at times neglect the internal stakeholder (stakeholders that are part of an organisation's formal hierarchy). Stakeholder group memberships are not mutually exclusive; thus, employees that fulfil the criteria to be part of an external stakeholder group are consequentially often part of both internal and external stakeholder groups (Gregory, Atkins, Midget & Hodgson, 2020:325). This highlights the important role employees play as stakeholders of an organisation. Namely, as internal stakeholders, they can influence the licence to operate or revoke it through industrial action and, as external stakeholders, they can have an effect through entities such as political parties or pressure groups.

The implementation of Industry 4.0 is occurring in a time of substantial change; as such, it is very important that it is undertaken with appropriate knowledge both of the operating environment in which this implementation will be conducted and of what requirements need to be met if the implementation is to offer a valuable contribution to global sustainability efforts. Cornelissen (2020:259) states that organisational performance can and should be evaluated against a multitude of criteria, including the economic environment, the natural environment and the social environment in which an organisation seeks to operate sustainably. In line with stakeholder capitalism, the triple-context environment approach to gauging the sustainability of corporate actions should be complemented by a fourth dimension that indicates the organisational set-up needed to facilitate long-term operational success. This dimension can best be described as the 'purpose' or 'governance' dimension of sustainability.

The economic context environment encompasses all aspects of an organisation's financial sustainability. As private organisations are typically profit-driven entities, a financial case needs to be made for the introduction of new technology; Industry 4.0 is no exception to this, as momentary profitability forms the basis for future investment (Alhaddi, 2015). Technological innovation is a key factor in long-term financial sustainability, as this is one of the many manners in which a competitive advantage can be created (Goetz & Jankowska, 2020:65). Industry 4.0 technology requires large capital expenditures but promises substantial gains in terms of improved operational efficiency in the production process and greater flexibility in the production process. From a production perspective, the increased amounts of data that are harnessed can lead to greater insights into the production process and positively affect product quality, in addition to potentially affecting quality costs.

The natural context environment describes all effects that organisations have on the natural environment due to their operations and all effects that the natural environment has on the organisation. For decades, society has been putting mechanisms into place to increase environmental sustainability and to mitigate global climate change, albeit with varying degrees of success. While academic literature does not conclusively indicate whether the introduction of Industry 4.0 will have a positive or negative effect on the natural environment, it can be noted that transnational organisations have included Industry 4.0 as a means of combating environmentally unsustainable manufacturing practices. The United Nations is aiming for carbon neutrality by 2050, and practitioners have highlighted that Industry 4.0 technology may be a contributor to the effort to streamline production and reduce the consumption of natural resources in an effort to meet sustainable development goals (Guterres, 2020; Chiarini, 2021:3195).

The social context environment encompasses all factors, including the influences that organisations have on society and social efforts that influence organisations' operations. Organisations hold special responsibility in a society, as their actions can have substantial influence on the society's prosperity; vice versa, organisations are highly dependent on the acceptance of their operations by the societies in which they operate. This is closely linked to the social licence to operate within a society (as discussed in the context of stakeholder theory). Without societal acceptance, the prolonged sustainability of an organisation is unlikely to succeed (Cornelissen, 2020:267).

The expected role of Industry 4.0 technology within the social context environment can arguably be best described as 'ambivalent'. On the one hand, the social context environment is shaped by changing demographics in the various global regions. Developed economies are facing a future that is shaped by decreasing birth rates, and most nations are expected to increase the life-expectancy of their citizens. This will lead to an ageing workforce in the future, with the associated limitations experienced by older persons. Industry 4.0, particularly cyber-physical systems and collaborative robots, offers an implementable solution to addressing workers' physical limitations by reducing the physical demands on the ageing workforce and thereby furthering inclusivity in the workplace (Schinner, Calero Valdez, Noll, Schaar, Letmathe, & Ziefle, 2017:543–545).

On the other hand, the increasing degree to which labour is becoming automated may pose an increasing risk in terms of displacing human labour opportunities that require little skill or are of a standardised nature. In light of large portions of the global population being dependent on income that is earned through low-skill labour, the displacement of such tasks will lead to a lowering of labour costs by organisations who wish to remain competitive or the replacement of such labour with Industry 4.0 technology. The implementation of Industry 4.0 does, however, require a society to provide high-skill and specialised labour, particularly in the IT sector, as well as a high-quality and stable infrastructure. The lack of such parameters in underdeveloped regions is expected to potentially lead to further wealth discrepancies in the globalised world (Bonekamp & Sure, 2015:33–35). The role of communicating such re- or up-skilling needs in societies and within organisations is one of the key challenges presented by the implementation of Industry 4.0.

The governance-context environment encompasses all actions by organisations that facilitate the future sustainability of an organisation through the proactive addressing of factors that will lead to future impacts on sustainability. This includes a holistic approach to business operations, with a focus on stakeholders and future societal interests (Engelbrecht & Ungerer, 2011:11-14). This concept is best illustrated by the sustainable development goals of the United Nations, which form an initiative that actively seeks input and cooperation from the private sector in an effort to reach its sustainability goals. This represents a shift away from the largely inter-governmental focus of the Millennium Development Goals that preceded this initiative (United Nations Development Programme, 2022).

1.2 REGIONAL BACKGROUND

This study explores organisational employees’ perceptions of the transition towards Industry 4.0. This exploration is executed in four case facilities, located in four different countries. These regions are culturally and economically distinct and often approach the introduction of Industry 4.0 in a region-specific manner. In the following section, a regional background to this study will outline the distinct natures of the four regions.

1.2.1 Germany

The German government has taken a proactive approach to the changes in industry and the resulting societal change. The strategic initiative *Industrie 4.0* has been the responsibility of the Federal Ministry of Education and Research and the Federal Ministry for Economic Affairs and Energy. Its purpose is to further the development and implementation of Industry 4.0 by supporting the digitalisation of the economy: creating norms, setting technological standards and funding public and private research initiatives with a total value of €200 million (Klitou, Conrads, Rasmussen, Probst & Pedersen, 2017a:3). The plan was initiated in 2011 and was designed to accompany the implementation of Industry 4.0 for the coming 15 years. As a result of government incentivisation, the segregation of industry has been reduced, creating value networks. Klitou *et al.* (2017a:4) report that the approach to enabling this change has been multi-dimensional. The federal government acted as a top-down steering organ by setting the agenda; however, on an operational level, it has chosen to closely cooperate with academia and form partnerships with private industry. Small to medium-sized enterprises are considered to be the traditional backbone of German industry. In recognition of this role, the government provides up to 60% of funding for Industry 4.0 projects and has enacted the *Mittelstand 4.0* initiative to complement the *Industrie 4.0* umbrella initiative (Klitou *et al.,* 2017a:7). The Internet of Things and cyber-physical systems are at the core of investment initiatives (Klitou *et al.,* 2017a:3). *Plattform Industrie 4.0* is a platform that enables the exchange of research and experience, in addition to providing a sphere that facilitates interaction between the government, academia and the private sector.

The initial focus of the initiative might be criticised for largely being on the technological and infrastructure aspects of Industry 4.0, with skills development playing a less prominent role and predicted social challenges being side-lined. However, there are complementary initiatives to the *Industrie 4.0* frame. The Federal Ministry of Education and Research of Germany (2017) initiated *Berufsbildung 4.0* to align the nation's education and vocational training with the anticipated resulting shift in the skills demanded by industry, resulting from the transition towards Industry 4.0. The core of *Berufsbildung 4.0* is the creation of curricula and degrees for vocations that result from the evolution of the economy. Furthermore, funding for the digitalisation of vocational schools has been allocated (Federal Ministry of Education and Research of Germany, 2017). To complement this, €5.5 billion has been provided by state and federal ministries to improve the digital infrastructure of state schools (Federal Ministry of Education and Research of Germany, 2019).

As of 2019, sustainability is a cornerstone of German industrial policy, with the idea embracing social inclusion and environmental awareness in a circular economy (Federal Ministry for Economic Affairs and Energy, 2019:2). A facet that needs to be highlighted is that this initiative is a collaboration between hundreds of members from academia, industry and government (Klitou, Conrads, Rasmussen, Probst & Pedersen, 2017b). The general approach to *Industry 4.0* has been viewed as overwhelmingly positive, framed as a possible approach to keeping German industry competitive while building national wealth. Germany (and Slovakia, whose approach will be addressed in the next section and in the context of the European Union [EU]) forms part of the EU and is, therefore, part of the common European product, service and labour market.

As of 2020, 85% of EU citizens access the internet. A lack of infrastructure has been cited as the largest barrier to internet access, accounting for 46% of cases. Insufficient skills to access the internet are a barrier for 44% of un-connected citizens, with the associated cost of accessing the internet accounting for the remaining percentage (European Commission, 2020a:52).

Within the context of the EU, Germany performs well in most aspects of digitalisation, but falls short on delivering on eGovernment; less than half of the population uses online government services, a figure that ranks the country's eGovernment rollout as second-to-last in the EU. The government is aware of this situation and has stated that it will be addressed in a timely manner (European Commission, 2020b:12). German infrastructure is well above average, with overall fixed-line broadband internet access used by 88% of households. This is in addition to the roll-out of 5G networking, for which the government has financially supported private enterprises during the concept phases of the technology. This is vital to a timely implementation of Industry 4.0 (European Commission, 2020b:3–7).

From a human capital perspective, Germany has no formal national digital skills and job coalition as of 2020; this can, however, be largely attributed to the state's federal organisation, which places education under the control of its 16 constituent states. Basic digital understanding among the population is above the European average. The digitally literate population has grown to 70%, and 3.9% of the domestic workforce are computer specialists with a tertiary education. This percentage is in line with the European average; however, in the context of Germany's digitalisation ambitions and innovation-driven economy, businesses have found it tricky to recruit IT specialists from the local labour market, as there has been a shortage of these skills for years (European Commission, 2020b:7).

While business has embraced the change that moves towards digitalisation and Industry 4.0, German business largely still lags behind some of its European peers. Electronic information sharing is only practised by 29% of enterprises, compared to an EU average of 34% of businesses. Compensating for this deficiency, Big Data is used more often by German businesses, as 15% use this source of data, compared to the EU average of 12% (European Commission, 2020b:10). Business is seen as apprehensive about migrating physical on-site servers to cloud computing services; only 12% of German enterprises utilise this constituent technology of *Industry 4.0*, compared to an EU-wide uptake of 18% of cloud computing services. This issue has been addressed by industry and government as part of efforts to promote the use of the aforementioned *Industry 4.0* technologies. The contribution of online sales of cross-border trade is above EU average; however, this has been outpaced by offline selling, with its percentage of German trade decreasing from 11% (2017) to 10% in 2020. The impact of the 2020 COVID-19 pandemic, however, is not accounted for in this figure. It can, therefore, be presumed that this will serve as a catalyst for the implementation of online trade (European Commission, 2020b:10).

On a global scale, Germany is regarded as highly competitive and well equipped to address future changes in production. The World Economic Forum (2018:12) lists Germany as home to the third-best adapted production structure for the Fourth Industrial Revolution, with its production drivers ranked as the sixth highest across the globe. The Readiness for the Future of Production Report 2018 accredits the nation's strong industrial base and the complex nature of its economy for this high ranking. The report explicitly highlights the previously discussed *Industrie 4.0* initiative as key to its leading role in the implementation of the Fourth Industrial Revolution. The domestic industry is dominated by medium hi-tech and hi-tech industries, accounting for 61% of value added by manufacturing. The nation ranks high in most metrics that facilitate innovation and future growth, with the number of patent applications originating from Germany being the fourth highest globally (World Economic Forum, 2018:122).

Italy and Slovakia initiated comparable initiatives in 2016 based on Germany's *Industrie 4.0* action. Although based on a common fundamental concept, these approaches have been adapted to account for local needs and contexts.

1.2.2 Slovakia

Slovakia formally introduced its *Inteligentný Priemysel pre Slovensko* in 2016, an initiative also known as Slovakia Smart Industry. However, the Slovakian government has not allocated any funds as a budget for the initiative, emphasising that funds should be re-allocated from existing budgets. A key fund that has been earmarked for such re-allocation is the EU-funded Structural and Investment Fund (Klitou, Conrads, Rasmussen, Probst & Pedersen. 2018:3). The country is considered to be a moderate innovator (unlike Germany, which fosters high levels of innovation). Areas of focus for the Slovak government are increasing the cooperation among local industry while promoting local research towards Industry 4.0. The government has committed to promoting smart factories and improving access to funding (Klitou *et al.* 2018:4). To complement the shift towards a digital society, the government has highlighted possible eGoverment initiatives that aim to adapt the labour market through skills development, with a focus on digitalisation. However, it needs to be emphasised that, without sufficient budget allocations, the successful implementation of these intentions and initiatives is doubtful. Klitou *et al.* (2018:5) view this as a slow start towards Industry 4.0. In addition, action plans have suffered delays, while the government has focused on short timeframes without addressing the funding issues affecting the implementation. This will put the Slovakian private sector in the position of having to implement modernisation largely without close support from the government, putting it in a disadvantageous position compared to its European peers.

Regarding the implementation of the digitalisation of its economy and society, Slovakia ranks behind some of its European peers and has continued to slip behind other EU nations over the past few years. As of 2020, it is ranked seventh from last in the EU, having ranked 20^{th} in 2018 (European Commission, 2020c:3). The nation's performance is under average in every dimension of the European Commission's (2020c:4) 2020 index, with connectivity via fixed-line broadband internet lying at 72%. This has improved over time and is closing in on the EU average of 78%. Furthermore, Slovakia has initiated the process of assigning and selling 5G-frequency spectrums to mobile telecommunication providers; however, the building of a 5G network is highly capital intensive. Nevertheless, Slovakia expects 5G networks to be rolled out by the end of 2020, although the progress of implementation measures is unknown and the short timeframe of this rollout is highly ambitious (European Commission, 2020c:6).

The Slovak Republic's human capital is somewhat literate in basic digital skills, with 54% of the population possessing basic digital skills. A total of 3.2% of the working population are IT specialists, a figure close to the European average of 3.9% in 2020. The proportion of IT specialists has been steadily increasing from 2.9% in 2018. This development is in line with the increase in local IT graduates. The number of IT graduates has increased, from 2.9% of all graduates in 2018 to 3.3% in 2020. However, the low levels of young Slovaks' digital literacy pose a risk to further development (European Commission, 2020c:7).

This lack is deeply rooted in the Slovak education system; the Slovak school inspectorate reports that 45% of schools do not have a qualified IT teacher. This is compounded by the very low degree of digitalisation within primary schools: 83% are not highly digitally equipped or connected. The European Commission (2020c:7) has criticised the resulting lack of digital skills within the upcoming Slovak generation. It found that 60% of students are unable to perform basic digital tasks such as building presentations ('PowerPoint' presentations), creating charts or using spreadsheets ('Excel' tables). In the IT sector, Slovakia has one of the largest gender gaps in the European Union: only 0.9% of IT specialists are female. Slovak industry has highlighted the high and increasing divergence of skills in terms of those available in the domestic labour market and those needed by industry. This divergence has prompted local industry to call for substantial educational reform, with industry becoming proactive at filling these gaps (European Commission, 2020c:7–9). In 2019, the government issued the Slovak Digital Transformation Strategy 2030; however, whether it will be successful remains to be seen.

From an industry perspective, Slovakia compares similarly to its European peers in terms of its human capital. The European average for companies sharing information electronically lies at 34%; Slovak business nearly matches this average by achieving a rate of 31% of businesses sharing information online. The European average indicates that the percentage of electronic information sharing is increasing, whereas the Slovakian proportion of this metric has stagnated since 2018. Big Data is harvested by 9% of Slovak businesses, falling short of the EU average of 12%, and the proportion of Big Data users in the country has declined since 2018. A similar trend has been observed in cloud computing; during 2018 15% of Slovak industry used cloud computing, a figure below the EU average of 18% that decreased to 14% in 2020. While the Slovak industry is regarded as willing to adopt new technologies, a lack of support from public institutions has been highlighted as a considerable hindrance to modernisation. Furthermore, the Slovakian government has not adapted its regulatory and legal framework to accommodate technological advancements. The country's eGovernmental services are ranked among the least developed in the EU, with few online services and little data available to its businesses and citizens (European Commission, 2020c:12).

Businesses in Slovakia report few high-digital-intensity operations, again substantially below the EU average. In comparison to the digital economy, in the realm of physical manufacturing, Slovakia is one of the leading car manufacturers in the world, with a high level of robotics employed in the assembly process (European Commission, 2020c:11).

On a global scale, Slovakia compares favourably. Despite lagging behind its EU peers, the nation was considered the 42nd most competitive in 2019, slipping down one position from its 2018 ranking. The World Economic Forum points to the nation's low inflation and low debt as positive indicators of its macroeconomic competitiveness. The quality of education, which compares unfavourably to other EU nations, does not reflect the nation's economic maturity on a global scale. The quality of Slovakia's workforce ranks 97th out of the 140 nations measured. Reinforcing industry comments on the severe difficulty of finding skilled employees in Slovakia, the World Economic Forum ranks Slovakia as the 9th most difficult nation in which to find skilled employees, ranking it amongst nations with low economic development and nations still suffering the after-effects of war and civil unrest (World Economic Forum, 2018a:1–3). However, the outlook for Slovakia's workforce is positive, ranking considerably higher at 68th globally. The nation ranks as one of the ten least favourable nations for businesses hiring foreign labour (World Economic Forum, 2019:511–513).

1.2.3 United States of America

The United States of America (USA, US or United States) is, as of 2020, home to the largest economy in the world. The nation is home to some of the world's largest businesses and to one of the world's centres of technological innovation: Silicon Valley. Thus, the United States is home to several Industry 4.0 technologies. The nation's manufacturing sector accounts for 11% of its gross domestic product and a total of 68% of all exports. The US Government asserts that the use of modern technologies to innovate within the manufacturing sector is one way that the competitiveness of the nation's manufacturing sector in the global context will be improved (US Department of Commerce, 2020:1).

Between 1990 and 2019, the United States has seen a gradual decline in employment in the manufacturing sector. This is not solely related to the increased use of technology and the related increases in labour productivity, but rather to growing manufacturing capabilities in regions, such as China, that offer advantageous operating environments to manufacturers. The increasingly dominant role of China in the global value chain is seen as a particular cause of the declining employment rate of the US manufacturing sector (US Department of Commerce, 2020:1). The unemployment rate, as of July 2022, is nonetheless relatively low (at 3.5%) compared to that of other developed nations (US Department of Labor, 2022:1).

The nation fosters an increase in its domestic manufacturing capabilities. One of the most prominent initiatives is the 'Manufacturing USA' alliance between the US Department of Labor, the US Department of Defence and the US Department of Energy. The aim of this alliance is to foster, among other topics, digital manufacturing, additive manufacturing, robotics, sustainable manufacturing, cybersecurity and smart manufacturing. The alliance between government, private business and academia aims to ensure the sustainability of domestic manufacturing in an increasingly competitive global environment. The Manufacturing USA alliance includes 1,900 member institutions, of which 61% are manufacturing organisations. In 2019, a total of $488 million was invested in research into and the implementation of modern technology in the manufacturing sector, academia and government (US Department of Commerce, 2020:1–6).

The introduction of Industry 4.0 represents a fundamental shift in manufacturing and therefore requires national and governmental support. In respect of digital competitiveness, it is noted that the United States has been the world leader in this realm since 2019 (International Institute for Management Development, 2021:25). The nation is regarded as the most prepared for an increased transition into the digital sphere and is one of three leading nations fostering and holding the knowledge demanded by digitalisation. The nation is further regarded as the fourth most competitive in regard to technological availability and readiness (International Institute for Management Development, 2019:172–173). The United States has also been highlighted as being one of the most business-friendly nations globally (World Bank Group, 2020:20).

Whilst the term 'Industry 4.0' is rarely employed in a US context, it has been identified that the United States is incubating such technologies and promoting their implementation. The United States and its domestic IT businesses can be highlighted as some of the most influential in several spheres that influence the implementation of Industry 4.0. Majstorovic and Mitrovic (2019:88) cite the Industrial Internet Consortium (IIC), founded in 2014 by Cisco, AT&T, IBM, General Electric, and Intel, as an influential industry cooperation alliance that acts as a coordination organ for the development of the Industrial Internet and furthers the development of technical applications for Industry 4.0 technology. This industrial alliance has seen rapid expansion in its membership, which has grown to include over 250 companies (Majstorovic & Mitrovic, 2019:88).

Canada, the United States' neighbour to the north, is approaching the introduction of Industry 4.0 in an internationally collaborative manner with Germany, developing and fostering the implementation of Industry 4.0 technology. In comparison, the United States is taking a largely national approach to Industry 4.0. The most notable US Government initiative related to the implementation of Industry 4.0 is the 'Strategy for American Leadership in Advanced Manufacturing' (Majstorovic & Mitrovic, 2019:88).

The initiative originally known as the 'Advanced Manufacturing Partnership' was launched in 2011 and is the US Government's principal initiative intended to foster and fund the development and implementation of technology (known as Industry 4.0 in most other nations). It is principally focused on these technologies in an effort to incubate high skill–high pay manufacturing occupations and to ensure US manufacturing remains competitive by lowering manufacturing costs, improving quality, and accelerating product development (The White House, Office of the Press Secretary, 2011). This initiative has evolved over the various US presidencies and is currently in its third iteration.

1.2.4 People's Republic of China

China, home of the world's second-largest economy, has seen exceptional growth since its market opening in 1978. Chinese economic development can be divided into three distinct phases. The first phase, the recovery period following China's cultural revolution, is regarded as being between 1978 and 1989. This was followed by the emergence of the non-public economy and the first private foreign investment in local manufacturing in the 1990s, considered to be the second phase of Chinese economic growth. The expanding Chinese economic interests in international markets and the start of Chinese companies' endeavours to compete with foreign businesses in foreign markets marks the advent of the third phase of Chinese economic growth (Ma, Wu, Yan, Huang, Wu, Xiong & Zhang, 2018:1–3).

'Made in China 2025' is the People's Republic of China's 10-year strategic plan, created by the Chinese Central State Council in an effort to convert the country's economy into a world leader in manufacturing by 2049, the 100th anniversary of the proclamation of the People's Republic of China (Ma *et al.* 2018:3). The strategic aims of this plan are the creation of a high-quality manufacturing sector, environmental sustainability and an indigenous drive towards innovation. Wang, Wu and Chen (2020:1) argue that the current state of the economy is between Industry 1.8 and 2.1. Through initiatives such as 'Made in China 2025', China may leapfrog to Industry 4.0 by combining its national information and communication strategies with traditional manufacturing initiatives (Zenglein & Holzman, 2019:23).

In the effort to become a world leader in the coming economic and social epoch, 'Made in China 2025' prioritises the implementation of nine tasks (Ma *et al*., 2018:4). These are increasing innovation in manufacturing, widening the nation's industrial base, converging IT technology with industry, promoting green industry, building Chinese brands, restructuring manufacturing, expanding the service sector and internationalising manufacturing.

Reflecting the state's high degree of involvement in the economy is its highly important role in the planning and implementation of change. China has, in addition to naming the aforementioned priority tasks, named 10 industries that are deemed to be vital to the future economic success of the nation. These are industries that will benefit greatly from the 'Made in China 2025' initiative (Zenglein & Holzman, 2019:20). These industries are:

1. Bio-medicine and medical equipment
2. Information technology
3. Computerised machines and robotics
4. Aviation and space production
5. Naval engineering
6. Rail equipment
7. The automotive industry
8. The energy industry
9. Agriculture
10. High-tech raw material.

China's economic model sees the state playing an integral role in most of the country's industries while allowing private enterprise to compete and cooperate with state entities and state-owned enterprises, features that distinguish China's economy from Western economies (Wübbeke, Meissner & Zenglein, 2016:20–25). This is the largest difference with Germany's initiatives, as the state plays a minor role in the business world in Germany, compared to the dominant position held by state-owned enterprises in China. The German government has limited influence on the private sector; the 'Industrie 4.0' initiative is described as consensus driven. While 'Made in China 2025' is also considered to be consensus driven, the role of the state as both a politically guiding entity and a market participant through its state-owned enterprises means that the economy can be considered, in part, as a closed-loop system. The guiding and executing entities are ultimately part of the same organisation, constraining market forces (US Chamber of Commerce, 2017:26). 'Made in China 2025' serves as a demonstration that authoritarian leaderships are able to develop innovative and competitive economies, contradicting Western economic assumptions (Zenglein & Holzman, 2019:20).

A further difference in China's approach to Industry 4.0 is that the country has historically proven to be highly reliant on foreign suppliers for high-tech products (Ma *et al*., 2018:5). As part of its leap-frogging effort, China is focusing on insourcing high-tech knowledge at a rapid pace (Zenglein & Holzman, 2019:24-25).

1.3 PROBLEM STATEMENT

Industry 4.0 technology will alter the contemporary work environment considerably. A paramount change in organisations' work-environments (such as the introduction of Industry 4.0 technologies) requires the management of change processes to ensure a smooth transition to a new structure. A key element in addressing change in this context, is the use of internal communication programmes that inform and facilitate the implementation of the new technology. From this perspective, it can be argued that the implementation of Industry 4.0 would need to be complimented by considerable communication efforts to be in line with responsible business conduct.

In an environment that is transitioning towards a stakeholder capitalist society, businesses will be required to carefully address the role of stakeholders in the transition towards Industry 4.0, since its implementation will affect them. Further, organisations are not operating in a social, financial, environmental vacuum and thus need to adhere to stakeholder expectations to ensure organisational sustainability. In the context of the stakeholder capitalist view, the purpose of an organisation and its operations is an additional factor upon which organisations' actions are to be evaluated.

Whilst there is sufficient literature available on change management, internal communication, stakeholders and sustainability, the phenomenon of Industry 4.0 and its introduction into organisations is novel. Against this background, the investigation into the phenomenon requires a multi-disciplinary approach.

1.4 RESEARCH QUESTIONS

The purpose of this research study is to explore perceptions of Industry 4.0 at a managerial and non-managerial level in order to highlight possible perception gaps between these groups. The shift towards Industry 4.0 may impact a large proportion of the working population; therefore, this thesis will explore the relationship between the transition to

Industry 4.0 and sustainable business conduct, while considering the influence of communication on this relationship. Whilst addressing this problem has numerous practical applications for businesses, the academic value cannot be ignored. The introduction of Industry 4.0 is an ongoing process on which little academic literature is available. This research aims to address one of the numerous gaps in academic literature. Thus, the primary research question is as follows:

Primary Research Question: How is the implementation of Industry 4.0 being perceived on a management and a non-management level in a multi-national organisation operating in four countries?

Some argue that responsible business conduct could counter the skills shortages and social inequalities that may result from a transformation that moves towards Industry 4.0. In addition, Industry 4.0 may reduce manufacturers' environmental footprints, which is one of the explicit goals of sustainability. In this way, Industry 4.0 can increase efficiency and increase businesses' financial performance, ultimately promoting the pillars of sustainable business practice: people; planet; profit; and purpose.

In support of the primary research question, the following seven secondary research questions will be explored:

Secondary Research Question 1: How is the implementation of Industry 4.0 being perceived from a managerial perspective?

Secondary Research Question 2: How is the implementation of Industry 4.0 being perceived from a non-managerial perspective?

Secondary Research Question 3: How is Industry 4.0 altering the role of stakeholders of the organisation?

Secondary Research Question 4: How can change management programmes facilitate the implementation of Industry 4.0 on managerial and non-managerial level?

Secondary Research Question 5: How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?

Secondary Research Question 6: To what extent do managerial staff link the introduction of Industry 4.0 with elements of sustainability?

Secondary Research Question 7: To what extent do non-managerial staff link the introduction of Industry 4.0 with elements of sustainability?

1.5 THEORETICAL BACKGROUND

The Fourth Industrial Revolution, a term often synonymous with Industry 4.0, describes the sum of evolutions towards an ever more digital world within which the borders between the digital scape and reality are beginning to blur. Unlike historic economic revolutions, the emergence of the Fourth Industrial Revolution was predicted, thus enabling business and society to prepare for the changes that it represents (Almada-Lobo, 2015:16). Schwab (2016:11) notes that this development is of a radical nature, resulting in abrupt and profound changes to economies and societies. These changes do not occur in a vacuum but are set in motion by various triggers. The megatrends that form the course of the Fourth Industrial Revolution can be physical, digital and/or biological. From an Industry 4.0 production perspective, biological megatrends, such as genetic engineering, can be regarded as the least influential of these trends. In comparison, physical innovations (particularly autonomous vehicles, advancements in robotics and the introduction of novel materials) are crucial in driving the Industry 4.0 revolution (Schwab, 2016:19–21). However, the sole application of physical innovations does not suffice to implement Industry 4.0; the ever-growing role of digital innovations both competes and complements physical innovations. The application of physical and digital innovations will enable the decentralisation of production and the accelerated interconnection of corporate operations and society at large (Pereira & Romero, 2017:1209).

However, digitalisation has proven to reshape entire business sectors without the need for physical input or adaptation. An example of this can be seen in Uber, a cab-hailing app that has, for better or worse, reshaped the taxi and chauffeur-driven hire car industries where its operations are permitted (Schwab, 2016:14). Uber's disruptive power highlights the key power that digital innovation holds. It balances supply and demand in a relatively cost-efficient manner for the service provider. Uber dynamically adjusts pricing for the services offered by third parties to the customer, in real time. In addition, it enables private communication channels to remotely facilitate transactions in real time. In an effort to build trust in the service and between the involved parties, public communication channels are offered to all involved parties, allowing them to communicate through an open feedback system. Using this example – that is, software that links an available and therefore under-used asset (a chauffeur-driven car) with an ad-hoc user for a single transaction – increased value is created for a business through increased asset utilisation. The Fourth Industrial Revolution can be described as taking this thought further and including physical innovation; namely, a service is executed and facilitated without the need for human service providers – in this case, through autonomously driven vehicles. While Uber is a service used by a wide range of members of the public and is widely regarded as a business-to-consumer (B2C) service provider, the underlying principle can be applied to industrial services and business-to-business (B2B) transactions.

Schwab (2016:14) observes the increasing value of the digital sphere in economies and societies by comparing the three biggest companies in Detroit in 1990, the historic centre of traditional manufacturing, to the three biggest companies in Silicon Valley in 2014. The 1990 revenue of the three biggest companies in Detroit is matched by that of the Silicon Valley companies in 2014. However, the 2014 market capitalisation of the three biggest digital companies in Silicon Valley is 30 times greater than that of the three biggest Detroit companies at their peak in 1990. This is achieved through the use of a direct workforce that is less than a tenth of the size of the workforce of the three biggest companies in Detroit.

The linking of the aforementioned traditional manufacturing industries and the digital industry to form a new paradigm can be seen as the first limited 'post-digital' revolution; or, more precisely, as an 'epi-digital' revolution. The digital and physical innovations involved reshape previously available methods to form fundamental paradigm changes in industry and society on a global scale. The resulting change forms the Fourth Industrial Revolution (Philbeck & Davis, 2019:18–19).

1.5.1 <u>Punctuated equilibrium theory</u>

When discussing the implementation of new technologies, it is important to address the underlying assumption of how society and organisations evolve over time, thereby creating the need for companies to adapt to ever-changing internal and external environments. Punctuated equilibrium theory highlights three key repeating phases in the lifecycle of an organisation: deep structure, periods of stability, and revolutionary periods (Gersick, 1991:13).

According to this theory, organisations are established around deep structures that determine their organisational setup and core beliefs. Rather than imagining a continuous process of change without key triggers, the theory suggests that organisations operate within the confines of their deep structure until a paramount change occurs. This change renders the deep structure unsustainable; a process of reorganisation that alters the paradigms determining the organisation’s core beliefs then takes place. These changes occur in a tumultuous period for the organisation, or even for wider society. Thereafter, a phase of calm follows, where operations continue based on the newly established deep structures (Gersick, 1991:13). Should the organisation fail to adapt its deep structure, it would consequently cease to exist.

Deep structure is the underlying, often implicit, foundation on which an organisation is built. This includes the underlying common beliefs of its members. In addition, it forms part of an organisation’s value to society, or its raison d'être. This is what gives the organisation its licence to operate in a society (Gersick, 1991:14), ensuring that the business complies with social, economic, and environmental standards that focus on the long-term contributions of its existence.

Most organisations are built around core attributes that they are commonly associated with. These form part of the organisation’s identity, which will generally outlast short-term managerial realignments. Furthermore, deep structure is seen as the organisational setup that is used to ensure the long-term stability of the organisation. Gersick (1991:14) presents these as the organisation’s fundamental choices that constitute its most basic structure and determine its basic operational patterns of activity, collectively acting to maintain its long-term existence.

Tushman and Romanelli (1985:175) identify five kinds of deep structure choices. The aforementioned core values and beliefs, which determine where and how the organisation will compete, are complemented by the organisation's fundamental structure and affect the formal hierarchy thereof. Business unit strategy influences the product range offered to customers, the timing of these offerings, and the regional focus of the organisation's commercial activities. A further choice that is part of the deep structure concerns the distribution of power and the associated allocation of resources within the business. Control systems form yet another part of an organisation's deep structure by ensuring efficient and clear operational procedures.

In addition to being the foundation of an organisation, deep structure can act as a boundary for its operations. During the equilibrium phase of an organisation's life, its daily operations are conducted within the confines of the deep structure, essentially maintaining the core of its existence while working towards achieving its business goals. This period of consistent operation may, at times, be seen as a time of stagnation. However, it must be noted that while the core values remain unchallenged, this phase is where organisational efficiency is created, operations are optimised, and product offerings are extended within the confines of the organisation to achieve the goals established within the deep structure (Gersick, 1991:16). This time could be characterised as a gradual evolution of the established paradigms or as the incremental change of isolated aspects of the organisation (Gersick, 1991:26).

The resulting network of interdependence will create an inertia that prevents the organisation from adapting in a timely fashion to changes in its environment. Organisations optimise their operations to meet the demands of a reasonably stable environment. Should the environment change, however, adapting within the parameters established by the deep structure will become problematic (Gersick,1991:19).

In practice, these periods can be exemplified by the history of the automotive industry. Evolving over 100 years, the industry largely followed the principles of geared combustion engines as a means to propel a vehicle that is assembled in a line consisting of automated robots and manual human labour. While the numbers of manufacturers and suppliers have varied over this period in line with the wider economic climate and other industries, a level of maturity was reached that led to the start of a tumultuous time aided by society's rapid digital growth.

Revolutionary periods are often triggered by performance pressures that may originate internally or externally. An organisation that is experiencing such pressures frequently addresses them by replacing key high-level executives. If they are replaced by outsiders, there is a high likelihood that the new executives will question the organisation's deep structure choices.

Endogenous stimuli for change are described as the results of internal pressures to adjust or adapt. Although Bouchey (2012:128) describes this from a governmental policy perspective, it also applies to organisational policy and the implementation of technologies. Revolutionary change that originates in internal factors is driven by internal communications and the influence of the parties involved. The failures of these deep structure elements or the inability to adapt such a structure to evolved environments will force the leadership or external actors to initiate paramount changes to the existing structure in an effort to remain relevant for stakeholders and to ensure the organisation's operational continuation (Gersick, 1991:23). The revolutionary period is associated with a quest for problem-solving approaches outside of an organisation's deep-rooted framework that will break its inertia (Gersick, 1991:23). Tushman and Romanelli (1985:173) argue that larger organisations, as well as ones with longstanding leading executives, struggle the most in breaking the equilibrium and instituting substantial changes.

The impulse for deep-rooted change does not have to be initiated from within the organisation. Exogenous stimuli, or exogenous shocks, are the second type of trigger that initiates the series of events that categorically change the context. They motivate the respective parties to engage in efforts to adapt to the new realities (Boushey, 2012:128). At times, the impulse is the result of environmental factors that amplify the need to rethink or re-invent. Such an external impulse for rapid change within an organisation can be seen in the Fourth Industrial Revolution. The most notable aspect of Industry 4.0 is the rapid rate at which change is implemented. This radical change is differentiated by its pace and by the deep way that it impacts wider organisational and social life (Bonciu, 2017:9).

The erosion of deep structure elements as a result of revolutionary changes can lead to uncertainty and will often result in periods where organisations seem to lack direction. This is, however, only a transitional phase, as new deep structures replace the superfluous previous ones. The revolutionary period should, however, not be seen as a period of constant change where all established deep structures are eroded simultaneously. It is rather a succession of interlinked changes over a short timeframe (Gersick, 1991:30). The revolutionary period will see an organisation re-evaluate its fundamental beliefs and values.

One can distinguish between two approaches to change in an organisation. Organisational reorientation is the process where key strategies are revised. These may include an organisation’s product line-up, the market it serves, the technology it utilises, and the timing of its product offering. Its distribution of power may also be realigned to better represent the new environment in which it operates or plans to operate. This will also affect the organisational structure and the control mechanisms that ensure that actions are aligned with organisation’s core values (Tushman & Romanelli, 1985:178–181).

Whether by choice or by the demands of external situational fluctuations, some organisations may choose to undergo further changes by altering some of the core values that formed the basis of their operations for decades. In such cases, organisations re-create, rather than simply re-orient, themselves. Examples of core values include the type of customer that the organisation sees itself as serving, the industry in which it operates, or the value it offers to society and the regions in which it operates (Tushman & Romanelli, 1985:178–181). Gregory and Willis (2013:33) highlight that communication competence within an organisation is a central element in the shaping of senior management’s perceptions of such needed changes.

The period between 2019 and 2020 could be considered tumultuous to a degree. The advent of Industry 4.0 and the transition towards electro-mobility changed the fundamental understanding of an industrial sector that was based on internal combustion motorisation for over 100 years. As has already been highlighted, electric cars and the resulting simplification of the product heavily impact suppliers of conventional car components. Entire business sectors are currently forced to reconsider their core purposes and this, in some cases, may motivate companies to drastically change industries and product offerings (Vetter, 2017).

This change is occurring in a context where the merging of the digital and the physical economies is gradually forming the cyber-physical economy, while simultaneously a viral pandemic at a scale unseen since the Spanish flu severely impacts society and business and results in deaths and economic hardship. Whilst the transfer towards electric mobility or the shift towards integrated Industry 4.0 technologies, or even the COVID-19 pandemic, may not constitute a revolutionary phase, it can be argued that the simultaneous occurrence of these events may lead to the implementation of new technologies and to substantial long-lasting global social changes.

Schwab and Malleret (2020:175) highlight that pandemics such as COVID-19 are not random events that occur at arbitrary historical moments. They are cyclical events that, in combination with other factors, form the impetus for change. The authors argue that throughout history, epidemics and pandemics have been revolutionary periods that have led to global economic and social re-organisation. The revolutionary character of the period since 2020 can be illustrated by the accelerated digitalisation of organisations. Digitalisation has been a buzzword for years, but many organisations have largely been confined to paying it lip service. The new realities of decreased personal contact, lockdowns and reduced accessibility to traditional company resources have led to unprecedented investments into digital work solutions and Industry 4.0 technologies to ensure the survival of organisations under these new conditions (Schwab and Malleret, 2020:175).

1.5.2 Systems theory

As highlighted by the previous discussion of punctuated equilibrium theory, there are numerous factors that influence an organisation and either function to initiate a period of rapid and deep-rooted change or to sustain a status quo (Tushman and Romanelli, 1985:174). Systems theory is a wide-ranging approach that describes the nature and structure of many complex elements that are collectively known as systems. According to Bertalanffy (1972:417), a system is any group of elements that have a relationship with themselves and with their respective environments. The concept has been applied in a variety of disciplines, ranging from the social sciences to physics and biology. This theory is highlighted as a suitable base for exploring organisational systems and the exchange of information via communication within the organisation or its environments (Cummings, 2015).

Cummings (2015) cites several scholars who argue that, in accordance with systems theory, organisations are to be considered as complex systems that interact in a non-linear fashion. These interactions are often said to be of a surprising and novel nature and difficult to predict; however, systems of interlinked elements that combine to create new outputs lend themselves to the promotion of organisational changes and innovation.

One can distinguish between open and closed systems. Closed systems theory is applied when researchers seek to explore or manage a single unit without considering its environment and its relationships with external elements. Such an approach is best applied when exploring the internal elements of systems without considering outside inputs. A core understanding of a closed mechanistic system is that of equilibrium; here, all disturbances are counteracted in order to maintain the status quo or re-establish the original equilibrium (Gregory, 2000:267).

One can also consider systems to be open, following an organismic or an adaptive model. Organismic models emphasis an organisation’s response to changes in its environment and examine how single units affect others within it. Adaptive models of open systems theory focus on the role of feedback to initiate changes with a particular purpose. This focus on how systems change themselves is also known as morphogenesis. According to this approach, adaptive systems require variety, tension, and an internal drive to learn through feedback loops. Open systems in a social context have two underlying assumptions. Firstly, there is the assumption that systems are open to inputs from their respective environments. Secondly, changes in one element of a system may lead to changes in other elements of the system. This results in open systems being in a state of constant adaptation and reaction to ongoing changes and thereby undergoing constant changes themselves (Gregory, 2000:267–270).

Cummings (2015) states that a system needs to perform at least four functions in order to remain viable. These four functions are:

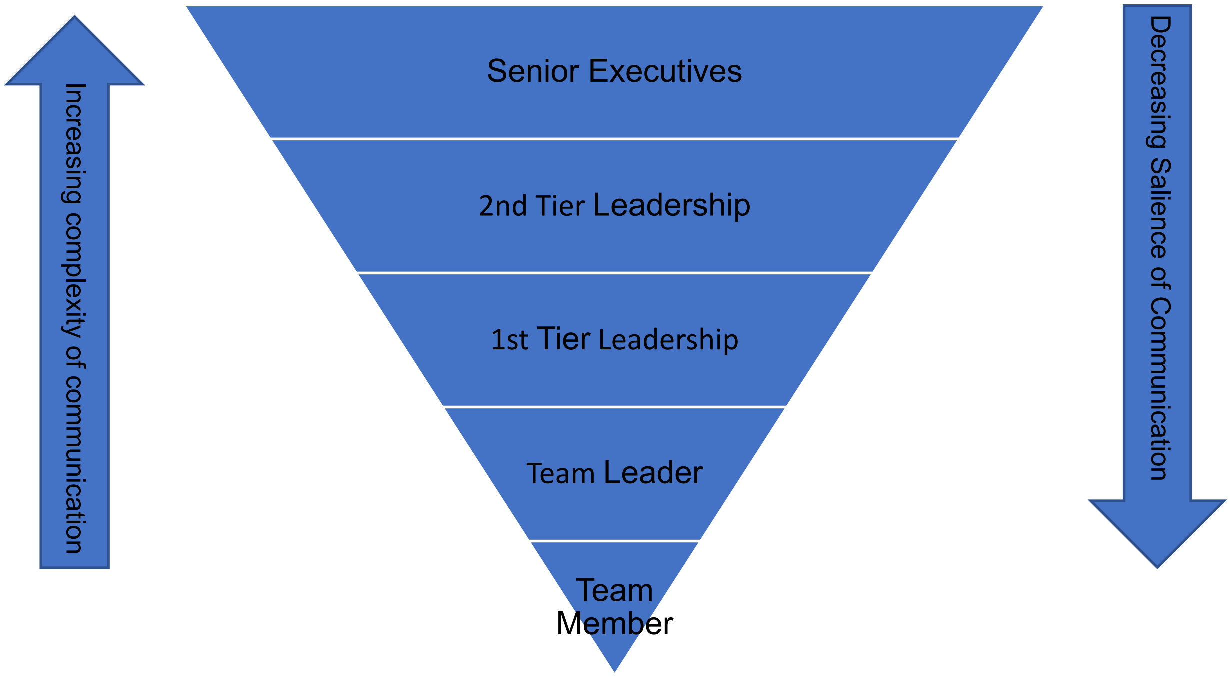
1. The system needs to transform inputs of energy and information into outputs that are useful to it or to its environment.
2. The system needs to engage in transactions with its environment to obtain inputs for its transformation and to disperse its outputs.
3. The system's behaviour needs to be regulated to achieve a stable performance.
4. The system needs to adapt to its environment and to changing conditions.

Katz and Khan (1978) model systems in a way that is similar to Cummings (2015), as they also state that systems require an input that is received from the external environment. In their model, the input then goes through a transformation process within the system, the result of which is dispersed to the system's wider environment. The Katz and Khan (1978) model highlights the role of the environment, as it can affect the entirety of a system's elements and input/output processes. Feedback is another critical element for any open system, as the communication and exchange of information between it and its environment allow it to adapt to changes and achieve sustainability (Gregory, 2000:267).

It can be argued that this creates an interrelationship between different systems, but also between a system and its immediate environment. These relationships require effective communication to achieve their objectives and establish a sustainable structure (Musheke & Phiri, 2021:659–664).

Grassmann (2021) highlights the role of communication as a central element in the understanding of systems. The utilisation of feedback and the maintenance of a feedback loop are based on the existence of communication mechanisms that allow a system to correct and sustain itself. Within a system, there is an identifiable hierarchy that structures the interdependence and roles of its constituent elements (Lai & Lin, 2017:3).

Figure 2: Communication & hierarchy within systems



Source: Kittelman, Amolio & Leon (2018:526)

From the perspective of communication, organisations may be regarded as systems in which the implementation of changes is based on both external inputs but also on actions from within their hierarchy. Executives form the leadership of the system and are located at the top of its hierarchy; alongside those directly beneath them, they process the highest level of informational complexity in the organisation. The complexity of the information that is communicated increases alongside the hierarchy. Furthermore, the salience of the communication decreases the lower the element is located within the system's hierarchy. This is illustrated in the above illustration (Kittelman *et al.*, 2018:526).

This theory is suitable when exploring the implementation of Industry 4.0 in an organisation from a management and non-management perspective. This highlights the implementation of Industry 4.0 as a change to a system and as a system itself within varied global contexts.

1.5.3 Stakeholder theory

Stakeholder theory is the explicit counterbalance to the shareholder approach in terms of defining the social roles and positions of business organisations. From the shareholder perspective, an organisation is only responsible towards its direct owners, or shareholders.

Thus, a business is not responsible to act in the interest of society, but rather to maximise the profitability of the direct owners irrespective of other interests. This approach is most often pursued by the business leaders of Anglo-Saxon organisations. Magill, Quinzii, and Rochet (2015:1686), highlight that perceptions of the role of organisations and the role of externalities vary between cultures. They cite a survey in which 97% of Japanese CEOs and 84% of German CEOs designated their organisations' roles as stakeholder-focused. By contrast, Anglo-Saxon organisations hold a different approach to European and Japanese businesses, with 76% of American CEOs and 70% of British CEOs espousing the view that their organisations' exclusive focus is on the interests of their shareholders (Magill *et al*., 2015:1685).

Stakeholder theory accounts for the impact that businesses have on their operating environment. Economists argue that most large companies are facing risks that originate from within; these risks could have a substantial impact on the employees and consumers that the companies serve. If confronted solely from a shareholder-centred perspective, these risks would not be adequately addressed to avert risk in the long term due to a short-term focus on profitability. This is averted when firms address these risks by refocusing on the total welfare maximization of their stakeholders (Magill *et al*., 2015:1687).

From a stakeholder theory perspective, business success is measured in the context of a business's operating environment. It is highlighted that business operations exist within society; the interconnections between wider society, businesses, and environmental factors create a network of interdependency (Palazzo, 2010:18–20). Stakeholders have a variety of definitions. Freeman *et al.* (2018:1) define stakeholders as the groups and individuals on whom an organisation relies to succeed in its operations. In addition, they also consider groups or individuals that have valid interests in the outcomes of an organisation's operations to be stakeholders.

Primary stakeholders – the focus group of most organisations – include customers, employees, suppliers of goods, suppliers of finances, and the communities in which a business operates. Secondary stakeholders include governments, regulatory bodies, special interest groups, non-governmental organisations, the media, labour representatives, and competing business organisations (competitors). Whilst secondary stakeholders are of high importance, in practice they are often given less attention by an organisation's leadership (Freeman *et al.,* 2018:1). Pesqueux and Damak-Ayadi (2005:6) discuss this two-tiered approach to stakeholders by highlighting primary stakeholders as those with direct contractually formalised relations with an organisation. Secondary stakeholders are defined as those that are at the borders of an organisation's actions but may still be affected by them. Secondary stakeholders do not have formal contractual ties to the respective organisation.

From an operational perspective, businesses address stakeholders successfully when the following minimal requirements are met: the group that is affecting or is affected by the organisation must be identified and well-defined; there must be benefits assigned to these groups, and these must be weighted in terms of their relative importance; and finally, it must be possible to provide incentives for the organisation to implement the objectives of the identified stakeholders (Magill *et al*., 2015:1688). Freeman *et al.* (2018:2) argue that stakeholder theory is not envisioned to compete with the shareholder theory, but rather builds on it. It is a widening of the understanding of value creation that highlights the importance of a long-term corporate focus beyond short-term value creation. When exploring stakeholder theory, several core elements become apparent that together form the contemporary understanding of stakeholders.

Firstly, the stakeholder perspective was developed as a guide for managers to enact strategic management. The role of stakeholder theory in the field of strategic management only developed slowly but was already established as a dominant theory in business ethics (Freeman *et al*., 2018:2). Contemporary authors highlight that stakeholder theory finds application in most management disciplines, including those of business management, finance, human resource management, production, law, communication management, and corporate social responsibility (Harrison, Freeman & Sá de Abreu, 2015:860).

Secondly, Freeman *et al.* (2018:2) characterise stakeholder theory as being a moral approach to management that includes having respect for basic human rights, acting with honesty, and holding organisations accountable for their actions.

Thirdly, the underlying understanding of stakeholder theory is that it obliges organisations to be assessed with reference to their overarching goals in relation to society (of which financial profitability is but one dimension) instead of only focusing on short-term profit. The implicit manner in which organisations act is determined by their values, and these need to reflect those of the respective environment. Businesses that adopt a stakeholder approach often follow the values and morals of their predominant stakeholders in an effort to ensure societal acceptance of their operations (Freeman *et al*.,2018:2–4).

Freeman *et al.* (2018:4–7) argue that, when seen through the lens of stakeholder theory, business creates more than economic value; it also contributes to the creation of societal value by ensuring the welfare of stakeholders. In such cases, the value created is not only financial but also utilitarian. Much like direct costumers, all stakeholders have the power of choice, and, without their support, the operations of a business would be severely hindered. The idea of reciprocity states that the conduct of business organisations has a long-term impact on the attitudes of its stakeholders. Good conduct is argued to lead to a positive reputation that will aid the business in its operations. The interests of stakeholders will converge over time. When exploring stakeholder interests, three dimensions come to light. Some stakeholders' interests overlap or match the interests of other stakeholders; therefore, catering to these interests creates value for several parties. Of course, some stakeholders' interests are incompatible, but having previously catered to their interests will increase the likelihood of them accepting the business's decision despite their wishes, thanks to its positive track record (Freeman *et al.,* 2018:9).

Stakeholder theory can be summarised as an idea that describes an effective, efficient, and ethical manner in which businesses conduct themselves in interconnected and rapidly changing environments. The consultation and catering to stakeholders' interests enables organisations to harness the ideas and initiatives of their operating environments to meet their goals (Harrison *et al*., 2015:859).

A closely related idea is that businesses require a societal license to operate, as the stakeholder theory highlights the interconnectedness of stakeholders and businesses in modern society and the power of the former over the latter. To obtain such a license to operate, businesses must communicate clearly with stakeholders. Such interactions are highly reliant on the successful identification of stakeholders.

When observing stakeholder theory, it becomes evident that stakeholders' expectations need to be addressed through management and communication in order to ensure an organisation's sustainability. Schwab (2021:171–173) identifies this drive for sustainability as a form of stakeholder capitalism that is based on four core contexts of sustainability in which organisations operate. These consist of the social context environment, the financial context environment, the environmental (natural) context environment, and the governance context environment (Schwab, 2021:171–173).

1.5.4 <u>The resource-based perspective</u>

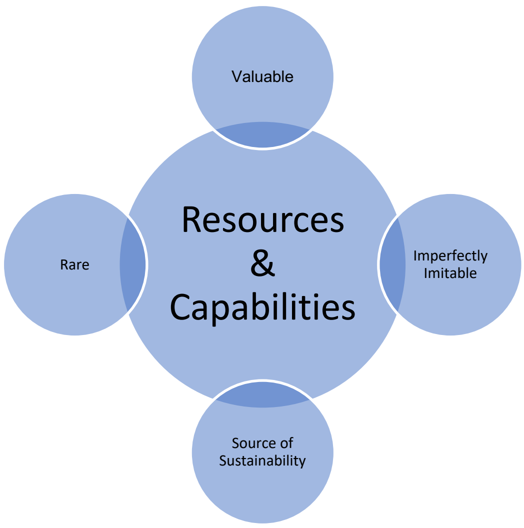
The resource-based perspective is an approach that is used to explore the allocation and use of resources by organisations to gain and sustain a competitive advantage. Barney (1991:99–100) argues that this drive to understand what sustains an organisation's competitive advantage is at the core of this theory. To understand what constitutes a competitive advantage, one first needs to establish an awareness of the characteristics of an organisation's resources. Following Barney (1991:101), a resource can be defined as any asset, capability, process, information, and knowledge that is under the control of the organisation and enables it to operate and implement strategies that ensure organisational effectiveness. It is further stated that competitive advantage is the ability to create value in a non-duplicatable manner that is not being simultaneously created by a competitor.

The resource-based view does not limit itself to the exploration of resources, but also extends to the exploration of an organisation's capabilities. Unlike a resource, a capability does not directly enable an organisation to implement a strategy to achieve a goal but is the means to utilise other assets to attain a goal. A capability is a subset of an asset (Barney & Hesterly, 2020:86). A capability and a resource can be of a tangible or intangible nature. For example, a machine may be tangible, but the proprietary software used to operate the machine is intangible (Barney & Hesterly, 2020:86).

The capabilities and resources of a typical organisation include financial, physical, human, and organisational assets. Financial resources are all monetary means and monetary incomes that enable the design and implementation of strategies to ensure a sustained competitive advantage. Physical resources are all the resources that are found in the physical realm and are used to sustain the organisation. They include manufacturing equipment. Some argue that intangible assets such as technology and software that form part of physical manufacturing equipment can also be categorised as physical assets and capabilities. Land and buildings are physical assets of an organisation, but its geographical location can also be classed as a physical asset, as various environments offer different strategic competitive advantages or disadvantages. Human resources are all the resources that refer to the skills, abilities, experience, and relationships of individuals within an organisation that can be harnessed to improve its position. Organisational resources refer to the attributes of groups and individuals within its structure. This resource is closely linked to the organisational setup of an organisation and to its governance. It includes formal and informal hierarchies, reporting structures, planning capabilities, organisational culture, reputation, and the relationship between the organisation and its external and internal environments (Barney & Hesterly, 2020:86–88).

Arend and Levesque (2010:914–915) state that all resources must display four characteristics. Firstly, a resource has to be valuable. Secondly, a resource must be rare. Thirdly, a resource must be imperfectly imitable. Fourthly, a resource must be the source of a sustainable competitive advantage.

Figure 3: Four characteristics of a resource



Source: Barney & Hesterly (2020:89-99)

Barney and Hesterly (2020:927) argue that value in the resource-based view goes beyond simple monetary means and that a valuable asset or capability is one that enables an organisation to successfully address external threats and exploit external opportunities. They further state that a valuable asset that is available to many competing actors is not a sustainable source of competitive advantage. Rarity, therefore, becomes another factor that determines the importance of an asset or capability. Rarity is the uniqueness of an asset or capability compared to the other assets in the external environment that are available to competing organisations.

The world is in a state of constant development and change. Because of this fluidity, an asset needs to be imperfectly imitable. Whilst assets are gradually being developed to imitate those of other organisations, true valuable resources and capabilities are impossible for competitors to reproduce. Some authors argue that an asset can be also considered to be inimitable when the costs of attempting to replicate it are prohibitive. This argument is a driving force that has led some organisations to constantly innovate in order to gain an advantage that cannot be eroded by competing organisations' strategic imitation (Barney & Hesterly, 2020:30–31).

One could name an organisation's introduction of novel proprietary production and technological approaches – such as the introduction of Industry 4.0 technologies – as an example. Factors that increase the replication costs for other firms include unique historical and situational conditions. Causal ambiguity may also contribute to an increased difficulty for other firms to replicate an asset, as the link between an asset and an organisation's competitive advantage can be difficult to determine from an external vantage point. In addition, it is argued that the cost of developing a resource or capability through natural evolution is lower than the cost of replicating it and forcing it upon an organisation. This is particularly relevant if the asset is of high social complexity. Lastly, particularly in relation to technology, the use of intellectual property and patents limits outside organisations' ability to directly imitate a resource or capability without explicit consent for a certain period. This often extends beyond the technical relevance of the technology (Barney & Hesterly, 2020:90).

1.5.5 The communication transmission model

The communication process lies at the heart of any exchange, including internal communications. Tubbs and Moss (2008:9) argue that the communication process needs to contain at least a sender, a receiver, a channel, and a message. The argument states that the communication process consists of an exchange where ideally all the parties involved are senders and receivers of messages. This assumption enables the authors to assert that those who participate in the process are not solely receivers or senders, but rather reciprocal communicators. Whilst one communicator may initiate the exchange by sending messages, the other party can react to the perceived messages that are transmitted. This reaction to stimuli designates the second communicator as a reactive communicator (Tubbs & Moss, 2008:1–19). As with many understandings of the communication process, this perspective is anchored in the Shannon–Weaver model of communication that was formulated in 1949 (Al-Fedaghi, 2012:12–19).

Exchanges may take the form of verbal messages, defined as all messages that consist of spoken words. On the other hand, non-verbal communication consists of all messages that do not rely on the spoken word to convey meaning. Non-verbal messages include facial expressions, tones, or movements (De Vito, 2015:25–28).
Cohen and Lloyd (2014:202) illustrate that channels are all the means that enable the conveying of a communication message from a sender to a receiver. These include senses such as hearing, seeing, touching, smelling, and tasting in their most elemental form.

Falkheimer and Heide (2018:92–105) argue that internal communication is traditionally reliant on organisational forms that are hierarchically structured. Where organisation is hierarchical, this type of communication is suitable to implement and communicate changes. The hierarchical nature of organisations lends itself to top-down communication methods. Senior management is identified as the driver of change and communicates in an ordered and established manner. The management acts as the decision-making organ of the organisation. The decisions of the management are to be dispersed throughout the organisation's structure to ensure that all its internal elements have the relevant information to act accordingly and efficiently. This communication can take various channels that facilitate the transmission of messages from the senders to the receivers.

Mass communication channels are often used to communicate within an organisation. A previous criticism of such channels is that they do not efficiently allow fruitful two-way communications. Mass communication through internal communication systems is nonetheless a tool to build bonds and relationships. Tools of mass communication include e-mails, company newsletters, informational videos, and digital or analogue placards (Tubbs & Moss, 2008:12–15).

Communication channels can consist of informal communication, or of formal communication that can act as an impetus to trigger informal exchanges amongst the members of the organisation (Falkheimer & Heide, 2018:92–100). All channels need to be accessible, able to transmit a message accurately and timely, and trustworthy (Verwey, Du Plooy-Cilliers & Plessis, 2011:160–163).

Verwey *et al.* (2011:164) state that formal communication channels within an organisation consist of downward communication, upward communication, and horizontal communication. Downward communication is the utilisation of communication channels to convey a message from a high level within the organisation's hierarchy to a member that is positioned lower. These channels convey messages that provide instructions on the manner with which to conduct a task, explanations of the purpose of a specific activity, organisational rules, feedback on the subordinate's performance at the workplace, and information on the organisation's mission, vision, and purpose.

Upward communication within an organisation involves the use of channels to convey a message from a subordinate member of an organisation to a member of a higher level in the structure. Vertical upward communication channels are the means to convey important information that assist the decision-makers in the decision-making process; they also serve to communicate work pressures and frustrations and to improve the participation of all members in internal activities. Upward communication channels may also serve as a means for helping the workforce accept decisions made by senior management, as they allow for feedback and participation in the organisation's internal communication processes. Further, the use of upward communication can foster constructive feedback upon which the downward communication process can be improved (Verwey *et al.*, 2011:165).

Horizontal communication as a formal channel of communication enables interaction within the same hierarchical position and often involves coordination or problem-solving activities. In addition to this, it is a means for social exchange. The utilisation of horizontal communication channels fosters productive and collegial communication within the organisation. The emphasis on teamwork and knowledge-sharing within an organisation is gaining importance in increasingly complex organisational structures (Verwey *et al.,* 2011:164–165).

The grapevine is an informal channel of spreading information. It often acts as a main source of information for employees, but from the perspective of an organisation this is often not desirable as the prerequisites of what constitutes a good communication channel are rarely met. Specifically, the criteria of accuracy and trustworthiness are often not clear (Verwey *et al.*, 2011:166).

Noise is a type of interference that distorts the message from the communicator to the receiver to the degree that the message that the receiver perceives is not an accurate representation of the sender's original output. Interference can take the form of a distraction from the receivers' side that inhibits them from accepting and processing the message as it was intended by the sender (Tubbs & Moss, 2008:15–16).

Workplaces are increasingly evolving towards a rise in the degree of digitalisation, a process that includes the introduction of Industry 4.0. While digitalisation has increased humans' ability to communicate with each other and with machines without geographical limitations, it has also created novel sources of interference in the human communication process.

Noise or interference in communications within an organisation can stem from the organisation itself. The term 'communication climate' describes the perceived way that communication is facilitated within an organisation. The communication climate can be supportive and limit interferences by enabling open and honest communication. A supportive communication climate allows for spontaneous communication and empathy is encouraged. Supportive organisational communication climates are also those that encourage employee participation. Unsupportive organisational communication climates are those that do not foster open internal communication; here, communication is solely predicated on one's status within the hierarchy, and employees are dissuaded from participating (Verwey *et al.*, 2011:166–167).

Beute and Pacinelli (2021:18) argue that digital communication is particularly vulnerable to noise. The authors frame this noise as digital pollution, an element that turns the digital communication channel into a source of lack of clarity, miscommunication, and friction.

Should a digital channel be susceptible to such noise, it is often the source of pollution and mistrust, since communication skills that are innate to humans are not as effective when communicating digitally. In remote forms of digital human communication, virtual channels often lack tone and intent. The use of visual means often addresses some of the aforementioned undesirable aspects. A key element that negatively affects employee productivity is the volume of noise, as employees are easily distracted or are spending an increasing amount of time evaluating and filtering inputs from a noisy digital environment. While it is evident that digital pollution negatively impacts internal communication and organisational efficiency, it must be noted that the use of digital channels is not per se harmful. The selection and use of digital communication channels must be careful, and they should only be used to the benefit of the organisation.

1.6 RESEARCH DESIGN

This section will provide an overview of this study's research design. A detailed account of the methodology, the design of items, and ethical considerations are discussed in Chapter Five of this document.

This study follows a qualitative approach. All research traditions are based on certain defined assumptions that characterise the approach to the phenomenon that is being investigated (Du Plooy, 2011:16).

Qualitative research is an umbrella description for a variety of approaches and methods for the study of social life (Saldaña, 2011:3). From an epistemological standpoint, qualitative research is concerned with the extraction of knowledge related to the meanings that people attach to their experiences. The subjective nature of understandings that are carried by the subject allows for the accommodation of multiple sources of truth; these are used to explore, understand, and interpret a subjective situation. In this study, the perceptions of management and non-management staff regarding the implementation of Industry 4.0 are to be explored (Du Plooy, 2011:35).

Yin (2016:6) highlights that qualitative research is a preferred research design thanks to its ability to adapt to research conditions. Furthermore, it is not constrained by a lack of sufficient academic knowledge of the phenomenon and can adapt to a variety of different research conditions in order to draw samples. Most importantly, it enables research to be focused on the present and is not limited to the representation of the past.

Qualitative research concerns itself with the study of meaning in the real-world environment and draws representations of the views and perspectives of the participants in everyday contextual conditions. It aims to contribute insights and introduce novel concepts and constructs to explain social behaviour, and it acknowledges the relevance of multiple sources of evidence (Yin, 2016:8–9).

A total of 50 qualitative interviews were conducted from December 2020 to June 2021 with the consent of all participants and the case organisations. All ethical requirements were fulfilled as stipulated by the University of Pretoria. No interviews were conducted prior to the receipt of ethical clearance. A total of five interviews each were conducted with non-management staff at the case facilities in the USA, Slovakia, and China. A total of 10 interviews were conducted with non-management staff at the German case facility. This was further segmented into five interviews with non-management staff working at a production line that has been upgraded to Industry 4.0 standards, and five interviews with non-management staff working at a production line that has been planned and is built to Industry 4.0 standards.

A total of five interviews each were conducted with the management staff at the case facilities in the USA, Slovakia, and China. A total of 10 interviews were conducted with the management staff at the German case facility. This was further segmented into five interviews with management staff working at a production line that has been upgraded to Industry 4.0 standards, and five interviews with management staff working at a production line that has been planned and is built to Industry 4.0 standards.

A non-probability sampling method was employed to address the limitations that arose due to this research endeavour being conducted during the normal operational hours of the facilities. Once interviewees were identified and approached, references for other possible participants were asked from the first interviewee. This method can be referred to as snowballing (Wagner, Kawulich & Garner, 2012:92).

Following a semi-structured interview schedule, items were developed to address the primary and secondary research questions that are highlighted in this chapter. Despite initial plans to conduct the interviews in person, global travel and contact restrictions made it necessary to conduct all the interviews remotely using computer-based communication. All the interviews were recoded and transcribed for later analysis with the aid of Atlas ti. Further details and extensive discussions of the research design are included in Chapter Five of this document.

1.7 IMPORTANCE OF THE STUDY

The importance of this study is however not solely related to the novelty of the phenomenon; its significance is further augmented by the scale of the impact that the introduction of Industry 4.0 may have on the manufacturing sector and on society as a whole. Its unique position during a time of severe uncertainty is a factor that highlights the uniqueness of the study.

There is little doubt about the importance of communication management in the introduction of Industry 4.0 in manufacturing organisations. Greater insights into the perceptions of management and non-management staff around the introduction of Industry 4.0 in four distinct regional contexts can inform practitioners' policies in relation to changes in communication to address the current technological transformations.

Due to the novelty of the phenomenon of Industry 4.0, very little relevant academic literature is available. It follows that this study will expand the limited academic literature on the phenomenon to further academic knowledge.

1.8 LIST OF CHAPTERS

Chapter One of this document introduces the relevant literature and the regional contexts of the present study. The object of the study is discussed, and the research questions are presented. This is followed by a discussion of the study's theoretical background that covers punctuated equilibrium theory, systems theory, stakeholder theory, and the resource-based perspective. This chapter is utilised to highlight the core elements of this study's research design and to illustrate its importance.

Chapter Two is the first of three literature chapters. The contents of this chapter explore technologies associated with Industry 4.0 and their implementation in manufacturing environments. The chapter also focuses on processes of change during the implementation of Industry 4.0.

Chapter Three, the second of three literature chapters, is focused on communication management in an Industry 4.0 environment. It discusses the issues of employee communication, the role played by culture in communications, and remote workplaces in an Industry 4.0 environment. As part of this chapter and of a discussion around stakeholder capitalism, stakeholder communication and their transitions related to Industry 4.0 are highlighted.

Chapter Four is the final literature chapter of this document and is focused on the presentation of sustainability in an Industry 4.0 environment. The quadruple contextual environment and various collaborations to apply technologies associated with Industry 4.0 are illustrated.

Chapter Five presents the research methodology, followed by the study itself. The ethical considerations of the study are highlighted, the sampling procedures and requirements are discussed, and the data collection process is described in detail. Lastly, the data analysis is discussed and the use of Atlas ti as a technology to aid data analysis is presented.

Chapter Six presents the study's findings. The large quantity of data that this study produced has necessitated the presentation of results in a tabulated manner to improve the clarity and comparability of the findings across the four cases. In particular, the total number of occurrences of codes and frequent co-occurrences of codes are presented. This highlights the commonalities and divergences of interviewee experiences of the introduction of Industry 4.0.

Chapter Seven is the final chapter and consists of a discussion of findings that combines the theory in the relevant literature with the research results to address the questions that were highlighted in Chapter One.

1.9 CONCLUSION

This chapter has presented an overview of the literature that will be utilised in the following chapters. It also introduced the methodological approach followed in this study. Most importantly, the problem statement, the research questions and the theoretical background of the study were introduced to the reader. Having outlined the regional background in which this study is set, this chapter is followed by the first section of the literature review. Particularly the regional differences in the approach to addressing Industry 4.0 are of importance for the understanding of this study and addressing of the formulated research questions and problem statement.

CHAPTER 2

2 INDUSTRY 4.0 AND ITS IMPLEMENTATION

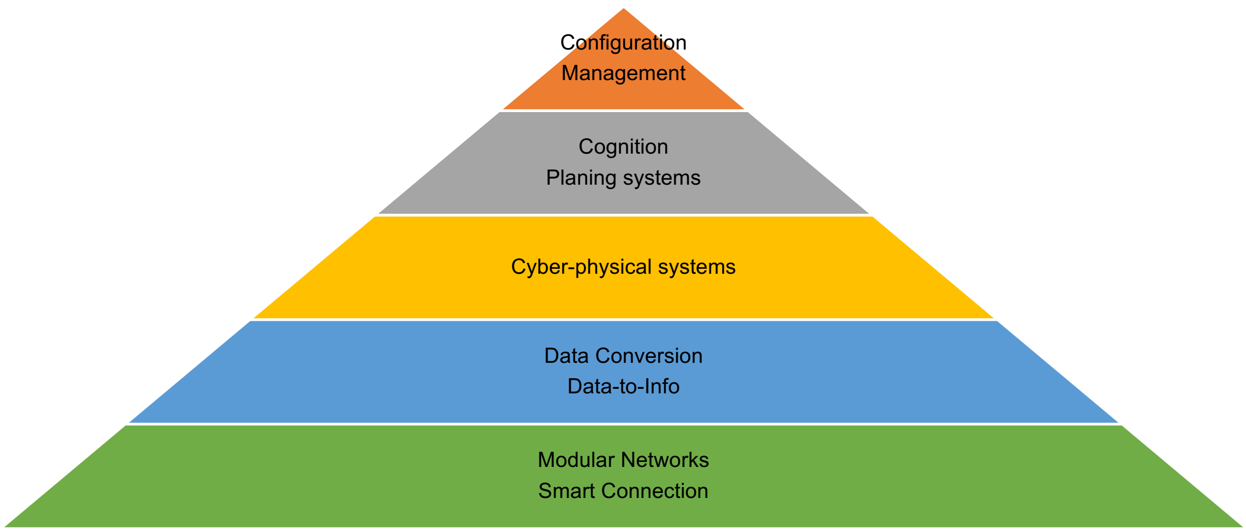
2.1 INTRODUCTION

When discussing Industry 4.0, it is important to recognise that this is a novel term that generally describes the technological advancements of the 21st century that are reshaping the industrial landscape. However, a consensus on the definition of Industry 4.0 has not been reached in either the realm of academia or that of industry, while certain trends that recognise the key changes and features of this novel development can be identified in the contemporary literature (Pereira & Romero, 2017:1208). In this chapter, the technologies that constitute Industry 4.0 are highlighted and discussed in detail. The aim of this chapter is to inform the unfamiliar reader with the elements of Industry 4.0 that are implemented by industry and may affect employees in a manufacturing setting. Further, this chapter provides the reader with a discussion of literature on the implications of the introduction of Industry 4.0. Finally, possible change management approaches are highlighted in context of the introduction of Industry 4.0. In context of this thesis, this content is of high relevance as the case organisation is implementing Industry 4.0 technologies at the case facilities, but not all identified technologies are addressed to the same degree and thusly not identified and communicated to staff in the same intensity. This is discussed in Chapter 7. The reader needs to be cognisant of the implications of the various technologies in context of the sum of technologies that constitute Industry 4.0.

2.2 INDUSTRY 4.0

One of the most frequently quoted factors that distinguishes Industry 4.0 from other forms of technical change is the implementation of cyber-physical systems (CPSs) (Pereira & Romero, 2017:1211). These systems largely consist of the physical machines that perform automated operations and that are already commonplace in the modern factory production landscape. However, while these conventional manufacturing systems are highly reliant on human input and often operate in an isolated sphere, performing largely repetitive work, cyber-physical systems mutually interlink to potentially enable fully autonomous production. The architecture of Industry 4.0 cyber-physical production has been illustrated as a five-tier pyramid system known as 5C CPS implementation architecture, as shown in the following figure (Juhás & Molnár, 2017:206).

Figure 4: Cyber-physical systems architecture



<u>Source</u>: Adapted from Juhás & Molnár (2017:206); Lee, Bagheri & Kao (2015)

When discussing cyber-physical systems, including the 5C CPS implementation architecture model, it is necessary to highlight that the physical act of creating or manipulating a product is the core of the operations, which can be regarded as 'level zero' of the aforementioned model (Jiang, 2018:1). Alcácer and Cruz-Machado (2019:900) refer to this physical production act as the 'asset layer', thus evolving the 5C architecture into a 5C+A model.

Regarded as level one, modular networking in a reliable manner is the foundation on which Industry 4.0 applications are built. Given that the removal of the human factor in manufacturing is a key aspect of this development, machines need to acquire and share data autonomously to ensure sustainable operations. Sensors within the machinery and remote servers need to communicate with each other through a reliable network (Lee, Bagheri & Kao, 2015). An example of a network that facilitates such networking is the newly established 5G mobile network. Technology of this level will enable condition-based monitoring of production and machinery without human input, making this essentially a plug-and-play' operation, or rather, a 'plug-and-work' operation. Implementing a standardised approach to this system is vital to ensuring future interoperability of devices in terms of physical connections, basic connections, discovery, capability assessment and configuration (Monostori, Kádár, Bauernhansl, Kondoh, Kumara, Reinhart, Sauer, Schuh, Sihn & Ueda, 2016:626–629).

The result of modular networks is high-speed data collection and communication in an interlinked environment; however, thus far, most machinery has served solely as a means of data collection and data transmission. By applying algorithms that convert the unsorted collected data into meaningful information, the machinery can autonomously monitor the state of the various components and the associated consequences, be it machine-performance predictions or predictions of the performance of the associated components. These analytical processes enable the machinery to become 'self-aware' and to have the capacity for self-monitoring (Lee *et al.*, 2015:19).

Meanwhile, the cyber-physical level forms a central hub for information that is generated by all the connected machines. The use and availability of such large amounts of information allows a single machine to compare its performance matrices to those of other machines within the fleet. Similarities and divergences in historical information form the basis on which the machinery will predict the future behaviour of its components in relation to its counterparts. Building on 'machine self-awareness', the superseding layer is best described as the 'machine self-comparing' layer (Lee *et al.*, 2015:20).

From a cognition perspective, human interaction is ensured by autonomous systems visualising informatics and providing real-time analytics to the controller (Lee *et al.*, 2015:20). However, the virtual nature of this representation of information enables human input to become a remote operation. As such, access to this information is not limited by geography or time since the generated real-time information can be accessed ad-hoc without being limited by data availability (Jiang, 2018:3).

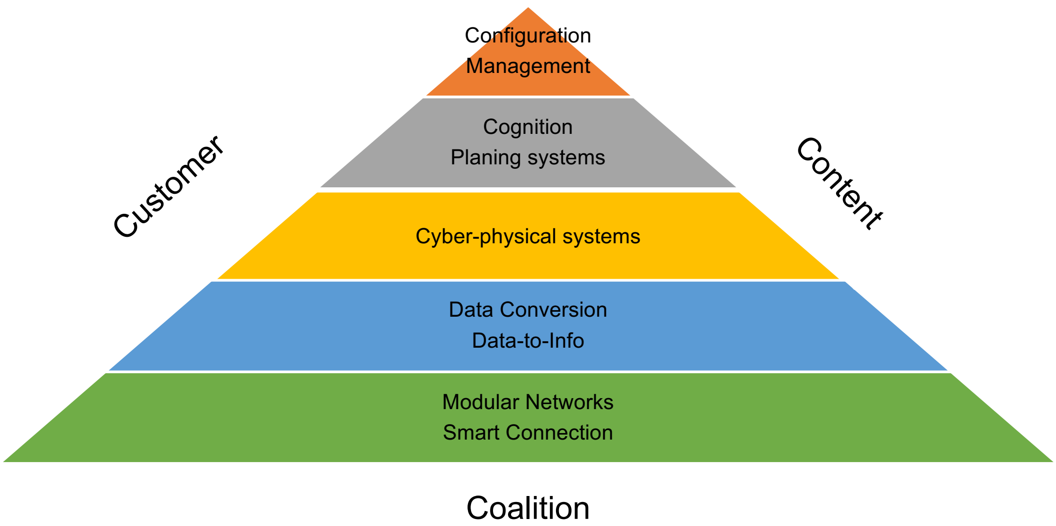
The top level of the 5C pyramid is the configuration and the management of the machines. Here, feedback from cyberspace forms the basis of the supervisory control over physical space, allowing the machines to be self-configurable and self-adaptable to varying situations without human involvement (Lee *et al.*, 2015:20). This leads back to the introductory quote of this dissertation, highlighting the absence of humans on a shop-floor level, replacing human workforce by augmented operators, smart products and smart machines (Magruk, 2016:280).

A redefinition of the internet is a further factor that features in numerous definitions of Industry 4.0. In brief, the internet can be understood according to three separate network perspectives: the Internet of Things, the Internet of People and the Internet of Services, which operate using the same network but for highly divergent purposes (Pereira & Romero, 2017:1211). A key element in the novel utilisation of the Internet of Things in context of Industry 4.0 is to build machine networks and facilitate the communication of networked information of machines towards machine operators. Thusly a discussion of the Internet of Things is the focus of the following section.

In exploring Industry 4.0, the understanding of the Internet of Things system is a crucial factor. The combination of the commonly known terms of 'internet' and 'things' already describes the fundamental aspects of this infrastructure element. However, more specifically, it is a globally standardised network of interconnected computer systems of individually distinguishable actors, such as humans or machines in the cyber realm, with the network used to connect virtually any device or person with any other device at any time or place through utilising any possible path and service (Alcácer & Cruz-Machado, 2019:901). Importantly, the combination of cyber-physical systems and with the Internet of Things will enable the creation of smart factories (Pereira & Romero, 2017:1210).

Given the high degree of connectivity of humans to machines, machines to humans and the autonomous networking among various machines, three further elements that have an effect on Cyber-physical systems may be added to the 5C+A model of cyber-physical architecture: the customer, the production coalition and the final content, as highlighted in the following figure 2 (Jiang, 2018:4).

Figure 5: The evolved cyber-physical systems architecture



Source: Adapted from Juhás & Molnár (2017:206); Lee *et al.* (2015); Jiang (2018:4)

The high degree of autonomy and the increasing capability to network complex tasks enables, as previously discussed, new possibilities for global networks in manufacturing. System integration will enable industries to vertically integrate their manufacturing systems, horizontally integrate their value networks and ultimately integrate end-to-end integration of the engineering operations throughout the value chain, which can be characterised as a value network (Pereira & Romero, 2017:1209).

2.3 ELEMENTS OF INDUSTRY 4.0

Having discussed the key technological aspects of Industry 4.0 and the complex network of interdependent systems it creates, the technologies themselves must now be identified. Bortolini *et al.* (2017:5703) state that Industry 4.0 is the amalgamation of numerous technologies that form part of the implementation of the 4th industrial revolution in the manufacturing context – commonly known as Industry 4.0. The technologies are mutually dependent and constitute the basic elements of Industry 4.0, as seen in the following figure, and these core elements are discussed in the following section in view of highlighting the technological factors and the role of the technology in implementing Industry 4.0 manufacturing.

Figure 6: Industry 4.0 technologies

Source: Adapted from Bortolini *et al.* (2017:5703); Parsons *et al.* (2018:20)

2.3.1 Mobile connectivity

Industry 4.0 is envisioned to merge the physical and virtual worlds, creating a fundamentally new understanding of interactions (Pereira & Romero, 2017:1208). This can only be implemented successfully through a solid, readily available high-speed real-time means of communication technology. When discussing the idea of fully automated interconnected digital factories, connectivity is a key factor to ensuring safe and efficient work processes, particularly when considering that a crucial aspect of Industry 4.0 is the reduction, if not the elimination of human input. Since 4G mobile networking has reached maturity and has demonstrated certain limitations due to its signal latency and maximum network speeds, a new network, ‘5G’, is being introduced to provide mobile networking at near real-time speeds (Parsons, Styma, Fuest & Krys, 2018:7). The use of mobile 5G networks will provide an infrastructure that facilitates the real-time cyber communications needed for the implementation of Industry 4.0 (Rao & Prasad, 2018:152). Current 3G and 4G network standards do not meet the infrastructure needs of cyber-physical devices, which are as follows (Rao & Prasad, 2018:152):

- A target network reliability of >99.99%
- Low energy needs to maximise battery life
- End-to-end communication with a latency under 1 mS
- High data transmission density for cyber-physical devices

During the course of 2019, the first networks became active in some global markets, forming the backbone of the 4th industrial revolution (Parsons *et al.,* 2018:11). Meanwhile, at present, mobile operators are further optimising the 4G network for mobile data communication using smartphones and other consumer electronics, while 5G entails a clear focus on networking entire countries and industries in their totality (Parsons *et al.,* 2018:18).

2.3.1.1 Mobile connectivity/5G in selected regions

In Germany, frequencies for 5G networks were sold in 2018 with the specification that the network will be live by 2020 at the latest (Federal Ministry of Transport and Digital Infrastructure of Germany, 2017:3). Three applications that rely on the new 5G network have been identified by the German federal government, the first of which is known as enhanced mobile broadband, which is essentially high-speed internet access for a large consumer audience. The remaining two applications for 5G are crucial to the application of Industry 4.0, with the first, massive machine-type communication, complementing the second, ultra-reliable and low latency communication. The former describes the communication between interconnected devices via the Internet of Things system via a high-speed wireless network. With the increasing number of devices using mobile networking, this network needs to provide for high volumes of traffic in an energy efficient manner. Meanwhile, ultra-reliable and low latency communication relates to the issue of reliability, which, in the industrial context, is of great importance since the minimal human input requires failsafe interaction between devices and interference resistance of the network, forming a basis for safe inter- and intra-machine communication (Federal Ministry of Transport and Digital Infrastructure of Germany, 2017:4).

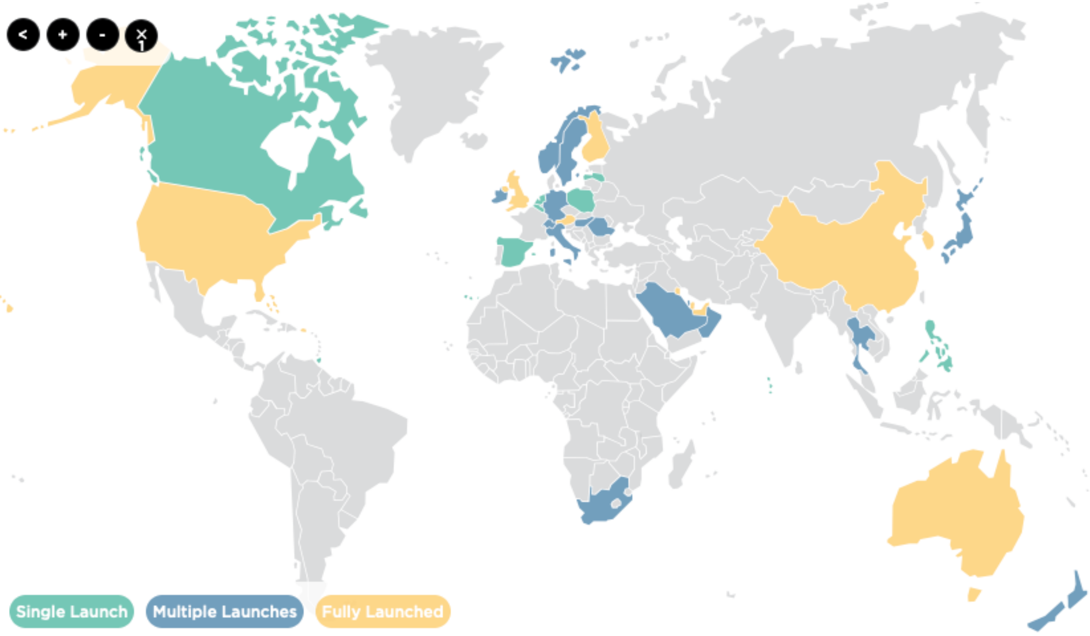
Due to the standardised nature of the 5G network, this aspect forms the basis of digitalisation for a wide variety of business and infrastructure applications, including smart manufacturing, smart farming, smart grid electricity supply and smart logistics (Federal Ministry of Transport and Digital Infrastructure of Germany, 2017:5). By enabling a rapid introduction of 5G, the German Government envisions becoming a pioneer in this field, facilitating the introduction of Industry 4.0 and the 4th industrial revolution in a timely manner (Federal Ministry of Transport and Digital Infrastructure of Germany, 2017:13).

However, Germany is not the only country that has identified 5G as the future backbone of the envisioned cyber-physical economy. In fact, Groupe Speciale Mobile Association (GSMA, 2020a, 2020b), the global association of mobile operators, reported that 79 5G networks had been launched globally by June 2020, reaching a total of 7% of the global population, and expects that the availability of 5G will increase rapidly and will account for around 20% of global connections by 2025, equating to 1.2 billion connections.

China, which launched 5G in October 2019, and the US, which launched 5G in October 2018, stand out as two of the nations that had fully launched 5G networks by July 2020 (Groupe Speciale Mobile Association, 2020b). Other nations, such as Germany and Italy, launched 5G networks in June 2019, but these are not yet fully operational on a national level. On a global scale, the majority of nations have not yet surpassed the 4G mobile standard (Figure 4). In most regions that have launched 5G networks, there exist multiple providers, indicating that 5G will be provided by a multitude of network providers (Groupe Speciale Mobile Association, 2020b).

In an effort to emphasise the role that mobile connectivity and the current development of 5G networks has on society, the following points must be highlighted. As far back as 2013, a point was reached where the number people that had access to mobile communication through the use of cellular phones eclipsed the number who had access to basic sanitation (United Nations, 2013). For certain, mobile communication is the backbone of communication in modern society and business, and it will undoubtedly form an integral element of the 4th industrial revolution and Industry 4.0.

Figure 7: 5G availability as of July 2020



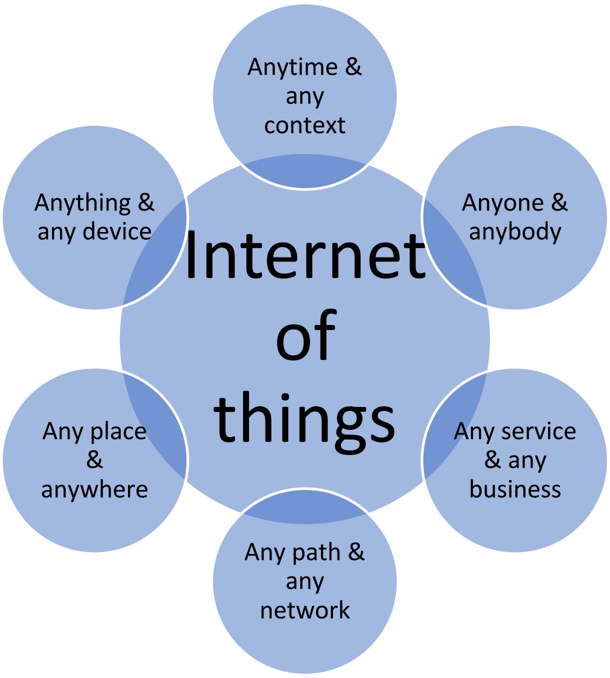
Source: Illustration by Groupe Speciale Mobile Association, 2020b

2.3.2 The Internet of Things

One aspect of Industry 4.0 is clear: to implement the technology and harness the benefits, global connection and communication is a key element that must be considered. While ultrafast networks and 5G technology enable live or low-latency data transmission, there is also a need for a standardised platform through which the exchange of data takes place, an example being the Internet of Things system. While traditional manufacturing has been utilising networked machines for many years, these networks are often non-standardised, meaning the potential for full integration of the manufacturing processes and sites beyond a single organisation has been severely limited. The term Internet of Things is ubiquitously used for the globally standardised and interoperable network that enables devices to interact with both other devices and people. Trappey, Trappey, Govindarajan, Chuang, and Sun (2017:210-213) attribute this to the universal global transmission layer standards, computation layer standards and application layer standards of this system. The core role of the Internet of Things is the linking of devices and enabling the exchange of data on a global scale, thus enabling technological advancement that goes beyond the limitations of a single organisation (Lampropoulos, Siakas & Anastasiadis, 2019:6).

Elsewhere, Sundmaeker, Guillemin, Friess, Woellflé (2010:44) summarised the Internet of Things using the following graph, highlighting its universal application in the majority of contexts.

Figure 8: Characteristics of the Internet of Things



Source: Sundmaeker *et al.* (2010:44)

Meanwhile, Atzori, Iera and Morabito (2010:2787-2790) argue that the worldwide nature of the Internet of Things allows for the technology's application in various domains. In the personal domain, the Internet of Things system's application relates to facilitating social networking or facilitating the querying of historic data, while the futuristic domain is enabled through facilitating the communication of autonomous personal mobility solutions and advanced regional infrastructure. In the transport and logistics domain, the system's application lies in the use of driver assistance systems, the ticketing of logistical tasks extending beyond the bounds of a single business, environmental monitoring and augmented mapping of transport paths. Meanwhile, in the smart environment domain, the Internet of Things system is the enabler of a network of connected and autonomous devices that can increase industrial efficiency or enhance personal comfort. Lastly, the Internet of Things technology plays a vital role in the healthcare domain in terms of various sensor and monitoring applications, facilitating data collection and the tracking of vital signs.

However, Sundmaeker *et al.* (2010:49) note that the above are not the only domains in which Internet of Things applications play a major role. Indeed, the system also has a role to play in the domains of the environment, society and industry. In the environmental domain, Internet of Things applications are widely adopted in the realms of agriculture and environmental management services, while in the social domain, Internet of Things applications include the provision of governmental online services for the citizens and the possibility of the digital inclusion of services for people with disabilities. Lastly, the industrial domain, which includes manufacturing, commercial or financial online transactions, is, of course, a particularly important element of Industry 4.0.

In fact, the industrial domain of Internet of Things is also known as the Industrial Internet of Things and represents a specific niche, as well as the most current interpretation of the technology as an enabler of other Industry 4.0 technologies. The realm of the Industrial Internet of Things and the attendant ubiquitous computing is of particular value for Industry 4.0 within the context of environmental monitoring, machine communication and the integration of complex networks through the creation of smart grids (Malik, Sharma, Singh, Gehlot, Satapathy, Alnumay, Pelusi, Ghosh, & Nayak, 2021:125–127).

Furthermore, the Industrial Internet of Things is highlighted as a facilitator of other Industry 4.0 technologies, such the standardised networking of cloud computing, big data collection and utilisation and the networking of Cyber-physical systems that aid intelligent Industry 4.0 manufacturing processes (Lampropoulos *et al.*, 2019:5).

2.3.3 Cyber physical systems

Cyber physical systems are essentially systems that merge the use of software to control a physical process through the blending of a physical manufacturing process performed by mechanical robotics and the control and coordination through software systems. This control and coordination can take the form of process management, the control of production systems or the coordination of logistics systems as part of a physical device or as part of a larger structure, such as a building. Through the combination of the physical process and the cyber elements of software, cyber-physical systems can directly record the data pertaining to physical occurrences through the use of sensors or camera systems. However, these systems not only record physical data in a digital manner but also have the ability to react physically, through robotics, to any changes or divergence from specified parameters in the physical process, through the analysis of the data collected digitally. In brief, these systems record physical data in a digital manner, save and evaluate it and possess the ability to actively or reactively interact with the physical realm and the cyber realm simultaneously (Hellinger & Seeger, 2011:15–19).

Due to the interconnection of the physical and cyber realms of these devices, connectivity is vital. In fact, the interconnected nature of these devices forms a core element of their definition: ensuring efficient communication on a global scale (Hellinger & Seeger, 2011:11). This global interconnectedness is enabled through the use of the internet alongside 5G networks to facilitate global real-time digital communication.

Cyber-physical systems need to communicate with humans to transform the cyber data and physical capabilities into an asset for manufacturing entities. Dedicated human–machine interfaces are the means through which the exchange of information is facilitated and through which humans can input commands and extract data (Hellinger & Seeger, 2011:15–19). These interfaces can take the form of smartphones, laptops and digital displays.

The omnipresent interconnection of the physical and cyber realm enables organisations to interconnect both horizontally and vertically within the supply chain in an attempt to increase the efficiency of the attendant processes and products. Cyber physical systems and their potential of future innovation are described as key components in transforming the realm of business and, consequently, society as a whole (Hellinger & Seeger, 2011:11–15).

Colombo, Karnouskos, Kaynak, Shi and Yin (2017:6–16) explicitly cite cyber-physical systems as presenting the backbone of the 4th industrial revolution and, as such, as a core element of the implementation of Industry 4.0. Its key contribution is the transformation of shopfloors where machine programmability and control is concentrated to a small number of computers, which are supplied with data by a large number of unsophisticated sensors that are custom made via an inflexible manufacturing process into a complex and customisable network of autonomous and customisable manufacturing solutions that enables the integration of data and processes that goes beyond the physical demarcations of the manufacturing facility. The result is a sophisticated manufacturing network that is highly adaptable and is able to collaborate with internal and external stakeholders, ensuring flexibility of the manufacturing process and an increased energy efficiency. Overall, cyber-physical systems are considered to be part of a critical infrastructure for developed nations.

2.3.4 Big data

As the name suggests, big data is, in its simplest form, a large amount of data. However, the amount of data needed to constitute big data is not conclusively defined. Typically, big data consists of datasets that are made up of several terabytes to several exabytes. This large amount of data results in certain practical limitations of the traditional solutions to analysing the data via the use of traditional software, which is, in fact, no longer a viable option. In addition, the storage and management of such vast amounts of data is beyond the scope of normal traditional data analysis instruments used within various industries (Koseleva & Ropaite, 2017:545).

The idea of big data is best described through highlighting its main characteristics. In 2001 it was established that big data sets share three distinct characteristics, which he termed the ‘3 Vs of big data’ (Koseleva & Ropaite, 2017:545). These characteristics have gradually been expanded to include the following:

Volume: As noted, high volumes of data is the primary characteristic of big data. While there is no defined quantity that constitutes such high volumes, any quantity that is too large to process via traditional technologies essentially qualifies as big data (Emmanuel & Stanier, 2016:1–5).

Velocity: Big data is collected in large quantities and is regarded as being collected at a high speed. However, some authors argue that not all big data is collected at high *velocity,* asserting that ‘velocity’ refers to the ability to support the gathering and processing of data at a high speed (Emmanuel & Stanier, 2016:1–5).

Variety: Unlike most conventional data, big data tends to be highly diverse, in the sense that these datasets consist of structured and unstructured data in a wide range of data formats (Emmanuel & Stanier, 2016:1–5).

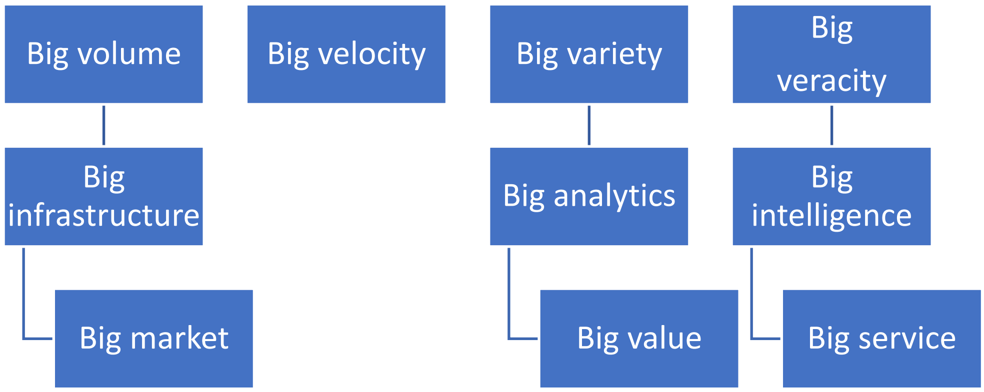
Over the course of the past 20 years, authors have expanded on this understanding of big data within the context of its widening application in both business and society. A commonly understood extension of Laney's definition of big data includes the two additional 'V' characteristics described below (Koseleva & Ropaite, 2017:545–546).

Value: Big data is explicitly not the collection of vast amounts of data for the sole purpose of collecting data; rather, the attendant process results in the creation of value by extracting information from the large amounts of data. In this context, value creation is most accurately described by the concept of big data analytics (Koseleva & Ropaite, 2017:545–546).

Veracity: Big data needs to be accurate and truthful to add value to any application, since this data forms the basic information on which machines and humans base certain decisions, meaning the data must be based on solid evidence (Sun, Strang & Lee, 2018:56–58).

All of these characteristics present the building blocks that will create a large infrastructure of data that offers ever-increasing analytical abilities and the availability of usable information.

Figure 9: The attributes of big data

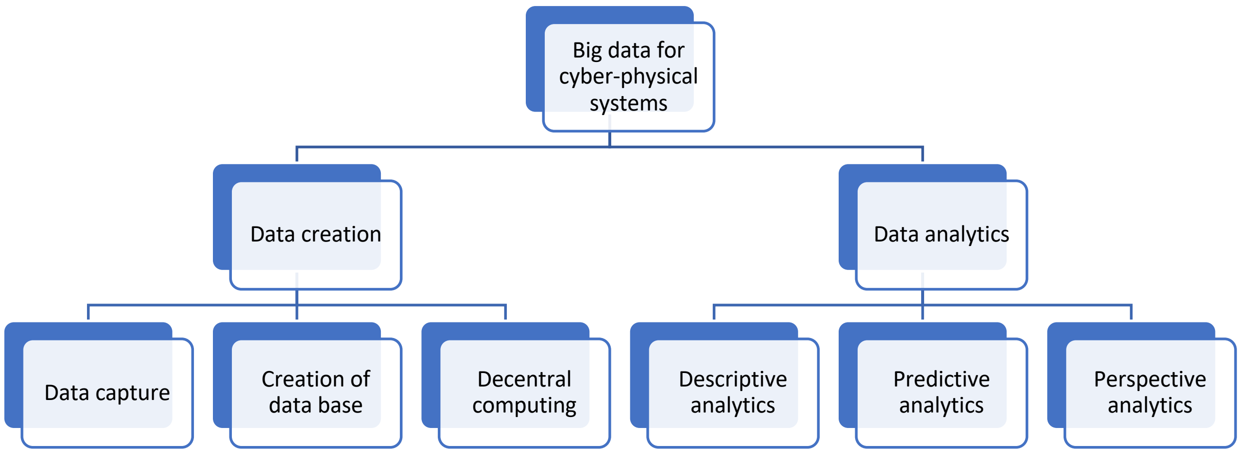


Source: Sun et al. (2018:59)

In the context of Industry 4.0, big data is an element that aids the introduction of various Industry 4.0 technologies, while it is also the result of the consequent application of these very technologies (Gökalp, Akyol, Kayabay & Koçyiğit, 2016:432). The generation of vast quantities of data is enabled through the use of cyber physical machines, while the data is stored in the cloud and analysed through artificial intelligence. The analysed data often forms the basis of machine learning and has practical applications in an industrial setting in forming the basis of wear-based maintenance and the automated ordering of raw materials without human input. However, the data is often generated by smart Industry 4.0 machinery and thus depends on these machines as both source and user (Angelopoulos, Michailidis, Nomikos, Trakadas, Hatziefremidis, Voliotis, & Zahariadis, 2020:2–6).

A benefactor system at established modern manufacturing facilities are Manufacturing execution systems (MES). Manufacturing execution systems are amongst the central operation organs of Industry 4.0 enabled facilities. These systems monitor and regulate process steps during manufacturing processes. This monitoring is based on big data produced by relevant manufacturing devices and influences manufacturing execution systems regulatory actions on the production process. Utilising the Industrial Internet of Things, manufacturing execution systems can perform shopfloor supervisory functions and leverage digital communication to relay data to remote workplaces in real time. This fosters 'Big Analytics' and 'Big Intelligence' for manufacturing organisations. Further, manufacturing execution systems are paramount in the analysis of overall equipment effectiveness (OEE) in modern manufacturing facilities. A well-known manufacturing execution system is known under the proprietary name Camstar (Siemens AG, 2022; Illa & Padhir, 2018:55163–55164).

Figure 10: Uses of big data in the age of Industry 4.0



Source: Adapted from Karnik et al. (2022:7)

As shown in the figure above, Karnik, Bora, Bhadri, Kadambi & Dhatrak (2022:7) graphically illustrated the dual role of big data in facilitating the implementation of Industry 4.0, clearly differentiating between the use of this data for data analytics and the creation of big data through Industry 4.0 technologies.

2.3.5 Cloud computing

The need for the connected storage of vast amounts of data is especially evident in the context of the above discussion on big data and the attendant interconnectedness in the Industry 4.0 landscape. This is where the concept of cloud computing comes into play, which Bortolini *et al.* (2017:5703) describe as the storing and analysis of large amounts of data (big data) through resources that provide utility on demand not owned by the user but leased or rented from an off-site provider via use of the internet.

One practical application of cloud computing is allowing the possibility of performing simulations based on big data collected by Industry 4.0 manufacturing devices. As Karnik *et al.* (2022:2–8) state, while simulations were a highly limited application of limited data, through the interconnectedness of Industry 4.0 technology, multi-level simulations have become a reality. The resultant real-time cloud computing is vital to various simulation scenarios, such as creating digital twins of products during the manufacturing process, where a digital 'twin' product's journey through the manufacturing process is simulated in the real-time creation of the physical product. This is based on the sensorics of cyber-physical systems, the application and creation of big data and – through cloud computing – the creation of simulations to ensure that the physical product parameters meet the digital specifications.

A further application of digital twins entails the simulation of entire factory operations with the aim of predicting machine faults and highlighting any efficiency divergences between the physical reality of manufacturing and the digital twin simulation. These processes are only possible through the use of off-site computing and data storage, as the cost and complexity of dedicated capacities entail a financial impossibility (Karnik *et al.,* 2022:3–8).

2.3.6 Machine learning

Machine learning, a form of artificial intelligence, entails the autonomous use of data to create information that serves as a basis for future decisions determined through the use of algorithms by a machine. This term was first coined by IMB and its data scientist, Arthur Samuel, in 1959. Machine learning is the process whereby a machine gathers experience through data training, which provides the basis for specific algorithms to build mathematical models upon which the machine will base its future decisions or predictions. These learning interactions can be divided into the following four district types of machine learning (Yalçin, 2020):

Supervised learning: This entails the process of machine learning aimed at learning a function by mapping inputs to outputs based on examples provided to the machine by an external source. While this may appear to be somewhat removed from everyday activities, this is most definitely not the case. In fact, as Yalçin (2020) highlights, the process of filtering spam e-mails on a computer is essentially supervised machine learning. Based on the examples of labelled spam items, as highlighted by the user, the machine can learn and make future inferences regarding what constitutes e-mail spam.

Unsupervised learning: Contrary to supervised learning, unsupervised learning is not dependent on active human input; rather, it involves autonomously clustering unlabelled data into groups and then automatically drawing inferences from these groups (Angelopoulos *et al.* 2020:3–4). In an industrial setting, the use of such learning can form part of wear-and-tear-based early machine fault detection and supervision, where all sensor data is clustered and analysed by the machine and inferences are made as to the physical state of the device and any need for maintenance (Amruthnath & Gupta, 2018:355).

Semi-supervised learning: This essentially combines the above two learning processes. During this process, both labelled data and unlabelled data are inputted into the machine (Yalçin, 2020). While the machine will make inferences regarding the unlabelled data, it will link outputs to inputs in the labelled data. A possible scenario for such a conjunction of learning is the combination of the machine fault detection from unlabelled data and the possible use of maintenance schedules to simultaneously combine scheduled maintenance with machine fault corrections.

Reinforcement learning: The final type of machine learning is characterised by the use of software to maximise the possible final gain, as defined in the machine task. It is thus the process of finding optimal actions and responses within a specific environment. The best known type of this form of machine learning involves the use of a so-called 'bot' (Yalçin, 2020). This is essentially a customer-help dialogue held via a user interface to resolve any queries without having to involve direct human input or to spread information via social media through impersonating a real human being (Angelopoulos *et al.*, 2020:3–4).

Machine learning is a constituent element of industry 4. 0, since its implementation results in the minimisation of human input while the efficiency and reliability of manufacturing continues to undergo improvement. Through the use of machine learning, machine down times can be minimised, with such occurrences predicted in real time, thus assisting in the aforementioned aims of Industry 4.0. However, the role of machine learning also encompasses performance reviews of human workers (Angelopoulos *et al.*, 2020:23), while the existing literature further suggests that the analysis of vast amounts of available data is beyond the capacity of humans and, as such, these tasks need to be appointed to automated learning devices and artificial intelligence (Gan, Kanfoud, Nedunuri, Amini & Feng, 2021:397–404).

2.3.7 <u>Collaborative robotics</u>

Robots are, in the most basic sense, mechanisms that are programmable in terms of performing a specific task via actuation in two or more axes with some autonomy while moving within their operational environment. A robot always includes a control system and a means for humans to interface with this system, while they can be distinguished into two general types: service robots, which perform service tasks for humans; and industrial robots, which perform specific applications within an industrial context, such as vehicle assembly or other repetitive tasks (ISO, 2012).

Robot technology has fundamentally changed human lives and has formed part of the increasing automation of the industrial processes. The number of industrial robots has steadily increased, while it should be noted that this technology has not been introduced evenly across the globe. Meanwhile, manufacturers across the industrial nations form the key user group of this technology. The total number of installed units has increased year on year for almost a decade; however, due to the global uncertainty following the COVID-19 pandemic, the total number of installed industrial robots has not eclipsed the previous year's installation numbers (International Federation of Robotics, 2020).

While the definitions of 'robot' vary in the existing literature, they share a common denominator in that the robotic device is able to sense, compute and act on the senses and computations. As industrial processes and automation applications tend to vary greatly, this leads to vast diversity in the dimensions, capabilities and design of robots that serve the uniquely industrial purposes (Guizzo, 2020).

The observation that industrial robots are playing an ever-increasing role in the modern manufacturing process means it is vital to explore the human–machine interaction and how industrial robots and so-called 'collaborative robots' or 'cobots' vary in ensuring human safety in the manufacturing site. Borrowing from Isaac Asimov's science fiction, the interactions and social expectations regarding the relationship between humans and robots have developed from his three laws of robotics (Murphy & Woods, 2009:14–17):

- A robot may not injure humans through its actions or harm humans through inaction
- A robot must obey human orders, with the exception being in the case where these orders cause harm to humans
- A robot must protect itself against harm and ensure its continued existence, unless this is in conflict with the human orders or injures humans through action or inaction.

The purpose of these laws is clear: maximising the utility of these devices while ensuring that human safety is guaranteed. Murphy and Woods (2009:14) note that most societies have built their expectations towards the interaction with robots on the above three laws.

The approaches to achieving human safety and maximum utility do, however, differ between conventional industrial robots and cobots, with this divergence presenting one of the elemental differences between these two types of machine. It is also the key difference that highlights how cobots interact with humans compared to their more conventional counterparts, and serves as the foundation of the notion of cobots being an integral element of Industry 4.0 and its implementation.

Conventional industrial robots have extremely limited reach, mobility and adaptability due to their limited ability to interact with humans and thus ensure safe interaction. The resulting physical barrier that is needed to separate human workers and conventional robots for safety reasons severely limits the application scenarios of these robots. Traditional industrial robots are typically large machines fixed in place and physically separated from the workers for safety reasons, moving fast to perform the programmed task. The interaction with a human worker only takes place during the programming and the repair of the machine, which generally performs a rarely changing repetitive task. The value and profitability of the machine is dependent on the high- frequency output of predetermined tasks (Knudsen & Kaivo-Oja, 2020:13–14).

Cobots, or collaborative robots, are ‘uncaged’ industrial robots that, through the use of sensors and high-level computing, can operate in a setting where human workers are present without the risk of physical harm, bypassing the use of protective caging or protective measures. Cobots are designed to directly interact with human workers in performing various manufacturing tasks and are typically much lighter than conventional industrial robots and more mobile in their application. Their role in the implementation of Industry 4.0 can be described as combining the positive traits of human workers, such as decision making and flexibility, with the positive traits of conventional industrial robots, which include strength, precision and endurance (Knudsen & Kaivo-Oja, 2020:15).

While 'cobot' is an umbrella term for industrial robots that do not harm humans in an industrial setting, there are varying degrees of the integration of human–machine cooperation. The International Federation of Robotics (2018) differentiates between four levels of human–machine cooperation:

<u>Coexistence:</u> This is the least advanced level of collaborative robotics in that there is no direct contact between the human worker and the cobot, while there is no need for a physical separation of the two to ensure worker safety.

<u>Sequential Collaboration:</u> At this level, the cobot and the human worker share a workspace and are dependent on each other to perform the work tasks. The cooperation is nonetheless minimal, since the actions of the cobot and the human worker are sequenced, without simultaneous actions of the two parties.

<u>Cooperation:</u> Human–cobot cooperation constitutes the second highest level of human–machine interaction, wherein the human worker and the cobot share both a workspace and a work output. To achieve this output, both parties cooperate in the same workspace while being active at the same time.

<u>Responsive Collaboration:</u> Similar to conventional collaboration, responsive collaboration is the process where a human worker and a cobot work together in the same workspace to achieve a shared goal. However, the key differentiator is that the cobot has the ability to respond and adapt in real time to the movement or cues of the worker in an effort to achieve a specified output. El Zataari, Marei, Lee and Usman (2019:163) state that this type of collaboration can also be referred to as 'supportive collaboration' since the human worker and the cobot share a space and are dependent on their mutual cooperation and adaptation for performing the task at hand.

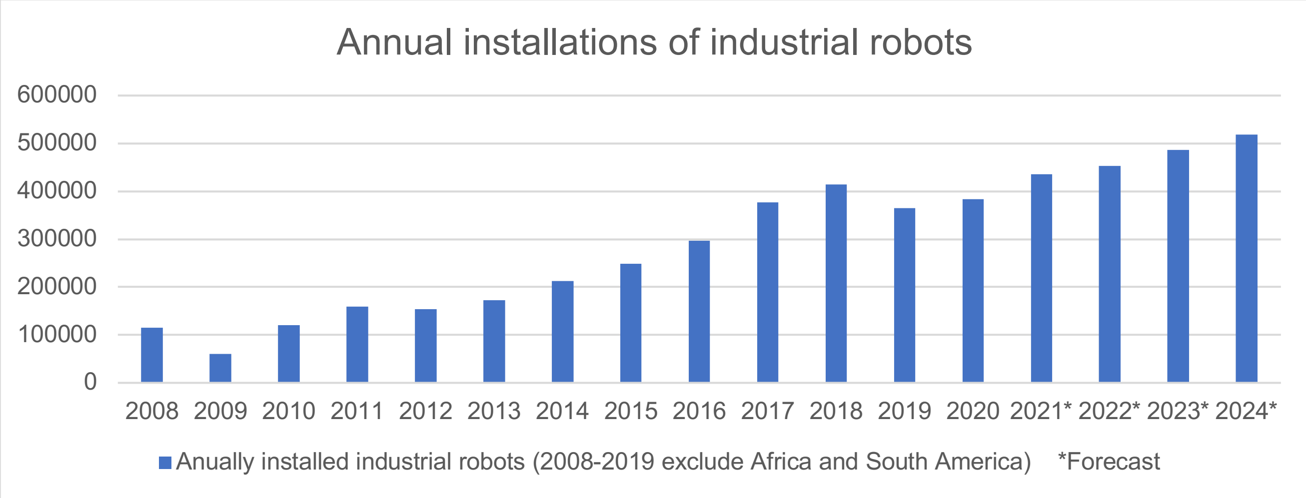
Cobots in all of the above forms are, or will be, an integral part of the industrial landscape in the age of Industry 4.0. The collaboration with robotics shifts the production capabilities towards the mass production of customised products, while increasing the organisational flexibility and enabling agile manufacturing. Cobots represent an integral part of human–machine exchanges and the use of Cyber-physical systems to enable the implementation of other Industry 4.0 elements (Knudsen & Kaivo-Oja, 2020:15).

2.3.7.1 Global introduction of industrial robots and collaborative robots

The total of newly installed industrial robots amounted to 373,240 units in 2019, compared to over 400,000 units in 2018, but only 60,000 units in 2009. In fact, the distribution of these devices across the globe is highly uneven. The five leading nations in the use of industrial robotics are China, South Korea, the United States (US), Japan and Germany, with these nations accounting for a total of 73% of all global industrial robot installations. China is the largest user of this technology by a considerable margin, with 140,492 units newly installed in 2019, which is considerably more than the total of all newly installed industrial robots in Europe, and North and South America combined, with a total of 119,741 units. The key users of industrial robotic products primarily operate within the automotive industry, closely followed by the electronics industry (International Federation of Robotics, 2020).

As of 2021, the total installed industrial robot capacity was three million (International Federation of Robotics, 2021). As illustrated in the figure below, the use of industrial robots presents a growing trend; however, as seen in 2008 and 2009, this is dependent on the global economic performance, which can be described as a megatrend of the 21st century.

Figure 11: Installation of industrial robots per calendar year



Source: Adapted from International Federation of Robotics (2021); International Federation of Robotics (2020)

As part of the industrial robot landscape, cobots represent the technological forefront and currently account for a relatively small number of units installed each year. The technology is nonetheless gaining momentum, and the share of cobots in the industrial robot landscape is continually growing. According to the International Federation's (2021a) data, only 11,000 units were installed in 2017, while a total of 19,000 units were installed in 2018, 21,000 in 2019 and 22,000 between January and December of 2020. Clearly, in less than five years, the annual installation of cobots has doubled, a trend that looks to continue, but one that still represents less than 6% of all industrial robot installations in 2020 (International Federation of Robotics, 2021a).

2.3.8 Additive manufacturing

Additive manufacturing is the industrial process of creating three-dimensional (3D) objects based on 3D computer-aided design data, without utilising part-dependent tools in the manufacturing process. The additive manufacturing process is also known as 3D printing and entered the industrial manufacturing process for the first time in 1987 as a form of rapid prototyping. The physical process of additive manufacturing is a process during which a specific medium is applied layer by layer to create the final physical product, meaning 3D printing is an accurate description of the physical process. The additive manufacturing process stands in stark contrast to the traditional subtractive manufacturing process, a process during which the material is removed through, for example, milling from a solid medium to create a desired product (Gebhardt, 2011:2).

In fact, 3D printing offers the advantage that it consists of numerous sub-categories that allow for the use of various materials to create the desired product, including the use of thermoplastics, fine powders, polymers, alloy metals, photo-active resin, nylon, sand and ceramics (Jandyal, Chaturvedi, Wazir, Raina & Haq, 2022:36).

The additive manufacturing process has two core applications in an industrial manufacturing setting. First, there is the use of the process for rapid prototyping. Instead of utilising more cost-intensive prototyping methods, prototypes can be created rapidly and in a cost-efficient manner through the use of 3D printers in the design phase of manufacturing lines and new products. From a manufacturing perspective, 3D printing can be utilised to create either finished products directly through the additive process or components that indirectly contribute to the manufacturing process of finished goods. An example of the indirect contribution of 3D printing is the use of the process to create moulds for the metal casting of components for finished products. Furthermore, 3D printing has the potential to reduce the machine maintenance costs, since the process allows for the creation of replacement parts for the machines at short notice, without the need for warehousing or for long lead-times for the parts to be delivered from external suppliers (Gebhardt, 2011:1–15).

Through the use of the additive manufacturing process, the product is sold to the end customer based on specific digital design files. This is followed by streamlining the manufacturing process into a single step in which the final product is created using 3D printing. The final product is then inspected, packaged and shipped to the customer (Horst, Duvoisin & De Almeida Vieira, 2018:3).

Furthermore, as part of a cyber-physical systems, additive manufacturing allows for the efficient use of manufacturing capacities through networking these capacities and forming cloud manufacturing networks of autonomous devices (Horst *et al.*, 2018:3).

2.3.9 Augmented reality

Augmented reality is a technology based on the integration of hardware and software that presents an element of the implementation of Industry 4.0 through the creation of virtual elements in the physical surroundings of factory staff. Augmented reality is the means through which the physical reality can be augmented by virtual elements and visualised in real time. This enables the users to simultaneously engage in the co-existing virtual and physical realities (Bortolini *et al.*, 2017:5705).

As such, in the Industry 4.0 context, augmented reality allows humans to view digital information overlaid onto their physical reality. It is argued that this positions augmented reality on the reality–virtuality continuum equidistant between the physical realm and the virtual realm. The existing literature indicates that the main applications of augmented reality in support of Industry 4.0 manufacturing are found in the fields of maintenance, assembly, logistics and quality control (Egger & Masooq, 2020:6).

As discussed above, cobots are designed to work with humans without posing a danger to them. Many manufacturing facilities are updating the manufacturing process to incorporate Industry 4.0 technologies. The introduction of these technologies is capital intensive and, in many cases, not all the technologies are implemented at the same time. Augmented reality is a means through which ordinary industrial robots can operate in the vicinity of humans without increasing the risk of injury. Unlike the approach of some cobots – where the device is limited in terms of speed, deployable mechanical force and awareness of its surroundings – the upgrading of industrial robots through the implementation of virtual safety boundaries presented to any humans in the manufacturing location via augmented reality devices is also possible. Alternatively, there exists the possibility of digitally predicting the industrial robots' movement and making these visible to the human workers to ensure their awareness of the industrial robots' movements. While this does not enable physical cooperation between human workers and industrial robots, it does enable a safe coexistence without the need for physical barriers (Egger & Masooq, 2020:11).

Industry 4.0 and its implementation will undoubtedly result in a shift in technological usage in the manufacturing processes and a change in the complexity of the machines and processes employed to achieve the manufacturing tasks. While presenting a more complex scenario, this offers manufacturers increased data acquisition, upon which decisions can be based, ultimately increasing the utilisation of the machine during its lifespan (Masood, Egger & Kern, 2018:183).

As alluded to earlier, manufacturing devices are becoming increasingly complex, meaning the attendant maintenance and repair processes are becoming equally complex. While automated servicing and maintenance is currently possible, there is still a need for direct human input. The traditional approach to sharing knowledge and instructions with service technicians involves the use of paper or online repair and servicing manuals. Augmented reality presents the technology that allows for the creation of virtual reality guides in which the steps to be taken and the items to be used are highlighted virtually for the technicians performing servicing tasks in the physical reality. Augmented reality also enables machine learning through which the servicing procedures can be optimised before being adopted by the technicians using augmented reality devices, a process only made possible by the virtual element of augmented reality. This represents a shift of fixed instruction manual authoring to the real-time situational-dependant authoring of servicing and maintenance instruction manuals (Egger & Masooq, 2020:11–13).

2.4 IMPLEMENTATION OF INDUSTRY 4.0

2.4.1 The pace of the implementation of Industry 4.0

The trend towards Industry 4.0 emerged before the advent of the COVID-19 pandemic; however, the pandemic, along with the constricted physical supply chains and the limitations on international trade, served as an impetus that has led a large number of organisations to implement Industry 4.0 technologies. The occurrence of a once in a lifetime event and the advent of new manufacturing technologies alone may not constitute a revolutionary period in society but the simultaneous occurrence of these may present the initiation of such a period. In short, these are cyclical events that reshape environments and societies. Currently, we are witnessing the age of the digital revolution, accelerated by the global pandemic, which has led to reduced personal contacts and disrupted supply-chains, but increased organisational investment in digital work-solutions to ensure continued operations (Schwab & Malleret, 2020:21–55).

A total of 65% of globally interviewed business leaders believe that the COVID-19 pandemic has greatly increased the importance of Industry 4.0, while only 12% believe the value of Industry 4.0 has been diminished by the pandemic. Organisations that implemented Industry 4.0 technologies in their operations find themselves substantially better equipped to address new situational changes. In fact, 96% of businesses that have implemented Industry 4.0 stated that they are able to respond to crisis, while only 19% of respondents that had not implement Industry 4.0 are in this advantageous position. Furthermore, the pandemic served as a point of such severe environmental change that it induced the implementation among many industries (Agrawal, Dutta, Kelly & Millán, 2021:1–9).

Within the context of the preceding industrial revolutions, it can be argued that the 4th industrial revolution and the implementation of Industry 4.0 can be considered as decidedly fast paced. In fact, this revolution has the potential to greatly change businesses and to disrupt society significantly. Notably, the rate at which the equilibrium is disrupted and new equilibriums are created has increased substantially. The leap from the first phone call to the internet has taken 115 years, while the evolution from the Internet to readily available data communications only took 16. Similarly, the process of printing has taken 505 years to evolve from analogue printing to computer printing, while the transition from computerised printing to 3D printing has only taken 31 years. Societies' willingness to adapt to new technologies has also accelerated dramatically, with radio needing 38 years to gather 50 million users, television needing 13 years and the internet three (van Dam, 2017:11).

While industrial robots have been part of the manufacturing environment for decades, the use of cobots is a relatively novel aspect. The term 'cobot' was first coined by Colgate, Wannasuphoprasit and Peshkin in 1996, and both the technology and the term have rapidly become part of the manufacturing landscape (Couroussé & Florens, 2007:3). Since their initial conception, the number of cobot installations is ever increasing globally, with industry experts reporting that the cobot market is increasing by 50% annually (Hand, 2020). The IoT systems emerged in a similar period of time, with the first mention of this technology dating back to at least 1999. While these technologies predate the idea of Industry 4.0, this is an indication that the shift towards Industry 4.0 actually began in the 1990s.

While there are clear differences between the industries and the geographical regions within countries, an indication of the degree of progress towards the implementation of Industry

4.0 in certain nations is the timing of official governmental support for these novel technologies. As previously stated, the term Industry 4.0 originated in Germany and one of the first government initiatives to explicitly advance the implementation of Industry 4.0 was 'Platform Industrie 4.0', which was initiated in 2013, and the propagation of the term Industry 4.0 at the Hannover Fair in 2011 (Klitou *et al.*, 2017:8; Yang & Gu, 2021:1312). Meanwhile, the explicit support of the Slovak government for the implementation of Industry 4.0 can be traced back to the 'Inteligentný priemysel pre Slovensko' initiative of 2016 (Klitou *et al.*, 2018:4–5), while in the US, the term Industry 4.0 is less prevalent but the government did formulate the Advanced Manufacturing Partnership in 2011, which focuses on the technologies and the capabilities of the 4th industrial revolution in the manufacturing sector through a partnership between government, academia and private enterprises (Yang & Gu, 2021:1321). Elsewhere, China has taken a time-sensitive approach to government support through its 'Made in China 2025' plan, a 10-year plan that was launched in 2015 (Ma *et al.*, 2018:3). While these governmental initiatives are an indication of the official recognition of the trend towards implementing Industry 4.0, there are numerous factors that are further influencing the pace of implementations in the above regions. These factors were discussed in the regional background section of this document.

2.4.2 Product quality and the implementation of Industry 4.0

A key element in which the implementation of Industry 4.0 is expected to have an impact relates to the quality of the goods that are manufactured using this technology.

The strongest impact that Industry 4.0 is expected to have pertains to the increased knowledge of the production process and the possible points of failure in the product and the manufacturing process. Through the collection of big data and the utilisation of digital twins, the quality assurance and product tractability can be greatly improved. Digital twins are, in essence, products that are created in the virtual realm and follow a virtual production process that mirrors the physical production process of a product. The use of the digital twin allows for accounting for the quality of the physical product and also allows the manufacturer to predict product failures and address any possible anomalies or errors in the production process. It has been noted that this process applies to smart manufacturing machines and large amounts of computing resources. Should these be remote resources, this would then be facilitated through the Internet of Things (Karnik *et al.*, 2022:5). This can only be made possible through the use of data collected by the manufacturing machinery and the use of tracker devices such as radio-frequency identification (RFID) chips or bar codes that are stored in the cloud. The resulting big data allows for the tracing of physical products and for the prediction of possible failures. This knowledge would, in turn, become the basis of future modelling (Karnik *et al.*, 2022:7).

Clearly, quality control forms a vital element of the manufacturing process, and while a substantial portion of quality control is automated through Industry 4.0 technologies, not all processes can or will be automated or autotomised.

In an effort to minimise human error in the quality assurance process, augmented reality can aid human workers by highlighting in virtual terms any goods or locations marked out for inspection by a human worker. This highlighting of specific goods or sections of a product can harness the realms of big data and machine learning to identify the aspects with the greatest likelihood of presenting diversions from the set quality standards and subsequently instruct human workers to inspect the suspect items (Egger & Masooq, 2020:10–12). Furthermore, it can be argued that the use of Industry 4.0 technologies would lead to the reduction in quality-related costs for the manufacturing entity, that is, the cost of assuring and achieving a quality standard.

2.4.3 Production costs and the implementation of Industry 4.0

One field in which the introduction of Industry 4.0 will change processes extensively is the field of logistics. The most labour-intensive process in the logistical process is the collecting or ‘picking’ of items in warehousing complexes. Reif, Günthner, Schwerdtfeger and Klinker (2010:8–10) assert that the use of augmented reality can substantially increase the efficiency of human labour in the process of picking goods, with their research highlighting how the use of augmented-reality-based ‘pick-by-vision’ systems increased employee motivation substantially and reduced the error rate when picking goods manually from a rate of 0.84% when using paper-based picking lists to a rate of 0.12% when using augmented-reality-assisted picking.

Elsewhere, Mättig, Lorimer, Kirks and Jost (2016:7) concluded that the implementation of augmented reality in warehousing systems that require human labour picking can reduce costs by 30% as a result of increased picking speed and more efficient use of the available space in the warehouse, complimented by more efficient *packing* of the items in transport containers.

Machinery maintenance costs present a substantial element of the total cost of ownership and the use of Industry 4.0 technology can, according to previous research, reduce the maintenance costs by up to 30% (Lamberti, Manuri, Sanna, Paravati, Pezzolla & Montuschi, 2014:411–421). This reduction in costs can be achieved through improved communication among the technicians and off-site engineers via augmented reality and through the assistance of holographs and the holographic representation of service elements for the on-site technician.

As noted by Bortolini *et al.* (2017:5703), additive manufacturing is one of the core elements of Industry 4.0. In conjunction with other Industry 4.0 technologies, additive manufacturing alters the supply-chain in a manner that ensures that the increased complexity does not negatively impact the manufacturing costs. As such, the financial bottom line can be positively affected since projects and products with higher degrees of complexity can be fulfilled by organisations at little or no extra cost. Traditionally, raw materials were shipped to organisations that produce intermediate products that are then sent to a central assembly site, where these intermediate products are finished and assembled. Once put together, these final products are inspected for any manufacturing defects before being stored and shipped to the end customer once the product has been successfully promoted. The additive manufacturing process is decidedly different. In fact, this process relies substantially less on a complex physical supply chain, consisting, in its most extreme form, of print-on-site solutions. This process allows for the traditional manufacturer to solely supply the customer with a file or chip such that they can print out the product when and where it is needed. The reduction in processes removes several variables from the manufacturing process as a whole and thus also reduces the production costs for the organisation that supplies the chip or file (Horst *et al.*, 2018:3).

The use of print-on-site solutions remains unviable in many industries and the need for traditional manufacturing continues to hold sway. However, this is one area in which the introduction of Industry 4.0 can positively impact the production costs. The pressure on manufacturers to reduce the costs and increase the efficiency and the machine utilisation has led to the cloud computing model being expanded into an all-encompassing cloud manufacturing system, with the aim of ensuring the sustainable operation of the manufacturing organisations. Cloud manufacturing turns the resource- and fixed-asset-intensive production of goods into a service-oriented model where the manufacturing is linked through cloud computing and online coordination of the manufacturing as a network of temporary supply chains that lead to a final product. Once the task is completed, all the manufacturing resources are reallocated into the virtual pool of available resources in the manufacturing cloud, which can be used by all constituent organisations (Fisher, Watson, Porcu, Bacon & Rigley, 2018:53–57).

Machine learning is a constituent technology of Industry 4.0. Its implementation results in the minimisation of human input, while the efficiency and reliability of the manufacturing process must continue to improve. Through the use of machine learning, the machine down times can be minimised, with the occurrences predicted in real time, assisting in the aforementioned aims of Industry 4.0. This reduces any time lost due to machine faults or the manufacturing of defective goods.

The role of machine learning also encompasses the performance reviews of human workers, which ensures that the maximum productivity is evaluated and serves as a means to highlight areas where the efficiency of the human workers can be improved (Angelopoulos *et al.*, 2020:2–4).

2.4.4 <u>Innovation, product development and the implementation of Industry 4.0</u>

Product development is a further field that will be significantly impacted by the introduction of Industry 4.0. A key Industry 4.0 element that will affect this area is the introduction of additive manufacturing. Additive manufacturing allows for product developers to produce a physical representation of the product prototype in a timely manner since this process can be facilitated in house through the use of 3D printing devices at a relatively low cost. This in-house manufacturing of prototypes also allows for rapid prototype production in comparison to the use of external prototype manufacturing services (Gebhardt, 2011:7–11).

The simplified manufacturing process created through the use of 3D printing allows for two further changes in the product development process: the blending of digital design and the instantaneous creation of physical products by means of standardised printing devices, which allows for high levels of customisation of previously standardised products at little extra cost, widely acknowledged as marking the shift from mass production towards mass customisation (Gaub, 2016:401).

Furthermore, as discussed earlier, Industry 4.0 is the source of a great wealth of data. This data presents a source of knowledge on an unprecedented scale that serves as the platform for improved manufacturing oversight and product quality assurance, while it also entails other advantages. In fact, the large amounts of data available to the specialists that are developing a product allows them to gain the knowledge to build novel products with greater confidence in the physical properties of the final product, which is not the case in the traditional product development process that must rely on less data and is often grounded in the experience of the product development specialists.

Yang and Gu (2021:1312) assert that there is a substantial link between the implementation of industry and innovation. This is also closely linked to the abilities of the novel Industry 4.0 technologies that impact the manufacturing process in its entirety, including the product development process.

Sarbu (2022:1–5) notes that the implementation of Industry 4.0 positively correlates with increased innovation in any given organisation. The usage of Internet of Things leads is regarded as a means that enables increased innovation in products. This is complimented by the finding that the use of big data and the increased knowledge base that this creates greatly increase the likelihood of a successful introduction of an innovative product in the market. In addition, the use of Industry 4.0 technologies can help organisations to create products with increasingly interconnected supply chains that enable them to lower their costs while retaining transparency and control over the entire process. Lastly, the interconnected nature of the manufacturing process enables product developers to increasingly include specific services in their physical product, with these services augmenting or complementing the traditional physical product. An example of this is the inclusion of subscription services into products, which is only made possible by the increased connectivity between the manufacturer, the manufacturing process and the final product. Sarbu (2022:1–5) notes that many argue that smart algorithms assist organisations in the creation of innovative products and services and that the use of Industry 4.0 technology is also linked to a greater intensity in the innovation of products.

2.5 CHANGE PROCESSES DURING THE IMPLEMENTATION OF INDUSTRY 4.0

When considering the concept of Industry 4.0, several factors become apparent. First, in the implementation of new technologies, the attendant changes must be both communicated and managed. It is therefore paramount to investigate the area of change management as a key discipline for ensuring a smooth and successful transition into the age of industrial automation, digitalisation and autonomous production.

In the ever-faster-changing environments, businesses face the challenge of assigning resources as effectively as possible; however, the dynamics of such environments may require increasing resources and capabilities. Phillips (1983:187–188) notes that organisational change entails well-planned operation patterns and strategies. In short, in addition to employing managers who are capable of implementing such changes, great situational awareness of the operational context is needed.

Failing to adopt a realistic change management approach may result in various negative consequences (Phillips, 1983:184–187). Ślusarczyk (2018:232) discusses the blurring of the distinction between work conducted by living people and the work of the fully autonomous machines associated with Industry 4.0.

Phillips (1983:184–187) argues that a lack of proactive change and adaptation will not only reduce the funds businesses have to directly invest in change, since any profits that might otherwise be reinvested into the business will be reduced, but will also have indirect effects, as less adaptable and innovative businesses will be less attractive to potential investors. In short, rapid innovators tend to increase their market share at the cost of businesses that are slow to adapt to new technologies or production methods. Phillips (1983:184–187) also states that poor change management procedures reduce the time a company has to respond to innovation.

To successfully manage change in an increasingly interlinked society, as noted by Kramer and Pfitzer (2016:7), change can best be achieved through cooperative and coordinated ecosystems of stakeholders that share a common goal or issue. The key to successful collaborative change lies in setting a common agenda in which all actors share a common vision with respect to the desired outcome of the joint effort. Furthermore, a shared measurement of the outcome is regarded as essential since a common agenda would be of little value if the results of a united endeavour were analysed by different stakeholders using different units of success (Kramer & Pfitzer, 2016:7).

However, a collective charge towards change does not entail all the participants engaging in the same task. In fact, alliances are generally created for the explicit purpose of increasing the capabilities of the group to address an issue with skills that are mutually reinforcing. The multifaceted nature of shared value ecosystems necessitates constant and efficient communication to build trust among the partners and to ensure that all efforts are coordinated to maximise the value created for all participants. This communication is facilitated by dedicated support structures that exist independently of the groups and organisations that cooperate to address a common issue or challenge (Kramer & Pfitzer, 2016:9–10).

In the macro context of Industry 4.0, this cooperative approach towards challenges has been manifested through several examples. For one, the German government initiated its aforementioned ‘Plattform Industrie 4.0’, an independent platform for businesses, government and academia to cooperate and exchange experiences and address shortcomings that impact the transition towards the 4th industrial revolution. This initiative resulted in numerous government ministries engaging with industry and addressing certain identified issues (Klitou *et al.*, 2017:3), which included the Federal Ministry of Education and Research developing the ‘Berufsbildung 4.0’ initiative to address the need for new vocational degrees and skill-development training for the existing workforce in light of the transition toward Industry 4.0 (Federal Ministry of Education and Research of Germany, 2017).

In all likelihood, the advent of Industry 4.0 will have a significant effect on all three of these dimensions. However, the technological and cultural dimensions in particular will both impact and be impacted by Industry 4.0 and the associated expected change in the work environment.

2.5.1 Networks and hierarchies

Kotter (2015:9) argues that large organisations with a hierarchical approach to management often face difficulties in terms of innovating, largely due to structural limitations. Here, the solution perhaps lies in the implementation of a network approach to innovation while relying on traditional, naturally evolved hierarchies within the organisation to ensure stability in the daily operations and an increase in efficiency, while networks enable organisations to approach changes with higher situational flexibility. Thus, both organisational forms have merit and a dual approach to change may be desirable. Small teams with low hierarchies address pressing topics and implement change in a rapid manner while not impeding on the operations of the rigid well-established hierarchies and efficiencies until the change is ready to be implemented on a larger scale. Such small teams are not limited by the typical issues experienced by strict hierarchies, such as bureaucratic processes and control prohibitions that often hinder the ability of well-established organisations to adapt to new contexts in a timely manner. With this in mind, van Dam (2017:14) highlights the substantially shortened lifespan of some of the world's most successful businesses.

The existing research reports that while the average lifespan of a Standard and Poor's 500 company was 90 years in 1935, this was reduced to 30 years in 1975, was further shortened to 18 years in 2011 and is expected to further decrease to 13 years in 2027 (van Dam, 2017:14–15). Companies are faced with a trifecta that can determine their life expectancy. First, businesses need to operate efficiently which, as previously noted, is the domain of established hierarchies. In addition, a new business must be developed and social needs must be addressed. Considering the shortened lifespan of businesses, a timely identification and implementation of opportunities is paramount, highlighting the need for small implementation networks within a business. Third, to ensure long-term sustainability, a business may divest and close operations that no longer contribute positively to its future. These operations may have formed part of the business's historic identity (van Dam, 2017:15). The importance of this shift is discussed within the context of punctuated equilibrium theory in the current paper. Furthermore, while long-term business sustainability is paramount to any commercial operation, such structural changes need to be explored within the context of a business' responsibility towards its stakeholders and within the context of contemporary corporate social responsibility, which this paper addresses at a later stage.

As van Dam (2017:15) states, corporations are faced by a dilemma, that is, the need to innovate to ensure long-term sustainability often conflicts with more short-term operational effectiveness. Kotter (2014:20) stresses that this conflict can be addressed via a dual approach to managing change. The use of networks for rapid innovation that are tailored for the adaptation to rapidly changing contexts and the use of established hierarchies that are used to implement incremental changes and develop strategic initiatives to address predictable changes that improve business efficiency presents a vital combination of networks and hierarchies. Crucially, networks for change and organisational hierarchies perform divergent purposes, while they are staffed by the same people within an organisation. This highlights the parallel implementation of change and the need for stability within a single entity staffed by the same people, who often preform a multitude of roles (Kotter, 2014:21). This understanding would enable organisations to harness specific networks to implement changes and to enact these within the efficient hierarchy of the business (Kotter, 2015:12).

A dual operating system is based on an understanding of internal crowd sourcing, since it is crucial to innovate within a global setting with various individuals adding their perspective, their know-how and their efforts to gather information and accelerate the change. This is carried out informally, but in a nonetheless well-managed manner in view of avoiding conflicts and doubling redundancies. Members of changing hierarchies and networks are to be recruited from a wide variety of backgrounds. The change networks and organisational hierarchies form an inseparable partnership. Ideally, these networks work in tandem, as previously discussed, in view of harnessing their respective strengths. A further strength of a dual system of organisation wherein both systems are staffed by the same people is the avoidance of 'silo' thinking and harmful competition between the respective systems. Kotter (2014:25) highlights that, in practice, the merging of the systems may at first appear somewhat foreign; however, this can be addressed through education, communication and the demonstration of success, until it becomes part of the organisation's DNA, or, using a term particular to punctuated equilibrium theory, its deep structure.

The management process must involve the adoption of a motivational and supportive role, communicating change in a positive manner, which will greatly improve employee buy-in, ensuring that the employees act as change agents, reducing any pushback and potentially creating a sense of a shared purpose (Kotter 2014:25).

Furthermore, the change must be framed as being more than a rational step, with both business and opinion leaders communicating emotion as much as appealing to individual rationality. While the fact-driven rationale behind the implementation of change is perhaps vital to justifying the attendant expense and effort, pure rationality alone will not motivate a wider audience and will certainly not serve as the sole driver for change. This is reiterated by Kotter (2014:23), who asserts that appealing to the emotions will greaten the willingness among individuals to participate, creating a sense of augmented meaning to the envisioned change by increasing the perceived purpose of the individual's action.

As previously discussed, effective management is vital to ensuring a coordinated effort toward change, but this is not the only vital role played by the senior management, with the coordination of change, the supervision of change networks and the established hierarchies also crucial management tasks, while strong leadership is perhaps equally important. Both motivation and a common understanding of the goals are needed when changing any given organisation. While the management of routine tasks and operations may be the core process, leadership is the means through which opportunities are identified and subsequently addressed. Good leadership does not only entail having a charismatic personality at the helm of the business; rather, it encompasses the skills of vision, agility, innovation, inspiration and the acknowledgement of success (Kotter, 2014:25).

2.5.2 Actions accelerating innovation

Within the context of the implementation and propagation of innovation, eight key drivers have been identified, with Kotter (2015:15) terming these as 'innovation accelerators'. According to Tang (2019:77), these drivers include the following:

1. Creating a sense of urgency
2. Creating an evolving coalition that guides the change process
3. Creating a vision of change and strategic initiatives
4. Enlisting volunteers to implement the vision of change
5. Empowering broad-based change by removing any barriers
6. Highlighting short-term successes
7. Consolidating positive changes and sustaining the momentum of change
8. Institutionalising the newly established approaches in the corporate culture

The creation of a sense of urgency surrounding substantial opportunities is the initial driver (Tang, 2019:77). Elsewhere, Phillips (1983:189–192) highlights a traditional approach to change as follows. When change is imminent, a sense of urgency needs to be created, even in instances where the intended change is not clearly defined. This is, however, not necessarily the main objective during the primary phase of organisational change, while it is paramount that the dynamics of the change are understood. While creating a sense of urgency, as Phillips (1983:190) notes, there is the need for managers to grasp their business's inadequacies with respect to the industry in which it is operating. This does not occur automatically; rather, a fundamental change must be identified and propagated by a core group of people who are convinced that change is unavoidable. As previously noted, Kotter (2014:26) stresses the strength of the dual system when creating a sense of urgency. This is not only achieved among the management but in a setting that includes as many people as possible. Such an inclusive approach would lead to organisations developing change networks that complement the established hierarchies. In sum, the sense of urgency is built around paramount opportunities and threats that are fast approaching.

Phillips (1983:187–189) points to three components that enable successful change from an organisational perspective. First, a business experiencing change needs a strategic vision to attain the envisioned destination, while new organisational skills and capabilities are needed to further enable change. These include the technological and managerial skills that will ensure a smooth transition to digitalised production. In addition, political support is required, meaning that top executives, opinion leaders and other stakeholders need to embrace and deeply commit to the anticipated change in the workplace.

Elsewhere, Tichy (1983:188) notes that change exists in several environments and that these changes are intertwined, much like strands of a rope, ultimately determining a business's actions, success and the need for situational adaptation. The technical environment manifests the pressures resulting from technological change. In fact, this is one of the focus areas of Industry 4.0, one that will not only change the manufacturing practices but will also create new markets for technology companies. As part of the political force, Tichy (1983:188) describes the pressure for change as resulting from the power or the allocation of resources. Cultural values are the final force driving change, values that are often brought about by societal standards or changes in individual beliefs. Such developments may be accelerated by changes in cultural diversity and/or changes in the labour market.

As Phillips (1983:190) states, the implementation of new technologies is built around an evolving coalition for change, one composed of individuals of various disciplines who act as guides. Typically, the group that instigates this sense of urgency is rather small and, while in ideal scenarios the group members operate at the top management level, they often operate in second- or third-level management. The latter are often closer to the market and may identify market trends sooner than top management. However, it is critical that at least some members of the top management are supportive of the change, since the change is unlikely to occur otherwise (Phillips, 1983:188–190). Kotter (2014:75–108) advocates for a similar approach to change management, with nuanced adaptations to the current context of change, while continuing to discuss the issue in a highly generalisable manner.

Following the Kotter (2014:29) approach to change management, the small change networks within the company would create small groups that serve as guiding groups to develop the change into more sophisticated forms, taking advantage of the diverse nature of the change networks. Involving individuals from varied levels of authority and business backgrounds around a substantial opportunity is a key point that determines the future course of the change endeavour. As highlighted by Phillips from a practical perspective, major change is often spearheaded by the CEO, who is supported by a second coalition of general management staff and a third group consisting of technical staff (Pollack & Pollack, 2014:56).

Meanwhile, as Kotter (2014:29) explains, to ensure successful implementation of change, a vision of the change and attendant strategic initiatives need to be clearly formulated. This becomes the principal role of the guiding coalition of change networks once these coalitions have been created around the sense of urgency. It must be acknowledged that in a regular hierarchy-driven organisation, change can also be driven by small groups, while these merely form part of the hierarchy, with no small networks operating as an ‘internal start-up’.

The dual system approach implies a shift away from a largely corporate focus on efficiency towards an integrated understanding that includes the understanding of the value of an increased rate of innovation (Kotter, 2015:7). The aspects that may be addressed in the vision and the attendant strategic initiatives are focused on the changing context in which the organisation operates. In short, the strengths and weaknesses must be highlighted and a vision must be developed with a focus on the future technical, environmental and social developments, especially in cases where the current business strengths may become unsustainable in the long term. In practice, this would result in the formulation of the future course of the business and the minimisation of the risk of losing a competitive advantage (Pollack & Pollack, 2014:57). The need to continue innovating and adapting in incremental steps during periods of calm and the need to reinvent in periods of unrest have already been widely cited. As highlighted by van Dam (2014:14), the continually decreasing life-expectancy of leading businesses is a further indication that a realistic and well-informed vision is essential for future corporate survival.

Once a vision and a strategy have been developed, these must be propagated within the organisation in an effort to grow the group of supporters of change. Kotter (2014:31) refers to this group as a ‘volunteer army’, one that is augmented in size through strategic communication of the change vision and the active dispersion of information by the original guiding change coalition of employees. Kotter (2015:19) goes on to argue that a volunteer army of around 5%–10% of the management-level staff and general employees is sufficient to creating a dual system within the organisation.

The attendant communication must ensure that every message is consistent and that a coherent understanding of the vision of the change is created among all employees. In fact, a lack of understanding of the key vision is seen as a prominent cause for ineffective implementation of change and inconsistent messaging. Pollack and Pollack (2014:57) state that the communication process that an organisation may adopt to facilitate this change is to be one of the most important phases in change models and one that is often underestimated by practitioners in terms of the complexity and time required for the implementation. This communication effort must be specifically developed to address local issues and needs, demonstrating senior management buy-in while building upon existing activities. While the communication process is not explicitly linked to corporate communication departments, good relations with this group of employees is nonetheless important. Positive coverage in the internal news medium and greater prominence in the internal media are most certainly an asset to the change efforts as a whole (Pollack & Pollack, 2014:58). If this is appropriately carried out, the employees will begin to follow the vision as they begin to personally experience its impacts. During this transition, the value of the change vision becomes apparent to the majority of stakeholders, who consequently become the drivers for change in their specific area or in a more general sense (Kotter, 2014:31).

Once success becomes manifest, the acceleration of change and the increasingly wider input from the change must be created. This is achieved via the change networks, the members of which identify and support initiatives that will impact the established hierarchies. These actions are characterised by a perceived need to eliminate any barriers that oppose or hinder the change initiatives, while remaining mindful of the established strengths and operational goals. Pollack and Pollack (2014:58) argue that the human resource (HR) department is a vital enabler of the removal of structural hindrances when reforming an organisation. Here, human resource practitioners should share their knowledge on local particularities with the change networks since a change in the hierarchal dynamic can be facilitated with intimate knowledge of the local power dynamics. In practice, HR practitioners often act as a liaison point between the networks and the local team members, aiding the development of trust, upon which communication specialists build their engagement and communication plan.

As Kotter (2014:32) notes, once the above steps have been implemented, the change network may experience the first successes in the implementation process, which present an opportunity to further motivate the employees driving the change to engage in their actions. Various authors argue that it is not necessarily important to celebrate such small incremental changes; however, many practitioners echo Kotter's sentiment that good news and positive reinforcement are paramount to motivating human workers, potentially assisting in the effort to sustain the drive towards change within the organisation (Pollack & Pollack, 2014:59).

It is a natural part of human nature to reduce one's efforts once successes have been regularly achieved; however, this tendency may threaten the sustainability of the achieved changes and may even jeopardise the implementation of the change in a wider context, since most celebrated successes have limited impact when isolated from the 'master initiative'. The final component of successful change is the institutionalisation of the changes in the hierarchy of the organisation (Kotter, 2014:33). This makes it an integral element of an organisation's deep structure, one that will guide corporate action until the next period of unrest necessitates further changes.

Kotter's discussion of change is often held as being ambiguous in terms of whether the change should be implemented in a single step or gradually realised throughout the organisation in multiple steps. For their part, Pollack and Pollack (2014:62–63) put forward the argument that the implementation of numerous changes in parallel is impractical from a practitioner's perspective, especially when implementing change in large multinational organisations. In fact, these authors suggest allowing for some flexibility and adapting the timing of Kotter's steps to implement change according to the environment and the stakeholders of the proposed change. While being an accelerating process from an organisational perspective, the change process is essentially the sum of changes made by the change network. From a stakeholder's perspective, the change may be seen as a punctuated drive towards a specific target. These actions will vary among the stakeholders and the timing will be influenced by the local contexts (Pollack & Pollack, 2014:63).

2.6 CONCLUSION

Industry 4.0 and the various iterations of the industrial revolutions are highlighted in the first chapter of this document. Some may argue that one could approach Industry 4.0 similarly to its preceding industrial revolutions, but this would solely be possible in a highly generalised manner. The literature review, highlighted in chapter 2, of Industry 4.0 technologies and the discussion of implications illustrates that the advent of this technology exposes opportunities and risks to businesses, employees and society. Established change management approaches, as discussed in this chapter, may pose a possible manner in which benefits of the introduction of Industry 4.0 could be harnessed. An understanding of Industry 4.0 and change in various regional contexts are of high importance to this study and guide the understanding of literature not only presented in chapter 2, but also guides the discussion of literature in the third chapter of this document.

Chapter 3 will build on this understanding and guide the reader through literature that illustrates the pinitol role of communication management in addressing Industry 4.0.

Particularly the role of culture and the increasingly central role of internal and external stakeholder and the associated communication are a central element of this study.

CHAPTER 3

3 COMMUNICATION MANAGEMENT IN AN INDUSTRY 4.0 ENVIRONMENT

3.1 INTRODUCTION

Having established an understanding of Industry 4.0, its technologies and implementation, this chapter will focus communication management aspects. It is the description of the act of managing an organisation's communication and managing through the use of communication. Utilising communication management, organisations can inform, persuade, build relationships, and engage in dialogue (Van Ruler & Verčič, 2005:241–251). This communicative engagement with audiences is a manner in which organisation can engage with their stakeholders. Van Ruler and Verčič (2005:256) highlight that communication management can take three distinct approaches. These are the product orientated approach, the marketing orientated approach and the society orientated approach. Considering the anticipated social impact the Industry 4.0 may have on society and an organisation's stakeholder, the following section will highlight several aspects of communication management. The role of culture is explored and changes in communication at the workplace are addressed.

Mohamad, Nguyen, Melewar and Gambetti (2019:73) argue that communication management is not solely focused externally or internally. Communication management is concerned with the entire communication of an organisation. This chapter will explore and illustrate internal and external communication in relation to the implementation of Industry 4.0. The case organisation is undergoing multiple changes including a change in ownership and the introduction of Industry 4.0 technologies at its facilities in a wide context of organisational and communicational cultures. The research has taken place during the time of a pandemic that has forced organisations, including some case facilities, to reduce the physical presence of staff at the workplace. Literature on the remote workspace and its impact on communication is highlighted in this section of the document. This Chapter highlights the theories from a communication perspective and form the basis of the discussion of findings found in Chapter 7 of this document.

3.2 COMMUNICATION AND CULTURE IN AN INDUSTRY 4.0 ENVIRONMENT

When exploring the implementation of Industry 4.0 in several regions, differences are to be highlighted and explored. Particularly for communication professionals, it is highly important to be aware of the cultural elements that are of great importance to the relevant parties. Communication is shaped by multiple aspects, including corporate, regional and communication culture. Communicating the implementation of Industry 4.0 is not done in a singular cultural context but rather on a global scale. Intercultural communication has over the years, and a key driver that exposes persons and organisations directly to other cultures is technology (Martin & Nakayama, 2007:5–14). Following this rationale, when communicating Industry 4.0 and exploring its effect on communication, a knowledge of cultural traits is vital. This study focuses on exploring the implementation of Industry 4.0 in four distinct cultures: Slovakia, Germany, the USA and China.

Culture is an influential factor in the communication process: it influences the perception of change. Thus, the approach to communication is dependent on the cultural environment in which it occurs. Culture can refer to the traits and values of societies on a large scale but can also take the view of exploring the values and norms of an organisation. When exploring change, one needs to recognise that, while there may be an identifiable organisational culture in certain businesses, these businesses do not operate in a vacuum. One can argue that regional culture may affect organisational culture in elements of multi-national organisations. It is stated that culture varies between regions; thus, the culture within the elements of an organisation may differ based on unique regional circumstances, and communication within an organisation can contain elements of intercultural communication. Culture is defined as a set of characteristics and values that are shared by a group of people over time. Elements such as customs, religion, political systems, language and art are further constituters of culture (Tubbs & Moss, 2008:312).

Intercultural communication is any communication between members of different ethnic or socio-economical groups (Tubbs & Moss, 2008:312–313). Communicators need to accommodate for cultural differences within an organisation when communicating change. This can play a particular and important role in a company-wide implementation of the novel technologies of a global organisation such as Industry 4.0.

Hofstede, Hofstede and Minkov (2010:53–300) highlight six dimensions upon which differences in cultures between various nations can be illustrated. These are (Delgadová & Gullerová, 2017:571–572):

- Individualism versus collectivism
- Power distance
- Uncertainty avoidance
- Masculinity versus femininity
- Long- versus short-term focus
- Indulgence versus restraint

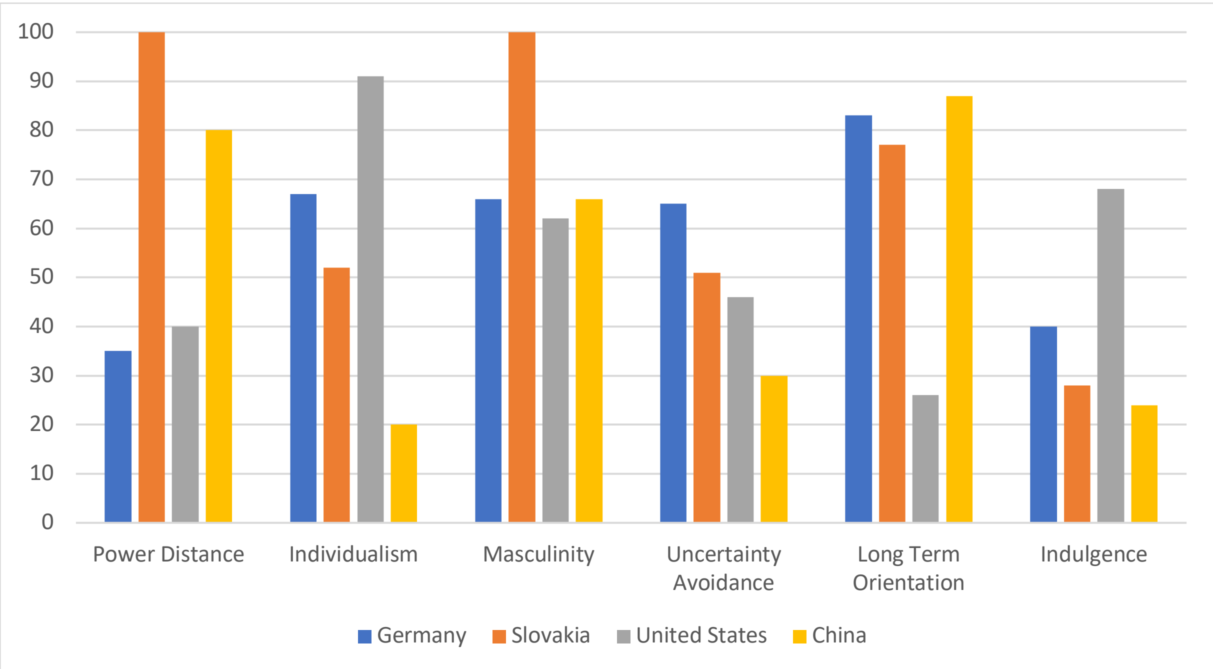
The first difference that needs to be accommodated when communicating the introduction of Industry 4.0 is the difference between individualistic and collectivistic cultures. Cultures with a high focus on individualism value an emphasis on the individuals' goals and the pursuit of self-realisation. Individualistic cultures cultivate collectivistic structures, such as families or occupational groups, but the influence that these groups have on individuals is limited. Members of individualistic cultures display traits of associating their identities with their individual characteristics. They tend to favour and engage in communication that is highly direct in its messaging, with precise, direct and absolute statements not being driven by context (Tubbs & Moss, 2008:316–319).

In contrast to individualistic cultures, collectivistic cultures emphasise in-groups aims and ambitions. This requires the individual to subordinate their goals and ambitions to the group's goals. Collectivistic cultures favour the assimilation of individuals into group structures and the minimisation of internal tension. The communication of collectivistic cultures centres on group identity and aims to avoid confrontation. The messaging that is utilised is highly context driven, with communication characteristics being indirect statements that are imprecise and non-binding for the communicating parties. Cultural differences based on the global region are also a key feature of the communication process.

As previously stated, there is a substantial difference between high-context communication cultures and low-context communication cultures. Low-context cultures include Germany, the United States and most central and northern European nations. High-context cultures include China, Japan and South Korea. A further characteristic where cultures highlight regional differences is power distance. Power distance refers to a culture's acceptance of hierarchies and authority (Tubbs & Moss, 2008:319–321).

The perceived masculinity or femininity in a culture refers to a culture's display of traditional male or female traits. Male cultural traits include the presentation and value of displaying achievements, financial wealth and individual assertiveness and fostering competition. Female cultural traits include a high regard for the natural environment, the building and maintenance of relationships and the care for elders. Cultures with a long-term focus tend to focus on future developments and accommodate the long-term developments in advance, whereas cultures with a short-term focus are said to place less value on preparing for the future than cultures with a long-term focus and put value primarily on the present and the past. Last, cultures that foster indulgence are often associated with hedonism, whereas cultures that value restraint often cherish work over any private or leisure activity by its members (Delgadová & Gullerová, 2017:571–572).

Figure 12: Hofstede's cultural dimensions



Source: Hofstede et al. (2010)

Regions of importance to this study are Germany, Slovakia, the USA and China. As displayed in the illustration above, regional differences in their cultures are identified.

Hofstede *et al.* (2010:57–60) rank these nations' cultural power distances as follows: Slovakia demonstrates the second highest power distance on Earth (only superseded by Malaysia). While still having a strong power distance, China displays a less hierarchical culture than Slovakia. The USA and Germany are both considered to display relatively low power distances.

The most collectivistic culture in this study is found in China, and the most individualistic culture is found in the USA. Germany and Slovakia are moderate, with both cultures displaying tendencies towards individualism (Hofstede *et al.*, 2010:94–97).

The culture with the most masculine traits is found in Slovakia. All the other cultures that are relevant to this study also display masculine traits. It is important to note that the difference in the scoring of Germany, China and the USA is negligible (Hofstede *et al.*, 2010:141–143).

Hofstede *et al.* (2010:141–143) state that, of the regions relevant to this study, Germany's culture is the most averse to uncertainty. China is the region with the highest societal acceptance of risk. The USA and Slovakia are balanced in their aversion to or acceptance of risk. Germany, Slovakia and China are amongst the nations that display the most dedicated focus on the long-term dimension of culture and values in their respective geographic regions, whereas the USA is highly short-term focused (Hofstede *et al.*, 2010:255–257).

The display of wealth and the acceptance of indulgence is most prevalent in the USA, whereas the approach to indulgence versus restraint in Germany displays a tendency towards restraint. The cultures of China and Slovakia are to be considered restrained (Hofstede *et al.*, 2010:282–285).

3.3 THE REMOTE WORKSPACE IN AN INDUSTRY 4.0 ENVIRONMENT

The introduction of the idea that employees may perform their work tasks from a setting other than the office is not novel to the time of the COVID-19 pandemic. The introduction of home office work using digital means dates back to the 1970s and 1980s. Remote work at that time was branded as Telework. It can be argued that since then, remote work using digital means has evolved over three technological generations (Messenger & Gschwind, 2016:195).

The first generation of Telework includes all the technology that was available to workers and employers that facilitated communication beyond the traditional limitations of the traditional office environment, such as the use of the early iterations of the internet and means such as telephone conferencing. One would associate this with the technologies that were pioneered in the late 1970s and the 1980s. The second generation of Telework was built on the technologies of the first generation, but it differentiated itself in a key aspect. Through the technological advancements of the 1990s and the early 2000s, employers and employees were provided with work tools and communication devices that were no longer prohibitive to travel. Thus, one can say that the second generation of workers outside of the office space is the first generation of truly mobile workers. Mobile communication devices, such as smartphones and laptops, have greatly improved the practicality of mobile work. A third generation of Telework was identified in the 2000s. The virtual office – the third generation of Telework – was shaped by the increasingly connected environments in which modern work is performed. Work devices such as laptops and smartphones shifted from being devices that store data and process information to communication devices that enable the user to remotely communicate and access the stored data and information. The office and a substantial percentage of its assets were no longer directly linked to physical devices but rather to cloud computing and internet connectivity (Messenger & Gschwind, 2016:195–201).

The remote or hybrid workspace largely focused on accommodating administration and knowledge workers in performing their tasks remotely. Ipsen, Veldhoven, Kirchener and Hansen (2021:2) highlight that the primary benefactors of the availability of home office work were knowledge workers. This is particularly the case in the timeframe that predates the

COVID-19 pandemic. Lopez-Leona, Forero and Ruiz-Díaz (2020:371) state that during the pandemic, the shift towards home office work was substantially accelerated.

The COVID-19 pandemic can be regarded as a once-in-a-lifetime event with repercussions that are not solely limited to a single industry, nation or society. Following the punctuated equilibrium theory, this event has created a period of great change and uncertainty (Schwab & Malleret, 2020:2). Further, the temporal conjunction with the early introduction of Industry 4.0 has substantially altered the manner in which organisations operate and how work can be performed.

3.3.1 <u>The remote workspace for knowledge workers</u>

From a knowledge worker's perspective, the ability to work from home using digital means is a necessity in times of mandated physical distancing. Irrespective of this, the ability to perform work tasks from locations other than those of the employer may be a desirable or undesirable aspect of the internal communication environment of a workplace.

Ipsen *et al.* (2021:8) highlight six distinct advantages and disadvantages to working outside of the traditional office setting: an improved approach to the work-life balance, work efficiency, work control and supervision, home office constraints (limited social interactions through work), work uncertainty and inadequate work tools at the home office.

In general, Ipsen *et al.* (2021:8) conclude that the majority of knowledge workers are content with home office work; however, a primary source of dismay is the lack of adequate equipment to perform work tasks at home.

From an industry perspective, a survey showed that up to 42% of US staff would consider resigning from their positions if no long-term possibility of a degree of home office work was offered by their employers. Further, an industry survey showed that during the COVID-19 pandemic, a substantial portion of the workforce started experiencing burnout symptoms. It is suggested that after the COVID-19 pandemic, a hybrid work environment is the most likely outcome as the decreased in-person interactions are limiting innovation within organisations (Flemming, 2021).

The forced transition towards remote work has shown that organisations need to adapt to changing operating environments. From an internal communication perspective, several aspects can be crucial: training and educating employees is possible using technologies to facilitate internal communication without substantially impacting the effectiveness of the training. Further, it is possible to manage employees remotely using modern technology. Communication is vital, whether at the office or the virtual office, for building relationships and employer branding. Internal communication is vital in making employees brand ambassadors. Finally, communication and the acceptance of changes towards the hybrid or virtual work environment are not only dependent on organisational culture but also on the age of the affected employee groups, as these factors affect the willingness to adapt to novel work manners and often influence the degree of information technology literacy (Vnoučková, 2020:19–21).

3.3.2 The remote workspace for shop floor workers

Industry research shows that in April, an excess of 60% of US employees worked in a home office setting. This is in the context of quarantine measures and the explicit limitation of physical proximity to others in the workplace It is argued that organisations are often content with home office work as it reduces their expenses (Immerman, 2021).

This raises the question of whether the use of Industry 4.0 technology could also enable the shop floor workforce to perform their work tasks in a remote office setting. Looking at the changing work environment that the introduction of Industry 4.0 creates for factory workers, one can state that there is a likelihood that in the future, the work tasks of the modern factory employees can be performed remotely. During 2021, a substantial portion of factory staff could not perform their production tasks remotely. This was in part due to the lack of remote manufacturing monitoring processes or capabilities. Even in some of the most advanced economies, such as the USA, fewer than half of the industries demonstrated such capabilities. According to Immerman (2021), the key elements that need to be present in an organisation to enable factory workers to work from a home office setting are:

- The ability to monitor the production remotely
- The ability of the manufacturing equipment to self-diagnose
- The ability to facilitate real-time communication between on-site and off-site staff

Looking at Industry 4.0 technology, several aspects explicitly facilitate such capabilities. Egger and Masooq (2020) link the use of augmented reality with the communication of off-site and on-site staff, as the use of the cyber elements fused with the physical reality of the production plant aid workers to collaboratively perform work tasks through the use of digital communication means, such as augmented reality.

The Internet of Things and the use of 5G networking are means to facilitate the transfer of data in real time, and the machine learning through the use of big data is a means that allows for machine self-diagnostics and remote monitoring (Atzori, Iera & Morabito, 2010; Koseleva & Ropaite, 2017:545; Yalçin, 2020). This further satisfies the aforementioned element of exchanging data in real time, the self-diagnostics of machinery and remote production monitoring.

In light of the increasingly vocal discussion on skills shortages in the industrial sectors and the increasing need for skills development, one needs to acknowledge that, while it is technically possible to perform certain production tasks from a home office setting, this blurs the distinction between the definition of a factory worker and that of a knowledge worker.

3.4 Employee Communication (Internal Communication)

When exploring any organisation, a crucial element is the role and effectiveness of internal communication. Mazzei (2010:221) states that internal communication is the exchange of communication within the limits of a single organisation between parties. The internal communication exchange is noted to hold an important role within organisations, as it serves as a relationship management role and functions as a means to build internal commitment to an organisation. Mbhele and de Beer (2021:154) note that the role of internal communication is central to an organisation's effectiveness and long-term sustainability. Internal communication is also crucial in ensuring that the staff of an organisation is engaged in the relevant organisation's endeavours. The explanation and the promotion of new programmes are amongst the key goals that are to be achieved through internal communication. In the context of the implementation of Industry 4.0, vigilant internal communication is a vital element that enables an efficient introduction of such new technologies. In addition to the aforementioned elements of internal communication, internal communication is important to inform employees of the organisation's financial performance and future financial goals. Last, Mbhele and de Beer (2021:157) highlight that effective internal communication aids employees in understanding the organisation's business. At the core of internal communication lies the communication process. This process facilitates the exchange of information and of meaning between parties and is described in the following section.

According to Gregory and Willis (2013:138), communication culture encompasses the use of various elements which are illustrated as follows.

Figure 13: Elements of communication culture

Source: Gregory & Willis (2013:138)

A key element in communicating at the workplace is the formality of the exchange. The choice of formal communication or informal communication is often associated with politeness. The selection of the appropriate degree of formality in communication is traditionally based on three core factors. The first consideration is the social distance between the interacting party. The second is the power difference between the parties that communicate, which is to be considered when selecting the formality of the communication exchange. The third factor that influences the degree of formality is the perceived imposition that the exchange represents to the communicating parties (Peterson, Hohensee & Xia, 2011:86).

Peterson *et al.* (2011:87–94) find that e-mail interactions are largely informal in a personal setting. In a business setting, the authors note that the vast majority of 78.3% of e-mails are formally worded. They further highlight that e-mails from employees that are four hierarchy levels lower than the addressee are formal in 84.4% of the cases, whereas mails between evenly ranked staff are only informal in 21.8% of the instances.

Organisational culture strongly influences the preference for using either formal or informal communication channels. Tenhiälä and Salvador (2018) argue that informality is ever-present in modern business organisations. This informality includes the use of first names in the business setting, informal dress regulation, employee self-organisation and hierarchies that are typically flatter than traditional models would suggest. Casual communication within organisations is a source of fast and flexible interaction.

However, this flexibility and fast-paced communication come at a cost. Informal communication may risk the dissemination of information that is not intended for certain staff members. In addition to this, informal communication may be a source of factors that compromise the quality, accuracy and completeness of messages sent through informal channels. The use of formal communication is seen by some employee groups as outdated and slow to achieve tangible results, and some may resist the introduction of formal communication protocols (Tenhiälä & Salvador, 2018).

While there is a trend that informal communication is increasingly utilised in modern business, there is still a need and a desire for some degree of formal face-to-face communication. However, particularly in an age of increased physical distancing and limited travel possibilities, there is a noticeable development towards the adaptation of home office, hybrid office and virtual work on a global scale.

Organisations have numerous possibilities to address their employees and engage these groups. Grunig and Hunt (1984:5) highlight four distinct eras of communication. While the Grunig and Hunt (1984) model is most often associated with public relations aimed at external (non-employee) audiences, it can be argued that the act of engaging audiences is also the act of internal communication, the main difference being the role of the message receiver in relation to the communicating organisation. Thus, such models may be used to highlight possible approaches for organisations to address their internal stakeholder (Zheng, 2009:11).

From a communication perspective, audiences often consist of stakeholders or stakeholder groups that can be approached in numerous fashions. These approaches vary dramatically in the manner in which the stakeholder is engaged and the information is exchanged, as well as based on the desired effect they have on the receiver of the messages (Falkheimer & Heide, 2018:38).

When following a publicity model approach to communicate with stakeholders or stakeholder groups, the main aim is to propagate the predetermined agenda of the propagating organisation. The communication process is characterised by a flow of information from the sender to the receiver, without any need or interest in receiving feedback. This type of one-way information dispersion is driven by the need to maximise the exposure to the message. The truthfulness of the content is not essential, as the desire to reach a predetermined goal eclipses moral and ethical consideration when engaging in this type of communication (Falkheimer & Heide, 2018:38). The use of purpose-driven one-way communication is associated with the advent of formal internal communications management in the 1940s (Zheng, 2009:11).

The information model is an approach to communication, whereby the main aim is defined as the dissemination of information in an efficient and timely manner. In an identical fashion to the publicity model, the information model engages with its audience (in this case with stakeholders and stakeholder groups) using one-way communication. There are, however, substantial deviations between the models in relation to ethics and morals. Whereas the publicity model ignores the importance of the truth when disseminating messages, the information model is characterised by a focus on the truthfulness of the content of these messages. The effect that this type of communication has on the relationship between an organisation and the stakeholders or stakeholder groups is that information is distributed while focusing solely on maximising the exposure to the message. Both the information and the publicity models aim to persuade the message receiver to varying degrees (Falkheimer & Heide, 2018:38).

With the dawn of the 1960s, internal communication in large organisations has shown developments towards a more feedback-enabling manner of internal communication (Zheng, 2009:11). The asymmetric two-way communication model is a strategic communication approach. It encompasses two-way communication, during which the control over the exchange of messages is held by the original message sender. This model of communication is in essence a blend of persuasion and adaptation. Unlike the above two communication models, the sender (in this case the organisation) investigates the effectiveness of the messages that were received by the stakeholder or stakeholder group. Of particular importance is that the feedback from the receiver is evaluated based on the messages sent and the channels used to communicate. While the receiver is limited in their communication to the initial sender, there is an exchange of messages that are at the core of this exchange (Falkheimer & Heide, 2018:38).

At the heart of the symmetric two-way communication lies the substitution of the sender and receiver understanding of communication by an understanding that the communication occurs between two equal parties. It follows that the organisation is a sender of messages and the receiver of the messages of the stakeholder and stakeholder group. Vice versa, the stakeholders and stakeholder groups are receivers of messages and senders of messages to the organisation. The parties regard each other as subjects of the exchange that add meaning and value to this exchange through their respective experiences. This is in stark opposition to the publicity and information models, in which one characterises the receiver as the object that is addressed through communication. In reference to internal communication, this is also known as the open era of communication (Falkheimer & Heide, 2018:38; Zheng, 2009:11).

As with many aspects of human interactions, the means and motivations of communication are rarely as distinct as the theory states. The mixed motive model accommodates for such occurrences. The initiation of the communication between the organisation and the stakeholder or stakeholder group is a difference in opinion or perception. The parties utilise communication in a symmetrical two-way manner to negotiate a possible mutually beneficial outcome, whereby both parties compromise to gain. This type of communication facilitates cooperation and diplomacy with the aim to enact a mutually beneficial change (Falkheimer & Heide, 2018:38).

3.5 Stakeholder Communication (External Communication)

3.5.1 Stakeholder identification

As previously stated in the discussion of stakeholder theory, it is vital to effectively identify and segment stakeholders to adequately communicate and manage their interests in light of the desired outcomes. While this segmentation presents itself as an achievable task in theory, in practice, there are substantial hurdles to the adequate identification of stakeholders in multi-stakeholder settings. Academics have developed several stakeholder identification and segmentation methods that will be highlighted in this section. This identification is particularly important as it forms the basis on which communication is tailored in situations where the introduction of change may need to use change communication by an organisation to ensure stakeholder cooperation and buy-in. Gregory, Atkins, Midget and Hodgson (2020:325) mention six principles when identifying stakeholders.

First, the group of stakeholders is identified; the number of stakeholders and the size of the group are dependent on the context in which the identification takes place (Gregory *et al.*, 2020:325).

Second and third, stakeholders are, as previously stated, not confined to a single role in a scenario. Therefore, it needs to be clear that conflicts of interest of certain persons and groups are possible as memberships in various stakeholder groups are not mutually exclusive. From a communication perspective, these stakeholder relationships need to be explored and highlighted when grouping stakeholders (Gregory *et al.*, 2020:325).

Similarly, the fourth principle states that stakeholders within a group do not necessarily share the same values and perspectives on topics. These differences and similarities can be explicit, but they should not overshadow the implicit or hidden differences and similarities when exploring and defining stakeholders (Gregory *et al.*, 2020:325).

According to the fifth principle, the roles of stakeholders are time and scenario sensitive; they may change over time and may result in changes in stakeholder alliances and demands. The knowledge of the context and history of stakeholder relationships is, therefore, important when basing decisions on identified stakeholder interests (Gregory *et al.*, 2020:325).

Last, one needs to recognise that the definition of a stakeholder group not only represents the grounds for the inclusion of members in a stakeholder group but is also the basis upon which members are excluded from certain but not all stakeholder groups (Gregory *et al.*, 2020:325).

3.5.1.1 Narrow and wide view towards stakeholder identification

A key distinction when identifying stakeholders can be made on grounds of what constitutes a stakeholder. The narrow approach to a stakeholder definition seeks to minimise the number of stakeholders of an organisation based on excluding non-direct influencers of the organisation. Within this understanding, authors differ in the restrictiveness of their definitions. Bowie (1988:99) states that stakeholders are solely those groups without whose direct support the business would not be able to continue its existence.

Wang, Liu and Mingers (2015:564) highlight that the often-popular approach to segmenting stakeholder groups by perceived importance represents a narrow view towards stakeholder identification. This identification is done by dividing known stakeholders into primary stakeholders that need to be addressed and secondary stakeholders who may be indirectly impacted by an organisation's actions but who do not interact with it directly and thus do not need to be addressed.

Primary stakeholders directly influence a business' operation or are directly affected by actions and are therefore prioritised when communicating. They are typically comprised of customers, employees, suppliers and public stakeholders. They constitute the relevant public entities and communities that directly affect the organisation and vice versa. Not all authors consider public stakeholders as part of the primary group; however, when defining primary stakeholders as the groups without whose support a business would not be able to sustain its operations, it is reasonable to argue that the supplier of critical infrastructure to an organisation (such as the government) and the suppliers of critical goods (such as the communities that make up the local labour pool) should be included as primary external stakeholders (Clarkson,1995:106). The internal stakeholders who are crucial for internal communication include managers, owners and non-management staff.

One can note that the narrow view of stakeholders should not be confused with a shareholder approach to segmenting interest groups that are to be address. This segmentation is not solely motivated by operational and immediate profitability motives, it also includes ethical considerations, such as sustainability and justice, that go beyond the short-term profitability of businesses (Wang *et al.*, 2015:564).

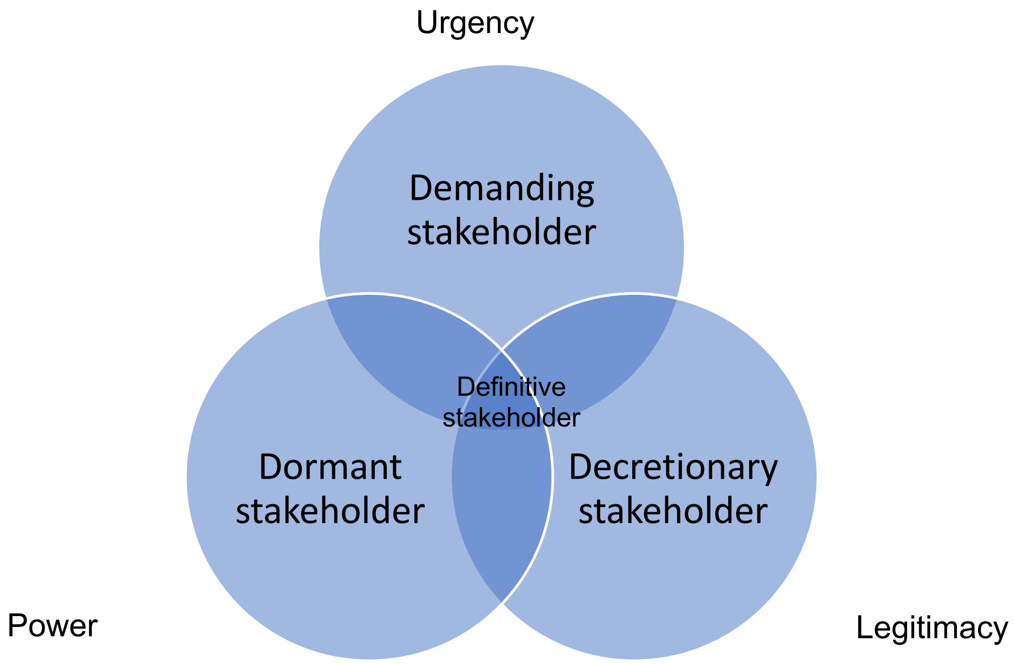
Stakeholder identification from a broad perspective identifies all groups that directly interact with an organisation and impact its sustainability. This is in line with the narrow view of stakeholders; the broad perspective goes further by including all groups that may potentially affect or be affected by the organisation. This exponentially expands the scope of relevant stakeholders to a project or an organisation (Gregory *et al.*, 2020:323).

Brauer (2018:798) highlights that community engagement is needed by all organisations with all potential stakeholders in an effort to follow a rigorous approach to stakeholder identification and engagement in order for the organisation’s actions to be considered legitimate. This is the broadest possible view on stakeholders, but whereas the argument is made that this broad engagement maximises inclusion and knowledge during a decision-making process, it can also be argued that this view is too broad from a practitioner’s perspective and that a broad approach needs to be limited by justifiable and pragmatic boundaries based on critical reflection (Gregory *et al.*, 2020:323–324).

3.5.1.2 Three-dimensional stakeholder evaluation

Cornelissen (2020:71) declares that the role and importance of certain distinct stakeholders can be determined using three dimensions. The importance and type of communication that the company and the respective stakeholder employee needs will be adapted according to the specific situation. The power a stakeholder holds over an organisation can be determined by the legitimacy and urgency of the stakeholder and their agenda. As a result, seven distinct types of stakeholders are identified.

Figure 14: Stakeholder salience model



Source: Cornelissen (2020:70)

Discretionary stakeholders hold substantial legitimacy to a claim or issue but lack the power and urgency to enforce them. Such stakeholders are often addressees of corporate philanthropy (should their needs be addressed). Demanding stakeholders are those that, while creating a sense of urgency, lack legitimacy and the power to enforce their demands; often, nuisance employees are such stakeholders and demonstrators with niche demands that fail to gain traction in a wider sense (Cornelissen, 2020:69).

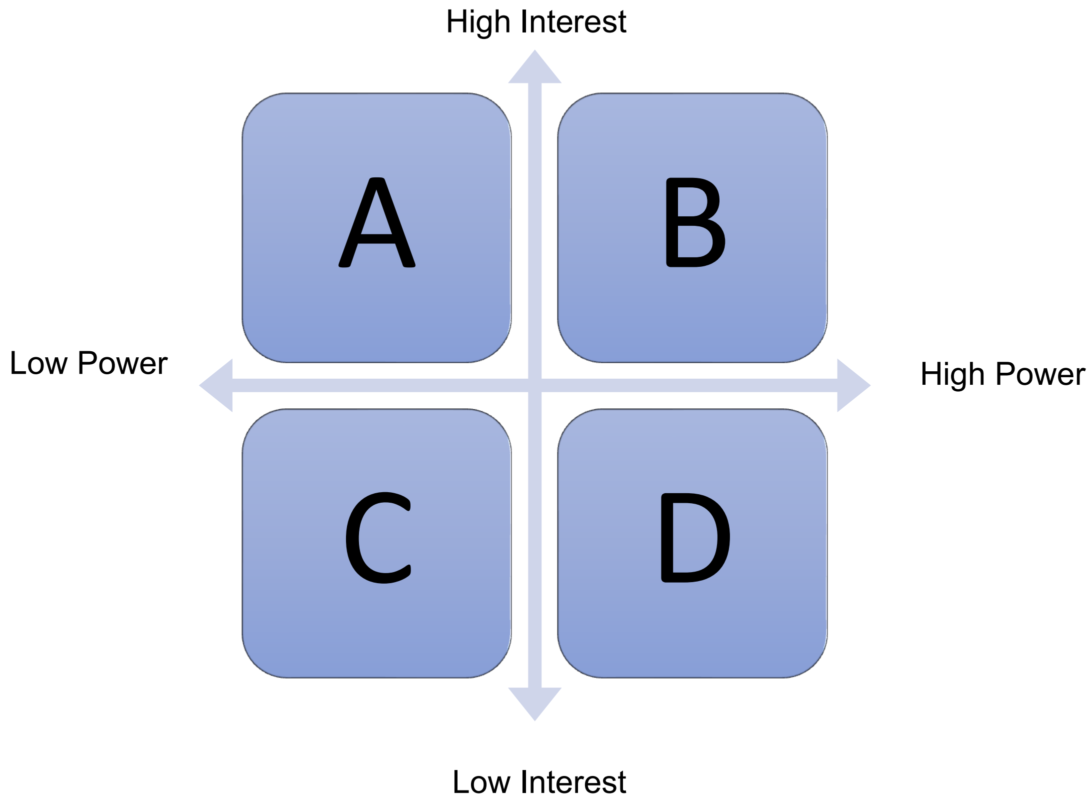
Stakeholders that hold two dimensions of power are often of high importance to organisations. Dormant stakeholders hold substantial power to influence organisations to cater to their demands; such stakeholders include financial investors and suppliers and certain kinds of employees that could withhold goods or services from the organisation. This would include a strike by employees, withdrawing their labour service. These stakeholders hold further power over the organisation as they have claims to legitimacy of their claims due to their explicit connection to the business. Dependent stakeholders may not hold power over an organisation's actions but will nonetheless need to be addressed due to the urgency and legitimacy of the raised claims. Such stakeholders will motivate other stakeholders that hold substantial or definitive power over the organisation and create coalitions for change to get their claims addressed, often through political or lobby representations. Dangerous stakeholders, while holding power and urgency claims, lack legitimacy, and failing to widen the claims to include stakeholders with legitimacy, they will resort to violence to coerce organisations to comply. Cases of violent attempts to coerce businesses to comply with claims include unsanctioned strikes and employee sabotage (Cornelissen, 2020:69).

Definitive stakeholders occupy a special position in stakeholder communication, as they hold legitimate power over the organisation due to their explicit contractual ties to the organisation's actions while holding financial power (often in form of a certain degree of ownership of the organisation). Once this group's claim is of urgent nature, it becomes of the highest priority to the organisation and communicators (Cornelissen, 2020:69–70).

3.5.2 Stakeholder engagement

Once the stakeholders with whom an organisation should communicate are identified, the degree and type of communication need to be established. Pandi-Perumal, Akhter, Zizi, Jean-Louis, Ramasubramanian, Freeman and Narasimhan (2015:6) suggest that all stakeholders should be mapped in a power-interest matrix in order to prioritise the engagement of certain stakeholders based on all the factors that were collected during the stakeholder identification process. The stakeholders' power and their interests are the basis on which an engagement plan can be formulated and implemented. Ideally, an organisation creates a stakeholder register that encompasses all stakeholders of all degrees of importance. Furthermore, it needs to be noted that the process of engaging stakeholders is dependent on human judgement, based on all available information.

Figure 15: Stakeholder Power-Interest matrix to guide engagement



Source: Adapted from Pandi-Perumal et al. (2015:6)

Stakeholders that are seen as having low interest in the organisation but high degree of power to influence its sustainability, highlighted as 'D' in the above figure, need to be kept informed by the organisation through communication. This communication can and often does take the form of one-way communication, otherwise known as the information communication model. This communication relies lightly on two-way communication and heavily focuses on spreading information from the organisation towards the stakeholders (Cornelissen, 2020:72). While these groups have the potential to substantially influence the course of an organisation, their situational low-interest in the organisation needs to be respected. Pandi-Perumal *et al.* (2015:6) also highlight that this type of stakeholders still needs to be engaged as it constitutes a valuable stakeholder group and needs to remain satisfied to avoid any unfavourable engagement. Ackermann and Eden (2011:183) refer to this group as the context setters as they can influence the future actions of the organisation; communicators should seek to increase the interest of these stakeholders without excessive resource allocation.

Quadrant ‘C’ represents the stakeholder group that has no power over the organisation and little interest in its sustained operations; it is a logical deduction that communication professionals may not actively need to engage this group and focus an organisation’s finite resources on other stakeholders. Pandi-Perumal *et al.* (2015:6) emphasise that the dedication of minimal efforts to engage this group does not imply a complete lack of effort as these groups need to be monitored to ensure an awareness of any changes to the established status quo. Ackermann and Eden (2011:183) refer to this stakeholder group as the crowd of potential stakeholders but argue that while engaging with this group is possible, it is economically unviable to do so.

Cornelissen (2020) and Pandi-Perumal *et al.* (2015:1–6) highlight that no approach or model is universal, as there is some degree of disagreement on the preferred method to engage with stakeholders that hold little power over an outcome but are invested to a degree where there is high interest in the success or failure of an organisation. This group of stakeholders is represented as quadrant ‘A’ in the above figure. Cornelissen (2020:71–74) argues that the stakeholders with little power but high interest in the sustainability of an organisation solely need to be kept informed by the organisation in an effort to ensure this group’s sustained commitment to the organisation. Such engagement can be regarded as unidirectional and may require few resources to be successfully implemented. The author argues that this would result in a positive word-of-mouth propagation of the organisation’s agenda. Pandi-Perumal *et al.* (2015:1–16) highlight that the key to engaging this group is not solely to inform them and that a positive word-of-mouth propagandisation of the organisation’s agenda is not given but is rather the result of the stakeholder engagement with the goal of ensuring that this group is satisfied with the organisation’s actions. Ackermann and Eden (2011:183) highlight that engaging with this group, referred to as the subjects, may result in the successful networking of these stakeholders, changing their relationships with the organisation. Communication practitioners are crucial to facilitate a shift in this relationship that is in the interest of the organisation, as there is also the potential to worsen the relationship between the organisation and the subjects. When engaging with any of the four types of stakeholders, a clear organisation within the business, which includes a holistic understanding of the issue at hand and coherent outward presentation, is of vital importance (Anastasi, 2018:192–195).

Stakeholders with high power over an organisation and high levels of interest in the sustained success of an organisation are clearly of the highest priority for communication practitioners. Cornelissen (2020:70) names these groups as key players in the success of any action made by an organisation. It is crucial to engage such groups proactively, as any negative reaction from them will endanger the sustainability of the organisation. The communication practitioner may not only engage in one-way communication, as the power and importance of the relationship between the stakeholder and the organisation warrant the use of symmetrical two-way communication. The role of the communication practitioner is to facilitate the constant exchange between the stakeholders and the organisation to remain informed about any reactions and positions of such invested and powerful stakeholders. The management needs to have a constant awareness of this group's stance on the actions of the organisation (Ackermann & Eden, 2011:183).

The process of engaging with stakeholder groups is highly dependent on the cause of the interaction between the stakeholders and an organisation. Anastasi (2018:66) distinguishes two types of engagements amongst the plethora of possible engagement methods.

First, there is the formal engagement of stakeholders; its purpose is to inform stakeholders of an organisation's envisioned aims and to seek the former's input on these aims. The open and consultative nature of such engagement, paired with the formal stetting and rigid processes, offers the organisation a decreased likelihood of having its aims challenged once implementation takes place, as all the involved parties had the opportunity for input and were offered a forum to put forward any concerns. While the consultations are held relatively publicly in a transparent manner, one needs to note that the analysis of the data that are gathered during the engagement does not need to be made in public. Furthermore, while respecting all inputs, it is unlikely that all the concerns of stakeholders can be addressed before the implementation of the proposed aims of the organisation. The data can thus be used to prepare for the resistance of stakeholders whose positions have not fully integrated into any proposed solution. The knowledge that is gained during the stakeholder engagement is the basis upon which any defensive actions are to be established (Anastasi, 2018:66–70).

Second, the organisations may engage the stakeholders in an informal process to engage with their audiences. These engagements are characterised as being proactively facilitated by an organisation with a focus on gaining insight and support from stakeholders on issues that are important to its sustainability. Unlike the formal stakeholder engagement, informal engagement is voluntary, and the willingness of stakeholders to engage is often limited. The communication practitioner may also experience increased difficulties to engage with external decisionmakers on the issues and gain support from internal decisionmakers. Opportunities for informal stakeholder engagements include meetings with external groups at conferences, celebrations or hospitality events or at external forums, such as seminars and round-table meetings. Communications such as briefings and in-person visits to sites of interest also offer the opportunity to engage with stakeholders in an informal setting. Trade associations also present opportunities to engage with stakeholders informally, particularly when the issue at hand spans organisations within their sectors (Anastasi, 2018:74–80).

3.5.3 Communicating change

When implementing new technologies in an organisation, a focus is often put on the managerial aspects that need to be performed to establish organisational alterations, but the practice has shown that the communication of these alterations is equally important in ensuring a successful implementation of new technologies. As a first step, possible methods of communication towards stakeholders need to be explored to select appropriate means to facilitate the implementation of the new technologies and the resultant changes within an organisation.

Johnson (2017) formulated a set of clear guidelines that can guide communication practitioners in the endeavour of implementing new technologies and facilitating the successful execution of the associated tasks. The importance of selecting the correct type of communication and audience engagement is highlighted by a 2013 study of 276 international companies that found that only 25% of all change management initiatives are found to be successful. An overwhelming 87% majority of managers receive change management training, but only 22% consider this to be effective. Particularly, the steep divergence in the understanding of reasons to implement changes in an organisation should be considered an opportunity for communication professionals. Research has shown that 67% of senior managers understand the reasoning behind the implementation of change, while 53% of middle management follows the reasoning behind the implementation of change initiatives, and only 40% of line supervisors understand the meso-level and macro-level reasons for the implementation of change. The latter group is the crucial link between management and factory staff in the implementation of Industry 4.0 technologies in factories and the front-line management workers that are approached with grievances associated with the implementation of changes (Lipman, 2013).

Johnson (2017) highlights that organisational leadership is needed to ensure the successful implementation of organisational change and the backbone of this leadership is clear communication. Formulating what management expects to achieve when implementing new technologies or any other change seems to be an obvious guideline to follow, but there is substantial complexity in ensuring clear communication and ensuring appropriate messaging to all audiences that are involved or affected in the implementation process. The key to ensuring buy-in is to engage in constructive exchanges where senior management gives insights into the reasoning behind the implementation of change to mid-level and even junior-level management rather than dictating outcomes without any clear background information. This background information includes the reason for senior management's decision to engage in the implementation of change, the full extent that this implementation entails, the targets of the change and the link of this decision to greater strategic goals.

Communication entails more than the written or the spoken word to ensure the institutionalisation of change. Leading by example is regarded as a vital means of communicating desired outcomes. Particularly in the modern business environment, it needs to be highlighted that leading by example is an effective means of communication because management taking the time to embrace the changes highlights the importance of executing the tasks at hand. Time is a finite good, and therefore management taking their valuable time to live the change is a clear signal to the entire organisation. It is reasonable to argue that it is the role of the communicator to ensure that management follows through on this crucial means of implementing new technologies and all associated changes. Further, the implementation of new technologies and organisational changes require resources, and it needs to be ensured that the resource reallocation matches the communicated actions and desired outcomes (Johnson, 2017).

3.6 STAKEHOLDER TRANSITION AND INDUSTRY 4.0

3.6.1 Occupations exposed to changes due to Industry 4.0

The fourth industrial revolution does not occur in a vacuum and is further augmented by fast-paced globalisation. Manufacturing has seen relocation globally, and wage structures have adapted to economic conditions. The US exemplified this trend during the financial troubles of the late 2000s; approximately 8.8 million jobs were lost from 2008 to 2010. While re-establishing employment opportunities, of the 3.6 million high-wage industry jobs, only 2.6 million were re-established from 2010 to 2014. Mid-wage industries have seen a net loss of over 900 thousand jobs. The largest shift in employment has been seen in lower-wage industries, where a total of nearly 2 million jobs were lost, but 3.8 million new opportunities were created. This highlights a slow shift away from high-paying industries towards lower-income employment. This trend is predicted to change, as the paramount shift that the implementation of Industry 4.0 will have on the labour market will differ substantially from historic trends, even though predicted negative impacts of technologies on employment goes back to David Ricardo in the 18th century and, more recently, John Keynes (van Dam 2017:17).

Previously, industrial revolutions have seen a migration of labour from agricultural jobs towards industrial jobs and then towards services; the fourth industrial revolution will differ in this aspect. Bonciu (2017:11) states that labour in the fourth industrial revolution will be affected differently. He argues that there is little opportunity for low-income employees as new opportunities will be limited to highly trained individuals. This type of education is not available to all members of society and is not needed by organisations in large quantities.

Estimates that have been formulated before the outbreak of the COVID-19 pandemic state that up to two-thirds of low to medium-skilled jobs will be affected by Industry 4.0 in developing nations. In developed nations, such as the US, estimates are that 80 million jobs will be affected by automation through Industry 4.0 in a timeframe of 20 years. Jobs lost as a result of this shift face the limited possibility of substitution through other vacancies (Bonciu, 2017:13).

Post-COVID-19 industry reports suggest that the pandemic has changed the equilibrium in society and business to a degree where the pace of digitalisation of the workplace has increased dramatically. Nations such as the US, China and Germany have seen substantial investment in the workplace that enables workers to work remotely or automated tasks to a degree where no human worker is needed (Lund, Madgavkar, Manyika, Smit, Ellingrud & Robinson, 2021).

While not all manufacturing organisations are or will introduce Industry 4.0 technology in the foreseeable future, there is a clear trend towards increased Industry 4.0 utilisation in manufacturing organisations.

Spöttl (2017) argues the prevalence of three trends concerning the introduction of Industry 4.0 and the effect on stakeholders (particularly the workforce). Organisations that choose not to introduce Industry 4.0 technology will experience little direct change and will therefore need to communicate little change to their workforce directly. These organisations do, however, need to account for the introduction of Industry 4.0 through indirect channels and therefore need to address the technology at some point in time. Organisations that introduce Industry 4.0 technologies in their manufacturing processes with little depth are to be expected to require more skilled employees, but this transition is rather stagnant. The full introduction of Industry 4.0 technologies will greatly impact the workforce of manufacturing entities. Spöttl (2017) states that such organisations need to account for an increased intake of skilled workers, such as master craftsmen and engineers, while substantially reducing the less-skilled and semi-skilled workforce.

Manyika, Lund, Chui, Bughin, Woetzel, Batra, Ko and Sanghvi (2017a) report that in the timespan from 2017 to 2030, the demand for workers that perform predictable and repetitive tasks will be reduced greatly in several key regions. In Germany, the demand for such staff will shrink by 21%, whereas the demand in the US will be reduced by 31%.

China is expected to experience substantially less decrease in demand for such occupations, as it is expected to shrink by only 4%. The demand for production workers in the US will be reduced by up to 34% and in Germany by more than 15%. Little change is expected in China. The demand for general manufacturing mechanics and machine operators will also fall significantly in the US and Germany, whereas little change is expected in China. Increasingly important stakeholders in a manufacturing organisation will be computer scientists and engineers. The demand for these professionals is expected to increase dramatically (Manyika, Lund, Chui, Bughin, Woetzel, Batra, Ko & Sanghvi*,* 2017b).

3.6.2 Changing supply-chains

The global nature of Industry 4.0 and cyber-physical systems enable machinery to communicate beyond physical barriers, as previously discussed. Industry 4.0 goes even beyond this by surpassing organisational constraints. This may aid in the evolution of businesses from isolated entities within a value chain to highly interlinked coalitions of devices and organisations that enable real-time co-scheduling of production activities and increased flexibility amongst production partners. The increased (selective) transparency of production will enable customers to increase their involvement in the production and design process without being physically embedded in the supplier's business. The interlinking of machinery across supply chains, recharacterized as supply networks, enables the harvesting of large amounts of data that will augment product knowledge (Colombo *et al.*, 2017:6–16). Smart supply chains are increasingly integrative through communication and data exchange beyond the scope of a traditional supply chain. Thus, it can be argued that the supply chain is increasingly transitioning into a supply network (Frank, Dalenogare & Ayala, 2019:16).

The extracting and storing of all relevant data will increase the autonomous traceability of an item's production process. Further, this wealth of knowledge on the item and its production process enables businesses to backtrack possible future product failures and address future product corrections with minimal human input. These smart factories, along with smart products, enable producers to shift from a mass production system toward customised mass production, offering economies of scale while increasing the customisability of products to customer needs (Vaidya, Ambad & Bhosle, 2018:236).

The integration of supply chains and the increased exposure of organisations in such supply chains will result in the increased specialisation of manufacturing organisations. Such specialisation and the increasing cooperation and exchange within supply chains will alter the role of the worker as data across supply chains is becoming available through the use of Industry 4.0 technologies (Frank *et al.,* 2019:17). These changes in work tools and the associated changes in responsibilities of factory workers are addressed in the following section.

3.6.3 Change in the scope of worker responsibility and novel work tools

The typical responsibilities of manufacturing staff in a non-Industry 4.0 manufacturing facility encompass activities such as machine operation, the physical supervision of machines to detect malfunctions and the repair of these machines. A further task of the manufacturing staff also includes the servicing of machines. The introduction of Industry 4.0 has changed the role of the modern worker. The modern worker is tasked with the remote supervision of multiple machines and the interpretation of data that the machines gather autonomously. A significant change in the tasks of the shop floor worker is that the labour process is becoming increasingly software-based and that the physical act of performing work tasks is less the focus of the majority of work tasks. This realisation leads to two conclusions. First, the degree of education needs to increase as Industry 4.0 is introduced, and second, these workers will have increased work responsibilities through the use of novel work tools (Spöttl, 2017).

Further, through the use of technologies such as augmented reality, there is the possibility of workers expanding their field of responsibilities even beyond a single organisation. Other key technologies are the internet of things, cobots and autonomous machines that create cyber-physical systems. These ever-increasingly interconnected networks enable remote workers to perform work tasks beyond the limitations of a single organisation. This would greatly expand their responsibility in the workplace (Sundmaeker *et al.*, 2010:44; Pereira & Romero, 2017:1208–1211; Bortolini *et al.*, 2017:5703).

3.6.3.1 Changes in the degree of collaboration and independent work

As stated above, the modern worker will experience an increased scope of responsibility and novel work tools. It is reasonable to conclude that these tools can foster the workforce to apply themselves in two very distinct manners. First, the use of Industry 4.0 technologies can be an enabling tool for workers to perform their work tasks with greater independence from others.

Looking at the use of augmented reality tools, their use can be regarded as fostering independent work and fostering worker collaboration in a novel manner. At its core, augmented reality devices are a communication tool. Egger and Masooq (2020) state that the primary application of augmented reality devices is the overlaying of cyber reality and physical reality. The main application of this is in the maintenance and assembly processes in a factory setting. Thusly, this device enables the worker to work with a higher degree of independence from others as the device empowers him to perform maintenance tasks with the aid of virtual reality tools instead of human assistance. In a contrasting setting, virtual reality in the assembly process can be utilised to aid the collaboration of humans across the globe to address a task without having to be in physical proximity to each other.

The application of big data is a further source of worker empowerment, as the digital nature of data greatly increases the transparency of the data and widens the insights that workers could potentially garner from their work tasks.

A specific technology that exemplifies the increased scope of workers' responsibility and the increased ability of workers to work individually is the use of the TicketManager technology, developed by Bosch. The TicketManager is a tool that enables a worker to supervise a multitude of machinery through the use of a digital communication interface instead of having to be deployed to supervise a single machine. This device provides the worker with alerts of machine errors and guides the worker through troubleshooting and maintenance processes. The guidance of the worker is based on the use of big data and machine learning to allow for the device to action pre-emptive measures by the worker. The data provided by the machinery and the data gained through the supervision of human work also enable the device to appoint the most suitably qualified worker to perform a task without the worker requiring any human assistance to perform the task (Robert Bosch Manufacturing Solutions, 2018).

3.7 STAKEHOLDER RESISTANCE

The introduction of Industry 4.0 is and will substantially change the work conditions of the manufacturing workforce. As with any change, this introduction of technology is the cause of uncertainty and reservations in the workforce. Building on this, resistance to the introduction of Industry 4.0 is not solely a factor that increases the cost of implementing Industry 4.0 technology but also a factor which may serve as a deterrent to organisations implementing Industry 4.0. In severe scenarios, the mere expectation of resistance to the change towards Industry 4.0 production technologies from the labour force can be a deterrent to organisations considering such a step (Herceg, Kuč, Mijušković & Herceg, 2020:14; Nagy, Oláh, Erdei, Máté & Popp, 2018:25).

Kiel, Müller, Arnold and Voigt (2018:17) echo the sentiment that without sufficient employee knowledge of the implications of the novel technologies, resistance is very likely. They argue that internal communication is a means to address such resistance to the introduction of Industry 4.0. Through internal communication, interdepartmental communication fosters cross-departmental collaboration. It is one of the core responsibilities of leadership to create an environment that fosters trust through an open and unambiguous vision for the organisation’s future and the role of the staff. Nonetheless, change is accompanied by a multitude of emotions that the implementing organisation needs to be cognisant of and address suitably.

3.7.1 Emotion during stakeholder engagement

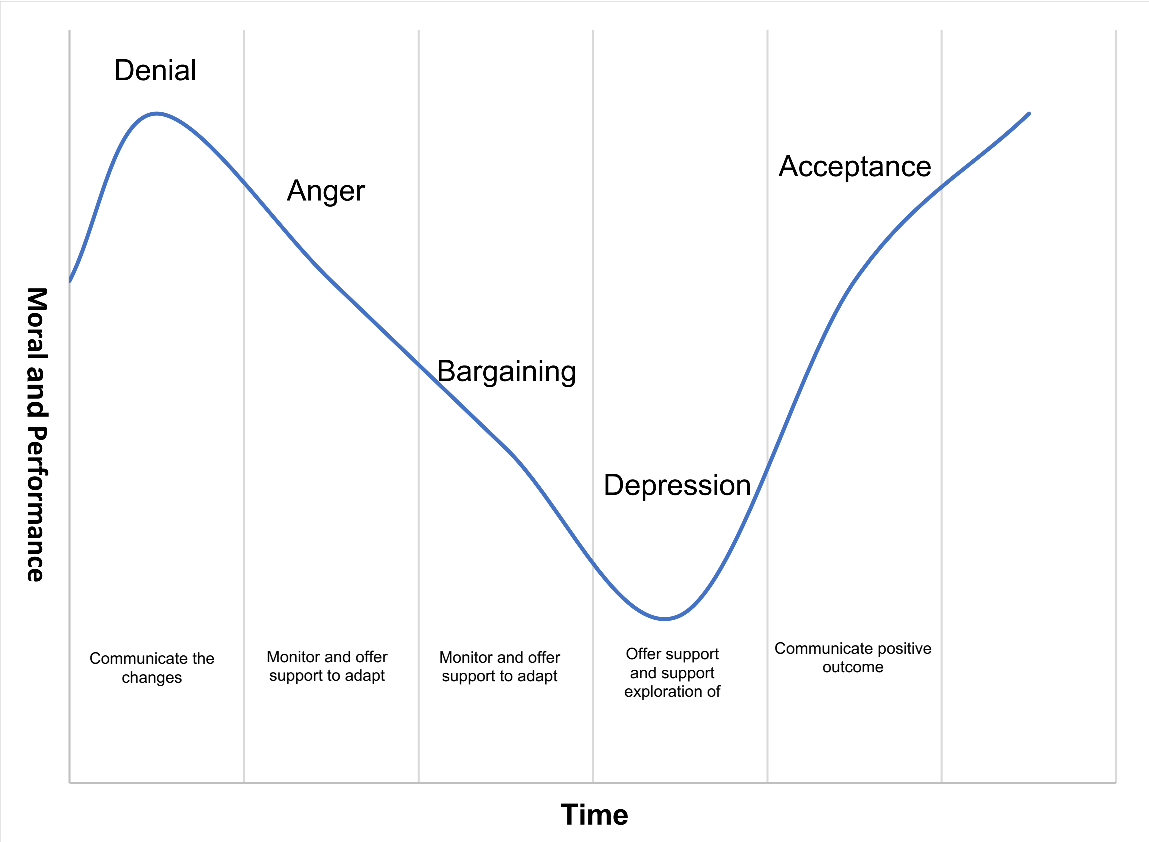
As much as stakeholder and change communication are processes that have a rich variety of literature that usually approach these topics from an organisational perspective, the reality is that these organisations are an amalgamation of groups of people. It lies in human nature that change or engagement involves emotion. For organisations to engage successfully with stakeholders, it is of vital importance that the communication practitioners are aware of the emotions involved in the proposed alterations for the stakeholders.

It is important to stress that stakeholders’ mood affects their critical thinking and that human thoughts and emotions are closely linked. The engagement of stakeholders needs to therefore facilitate the emotions of all involved parties and maximise the utility of the emotions for the desired outcome. The communication practitioner must accurately gauge the emotions of all stakeholders in advance of any interactions between the organisation and stakeholders, in addition to actively managing the emotions of all parties involved during the engagement of stakeholders (Ludovino, 2016:15–23). Concerning the introduction of Industry 4.0 technologies to ensure organisational sustainability, one can argue that the engagement of stakeholders concerning the implementation of this technology needs to go beyond mere stakeholder engagement, as the introduction of Industry 4.0 technologies also represents a change for stakeholders in a multitude of dimensions. This is where the activity of stakeholder engagement needs to include the emotional dimensions of change communication to successfully aid the implementation processes that ensure an organisation's sustained existence.

The emotions that are associated with change are most notably explored and described in the seminal work of Elisabeth Kübler-Ross. A person typically goes through five distinct stages in processing changes to an established status quo. Such varied emotional experiences of stakeholders who experience change are not addressed by organisations' senior leadership, and a sole focus on implementing new technologies may be counter-productive. Research has shown that a singular focus on quantifiable metrics results in reduced productivity and increased direct and indirect costs, that ultimately lead to lower stakeholder value generation. When engaging with stakeholders, particularly internal stakeholders, the impact on the organisation's morale, productivity and stakeholder satisfaction needs to be managed through stakeholder engagement with emotional awareness (Castillo, Fernandez & Sallan, 2018:472).

The first step when processing change is denial and isolation. During this phase, stakeholders often seek isolation and do not acknowledge the change that the implementation will have as a consequence. Denial is followed by anger at the situation, which leads to internal bargaining to cope with the seemingly overwhelming situation. Further, Kübler-Ross (1969) states that internal emotional bargaining leads to a phase of emotional depression that leads to a degree of acceptance and hope.

Figure 16: Stakeholder engagement and emotional stages of acceptance



Source: Adapted from Kübler-Ross (1969); Austin (2015:6); Saboe (2018)

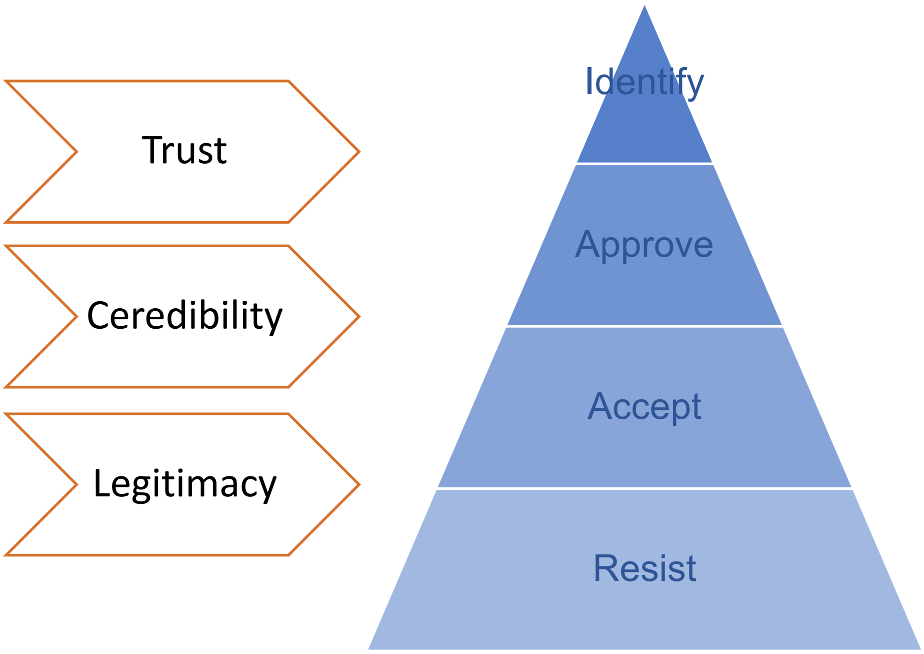
3.7.2 License to operate

A further key issue when discussing the role of stakeholders and sustainable business conduct is the understanding of an organisation's 'social license to operate'. Through a 'license to operate', organisations legitimise their actions and thus ensure sustainable operations in the long-term (Gehman *et al*., 2017:301).

Successful initiatives and proposed changes are substantially aided by stakeholder buy-in. The perceived legitimacy of an organisation and its proposal are often key factors that determine the implementation of change. Stakeholder resistance often jeopardises projects and causes unpredictable costs, whereas stakeholder acceptance and the resulting legitimacy can form the base of fruitful cooperation (Gehman *et al*., 2017:294–296).

The credibility of an initiative is gained by transforming simple stakeholder acceptance into support of (opinion) leaders within the stakeholder groups and the formal agreement between an organisation's representatives and these stakeholder representatives. A true license to operate is established once stakeholders begin to identify themselves with the organisation's project, and a sense of co-ownership of the proposed change is created (Gehman *et al*., 2017:294–296). This progression is illustrated in the figure of the Gehman *et al.* (2017:296) adaptation of Boutilier and Thompson's pyramid model.

Figure 17: Pyramid Model



Source: Gehman et al. (2017:296)

From a communication perspective, the evolution from change resistance to spiritual co-ownership of a project can be aided through several means. As part of an informational strategy, awareness of the proposal is created through initial one-way communication. Publication of an organisation's intentions may be communicated on web pages, through newsletters, formal reports and memos. The approach to communication is highly dependent on the type of stakeholder that is addressed (Cornelissen, 2020:72). Such use of one-way communication is informative but is characterised by a lack of persuasive elements needed to foster understanding and acceptance amongst stakeholder groups. Following Cornelissen's (2020:72) stakeholder communication model, open dialogue with stakeholders in a persuasive manner is a vehicle that leads to stakeholder awareness. Persuasive strategies, such as open meetings and discussions, are intended to create stakeholder understanding from the perspective of the organisation. Once opinion leaders buy into the proposed change, they may be involved in the implementation process through a dialogue strategy. Such communication engagements arguably lead to greater community commitment compared to a passive approach to stakeholder engagement in the quest for a 'license to operate' (Cornelissen, 2020:73).

Literature focuses on the social license to operate while differentiating between organisations and stakeholders; it is important to note that members of organisations that wish to obtain a social license to operate cannot be excluded from stakeholder groups. Gregory *et al.* (2020:325) highlight that stakeholder group membership does not imply that membership in a group is mutually exclusive with all other stakeholder groups. Therefore, it is possible that internal stakeholders of an organisation, such as employees, are simultaneous members of external stakeholder groups. It is therefore of high importance to not simplify the communication implications in obtaining a social license to operate, employees can form a part of various stakeholder groups, and it follows that internal communications and external communication can influence an organisation's social licence to operate. Particularly an organisation's internal conduct and communication may have an influence on its external perception by some stakeholder groups. The membership of a single person in several stakeholder groups does not only imply that this individual serves in several roles within the organisation, but it is reasonable that an individual may have more than a singular attitude to the organisation and its agenda.

As previously stated, stakeholders have a substantial influence on an organisation's sustainability and ability to operate. Industry 4.0 represents an internal change in organisations, but its implications are wide-reaching and far beyond the confines of a single organisation. Freeman *et al*. (2018:9–13) highlight the holistic nature of stakeholder theory and the social license to operate; it is, therefore, crucial to carefully segment stakeholder positions to address these in a holistic approach.

Forms of consequences of failing to achieve a social license to operate can include internal resistance to proposed endeavours. Employees hold the power to withdraw their labour in severe cases of resistance towards a change. Further, conflicts over a social license to operate can lead internal stakeholders to resort to drastic measures that include sabotage (Cornelissen, 2020:70).

3.8 STAKEHOLDER CAPITALISM

In an increasingly fast-paced world, change is inevitable, and the competition of the various political and economic approaches in society has greatly evolved since the advent of the first industrial revolution. Schwab (2021:171–173) argues that the world has reached a point where economic and social models are on the cusp of further change. The notion of a stakeholder-centric capitalist system is not novel to Schwab but can be credited to placing it into the public domain in recent years through the World Economic Forum and the proposition of a new Davos manifesto (Tyson & Mendonca, 2020).

Sundheim and Starr (2020) agree that stakeholder capitalism is seeing a renascence in modern business with an ever-greater focus on long-term sustainability. They argue that the increased focus on the shareholder has reached its apex during the beginning of the 21st century. The authors argue that this can be regarded as the advent of a trend toward community-focused capitalism, similar to the US capitalism of the 1950s and 1960s.

Stakeholder capitalism is, in essence, the application of stakeholder theory principles in the context of a capitalist society. This is done to address the shortcomings of the past drivers of economic growth, shareholder capitalism – common in western nations – and state capitalism – pioneered by mainland China (Schwab, 2021:171).

It is argued that in scenarios where the bulk of an economy is privately owned, business holds special importance in ensuring the sustainability of its operations and sustaining social and environmental sustainability through its operations. Thusly, a focus is placed on the stakeholder of each business enterprise to which it needs to cater to ensure global sustainability. Schwab (2021:179) highlights that this arrangement places social and environmental interests at the centre of business operations. He highlights four crucial stakeholders in the stakeholder-capitalist system that hold particular importance in maximising social and environmental prosperity: governments, civil society, businesses and transnational organisations.

Considering that a drive for profitability and financial sustainability is a given in a capitalist system, Schwab describes a practical approach to measure operations and business conduct in the quadruple context environment in a globalised world. Schwab (2021:186) highlights that as a result of increased globalised business and the growing ability for work to be performed remotely, it has become more difficult to ensure the participation of stakeholders (particularly employees) using traditional means. This will lead to a change in the way organisations' performance and national value creation will be formulated.

3.8.1 Measuring stakeholder capitalism

As previously discussed, there are numerous links between the quadruple bottom line, the introduction of Industry 4.0 and the associated expected social, environmental and economic shifts. Moynihan and Schwab (2020:6) argue that corporate actions are to be evaluated based on the four pillars of people, planet prosperity and governance. This closely echoes the quadruple bottom line.

The 'governance' pillar is composed of metrics that include the setting of an organisational purpose and the governance body composition; this includes the adequate representation of underrepresented groups and stakeholders. In addition, stakeholder engagement, ethical conduct safeguards and risk oversight augment the governance pillar by ensuring that organisations base decisions on substance knowledge and avoid corrupt business conduct (Moynihan & Schwab, 2020:21).

The 'planet' pillar is composed of metrics that include the evaluation of the organisations on the core themes of climate change, nature loss and freshwater availability. These metrics are augmented by the inclusion of measurement mechanisms that account for the organisational impact on air and water pollution, the creation of solid waste (with a special focus on single-use plastics) and resource circularity, which aims to gauge the efficiency of resources used during production (Moynihan & Schwab, 2020:25).

The 'people' pillar is composed of metrics that include the evaluation of the organisations on the core themes of dignity and equality, human well-being and skills for the future. Dignity and inclusion metrics include workforce diversity factors, such as age, gender and ethnicity. Furthermore, pay equality, wage levels and risk factors that may lead to child or forced labour by the organisation or its suppliers are factors that are included in the dignity and equality measurements. Skills for the future is a measurement of organisations' training of employees that ensures employees' skills meet the current and future demands of the labour market (Moynihan & Schwab, 2020:32).

The 'prosperity' pillar is composed of metrics that include the evaluation of the organisations on the core themes of employment and wealth creation, product innovation and organisational contribution to communities. This matrix diverges from the typical financial measuring of organisational performance in the quadruple context environment, as it takes a wide and more inclusive approach to the evaluation of financial sustainability (Moynihan & Schwab, 2020:37).

'Prosperity' is composed of organisations' total number of employees in the context of regional settings, organisations' economic contributions directly to society and capital expenditure. In addition to these factors, organisations' research and development expenditure and the payment of taxes contribute to social prosperity (Moynihan & Schwab, 2020:74).

3.8.2 Stakeholder trust

Businesses are centres of power and entities that impact society and the environment during their operations. State-centric economies, where business conduct is largely regulated and defined by state entities, are an increasingly popular form of the capitalist system. The state, while allowing private property ownership, holds strong control over all private actors. It does so through the control and distribution of all resources and opportunities to private entities. The state also holds a strong position in the economy that enables it to regulate and intervene in industries that are deemed to be of strategic importance. A further lever that governments of state-controlled economies hold is the means to influence economic development by allocating resources to support infrastructure and support projects without large-scale stakeholder consultation. Thusly, trust in private enterprises is not necessarily needed to initiate change or economic/social development. Similarly, following the shareholder approach, the trust of stakeholders is not a focus of private businesses. The focus is purely on maximising shareholder value by any means (Schwab, 2021:172).

In contrast to this, stakeholder capitalism is a consensus-driven approach to business operations and requires buy-in from stakeholders to ensure sustainable operations that also maximise value for the relevant stakeholders. From a macro perspective, actions such as ensuring stakeholder buy-in are focused on building trust towards the business's actions in the quadruple context environment. Covey (2008:24) states that trust is the core issue that any entity needs to consider in its actions, as trust impacts all aspects of operations all the time. Trust is a key element of societies that can act as an enabler, but a lack of trust can also become a liability to an organisation's actions and long-term sustainability. A key indicator of social trust towards large entities is the Edelman Trust Barometer.

The Edelman Trust Barometer classifies trust in institutions on a scale from 0 to 100. All values including 49 and below are considered to be an indication of distrust. Neutral attitudes towards institutions are represented by all values between 50 and 59. The values including and above 60 are a sign of a trusting attitude towards institutions. The scale distinguishes between the informed public (15% of the global population) and the mass population. The 2018 report highlights that the global general public trusts media and government the least, scoring 43, whereas the informed public trusts these institutions, while only scoring 53 points. Private institutions and non-governmental institutions are tied with a score of 64 by the informed public. The general public trusts non-governmental institutions marginally more than private businesses, scoring 52 and 53, respectively (Ries, Bersoff, Adkins, Armstrong & Bruening, 2018).

The public of the United States is considered to be generally distrusting in 2018. The informed public averaged a score of 45 and the general public 43. This is in stark contrast to China, whose informed public scored 83 and the general population scored 74. China's public particularly holds faith in government, with a score of 89 and 87, respectively. The German public has shown to be rather distrusting in 2018. Germans distrusted non-governmental institutions the most (scoring 37) and distrusted government the least (scoring 43) (Ries *et al.,* 2018).

In 2021, the globally most trusted group of institutions are private businesses, scoring 61 out of 100, whereas the least trusted institution is the media, scoring 50 out of 100. Globally (excluding China, Russia and Thailand) government is seen as a dividing force in society by 48% of respondents; this is in contrast to businesses which are seen as a unifying force by

45% of respondents. Government is no longer seen as an enabler of social development by the majority of respondents, unlike private businesses, which are regarded as being able to execute plans successfully. While businesses are amongst the least distrusted institutions, a topic that is often closely associated with the fourth industrial revolution and Industry 4.0 is the fear of joblessness. During 2021, 85% of respondents named joblessness as a primary fear, outranking climate change and prejudice. This is a vital insight when approaching Industry 4.0 in a stakeholder-centric economy, in which stakeholder support is a vital element in sustainability. Trust in institutions is substantially lower in democracies. A total of 46% of the German general population and 43% of the US general population trust institutions; this is in contrast to 83% of the general global population that holds trust in institutions.

Schwab (2021:171–173) argues that stakeholder capitalism is an economic setup that may displace the state-centric and the shareholder-centric economy. Such an observation is underscored by the 2022 Edelman Trust Barometer, which highlights that 52% of respondents of 27 nations regard the current capitalist system as primarily causing harm to society and nature. The 2022 Edelman Trust Barometer further highlights that 33% of respondents consider centrally managed economies as superior to free-market economies. The considerable distrust in the democratic and authoritarian systems lends further credibility that stakeholder capitalism may be a system in which a larger number of businesses will need to navigate in future.

Employees, an important stakeholder group, expect leaders of businesses to inform and lead the conversation on economic matters and employment in the region. Further, a leading role of CEOs is seen in the introduction of new technologies, wage inequality and climate change. In the context of ever-evolving globalisation, trust in leaders and peers is increasingly localised. This offers an indication that leadership of change in organisations is to be championed locally, rather than relying on external leadership for change (Ries, Bersoff, Adkins, Armstrong, Bruening, Fox & Ritzman, 2022).

3.9 CONCLUSION

As concluding remarks to this chapter, one needs to note that communication is a pivotal element in the understanding of this study, the approach to the introduction of Industry 4.0 and its implications for workers and society. Particularly the modern understanding of the position of stakeholders and the increasing propagation of stakeholder capitalism informs this exploration of employee perceptions of the introduction of Industry 4.0. In the next chapter, sustainability is addressed from a communication perspective. As discussed in the preceding chapters, the introduction of Industry 4.0 can and is shaped by communication management. In addition to this, Industry 4.0 is changing the ability of persons and machines to communicate in future.

Cognisant of such factors that inform the academic understanding of the introduction of Industry 4.0, it is necessary to include literature that highlights the broad practical and academic implications of the introduction of Industry 4.0 in the previously discussed regional settings. This is addressed in the following chapter by a thorough discussion of relevant literature centred on sustainability with a focus on the implications on communication and the introduction of Industry 4.0.

CHAPTER 4

4 SUSTAINABILITY IN AN INDUSTRY 4.0 ENVIRONMENT

4.1 INTRODUCTION

Several constituent technologies of the fourth industrial revolution, such as the mobile internet, still hold the potential to connect the remaining 4.2 billion persons without internet access, which would enable one billion worker interactions and account for 40% of the global workforce. Digital assistance applications aid 1.1 billion smartphone users and over 230 million knowledge workers. The internet of things offers connectivity to over one billion manufacturing, healthcare and mining devices and 100 million machine-to-machine connections. Advancements in robotics technology affect 320 million manufacturing occupations; this is 12% of the global workforce. These workers are equally affected by advancements in three-dimensional (3D) printing. Advancements in renewable energy and reduction in CO_2 emissions can impact the current 13 billion tons of CO_2 emissions that result from power generation (van Dam, 2017:12).

A critical element when discussing change, particularly change of global proportions, is the future of employment and the resulting impact on society. Exploring this element, several questions arise. So far, the previous industrial revolutions have changed society but at its core were limited to a predictable change in labour practices and labour opportunities. Historically, the focus of human labour has migrated from agriculture to urban manufacturing jobs and from manual manufacturing labour to economies-focused services. This resulted in the creation of some alternative jobs and the displacement of some existing occupations (van Dam, 2017:16).

The need to build competitiveness and the virtually unstoppable development towards Industry 4.0 may be for the benefit of society in general but also pose a conundrum to businesses, governments and society. Income generated from work is the basis for most people's existence and sustenance (Bonciu, 2017:11). Nations are facing a situation where technological development needs to be fostered and changes supported; the same governments and businesses need to simultaneously take mitigating steps to minimise negative effects on income equality, privacy protection and employment opportunity (Kenney, Rouvinen & Zysman, 2015:4). To do this, business's perspective and role in societies need to be clarified. Two well-established perspectives are stakeholder theory, which highlights organisations' role in society, and sustainability, which highlights businesses' responsibilities and multiple bottom lines that affect their operations. The case organisation is operating in the quadruple context environment. In light of an increasingly strong focus on organisation's sustainability, sustainability theory is selected as one of the guiding theoretical approaches to explore the implementation of Industry 4.0 at the case facilities. The perception of Industry 4.0 enables the evaluation of a multitude of dimensions. These are the environmental-, financial-, governance- and social context of the case facilities' implementation of Industry 4.0.

4.2 QUADRUPLE CONTEXT ENVIRONMENT

Literature highlights that the field of sustainability has seen substantial developments and re-interpretations over time. Initially, sustainability can be argued to be the intentional effort to minimise the negative impact on or positively impact three dimensions of sustainability: social, economic and environmental. This is also known as the triple bottom line and is colloquially referred to as ‘People, Planet and Profit’ in management literature (Cornelissen, 2020:259). The intention of highlighting multiple bottom lines is to refocus the impact analysis of business operations on a wider basis than solely citing financial performance. This shifts the understanding of value creation into multiple contexts driving organisations towards positively impacting dimensions within society, the natural environment and business operations (Harrison & Wicks, 2013:111).

4.2.1 Sustainability as driver of change towards Industry 4.0

Sustainability encompasses the understanding that all activity needs to be performed in a manner to meet the needs of the present without compromising the ability to meet the needs of the future. It is highlighted that today’s society is facing a plethora of difficulties that are to be addressed to sustain its existence. This entails a substantial change in society and business. In recent years, pressure towards addressing social and environmental improvements has seen an increasing need for sustainable policies and actions. Manufacturing organisations are addressing this shift in operating environments by utilising novel assessment metrics, as suggested by stakeholder capitalism’s focus on governance. Literature suggests that with the shift of focus to a holistic focus on society, the environment and financial interests, manufacturing organisations are driven towards investment in novel technologies (Furstenau, Kremer-Sott, Mahlmann Kipper, Leandro Machado, López-Robles, Dohan, Cobo, Zahid, Abbasi & Imran, 2020:140079–140096).

Industry 4.0 is the key group of technology that enables organisations to reorganise and create long-term sustainable manufacturing (Stock & Seliger, 2016:539–541). Organisations are driven towards Industry 4.0 because the technology is closely associated with cost reduction and increased competitiveness and productivity. Short-term labour shortages may be argued to be a barrier to manufacturers introducing Industry 4.0 but in light of demographic changes may be regarded as a further driver towards the technology (Herceg *et al.*, 2020:1–5). The following section highlights the quadruple context environment and its links to Industry 4.0.

4.2.2 The ecological context environment

Organisations do not operate in a vacuum. All actions have consequences, and therefore all actions need to be evaluated in numerous contexts, including the ecological factors that organisations affect and the impact of the natural environment on organisations.

The ecological bottom line of sustainability refers to the impact of organisations on the natural environment through their actions. Sustainable organisations act in a manner that minimises the impact of their operations by the efficient use of energy, the sourcing of climate-neutral energy and the reduction of greenhouse gases emissions and products' ecological footprints (Alhaddi, 2015:8). In light of Industry 4.0 and its drive towards six-sigma production, this bottom line will be impacted by the current innovation drive towards the fourth industrial revolution. Further, Alhaddi (2015:8) highlights research that indicates a correlation between strong, sustainable business conduct and higher organisational resilience to periods of hardship.

4.2.3 Linking Industry 4.0 and the ecological context environment

Shaikh, Shinde and Kasat (2022:1) argue that it is evident that most industrial manufacturing methods are largely unsustainable and bear a large burden on the natural environment. This realisation has led to a substantial drive towards environmental sustainability concerning the natural environment. A result of this awareness is the global drive towards more efficient allocation and utilisation of natural resources in industrial processes. The increased awareness – originally consumer-driven – has evolved into an awareness that spans industries and continents.

Key areas identified in the drive to increase ecological sustainability are the use of energy, reduction of carbon emissions and resource utilisation. Industry 4.0 technology will be a substantial factor in achieving improvements in the key environmental areas. The industrial sector accounts for 40% of global CO_2 emissions caused by energy production. Estimations by the International Energy Agency indicate that the use of high-end technologies, which includes Industry 4.0 technologies, in the five highest energy intensity industries could lead to a decrease in energy of 13% up to 29% (UNIDO, 2017). Whilst the increased efficiency in manufacturing processes that can be achieved through the use of big data and cyber-physical machines is highlighted as a key element to achieving environmental sustainability and machine learning that may lead to the utilisation of elements that otherwise would have been discarded, it is essential to note that all of these processes are highly reliant on the use of energy. The network that connects all these processes is the internet. This network has an increasing impact on global energy demand as its use increases.

The internet accounted for 8% of the global energy consumption in 2012 and is predicted to account for 20% of global energy consumption in 2025 (McKenzie, 2021). Therefore, increased reliance on Industry 4.0 technologies is anticipated to increase environmental sustainability locally but will only increase sustainability in a wider sense if the Industry 4.0 technologies are powered sustainably.

Research suggests that the impact of Industry 4.0 technologies on environmental sustainability is not limited to the confines of singular organisations. As part of a global network, it may aid energy efficiency globally. Industry 4.0 technologies will enable manufacturing entities to increase oversight of processes and streamline supply chains through increased machine-to-machine communication. This communication exceeds the boundaries of a single factory and represents an important source for collecting big data. Whilst the increased oversight of processes is largely driven by a need to increase operational efficiency and reduce maintenance costs, it may also provide insight into current and future energy consumption. Sharing such data, thereby increasing data transparency with energy suppliers, would enable these to forecast industrial energy demand accurately and schedule supply accordingly. The insight into the demand for energy has gradually increased in importance because the increase in renewable energy generation has led to increased fluctuations in the supply of energy. After all, some renewable energy generation methods rely on wind and solar rays to produce energy. The coordination of fluctuating energy demand and fluctuating energy supply is expected to be greatly aided by Industry 4.0 technologies such as big data and cloud computing (Scharl & Praktiknjo, 2019:3896).

Whilst there is potential for environmental sustainability through implementing Industry 4.0, there is no clear consensus on the role and efficiency of the constituent technologies. Chiarini (2021:3195) found no consensus in the current literature on the effect of Industry 4.0 technology on environmental sustainability; in several cases, it comes to contradictory conclusions on the link between Industry 4.0 and environmental sustainability.

In addition to the novelty of Industry 4.0, it is clear that the global community is steering towards an increasingly sustainable society and that Industry 4.0 is a key factor in determining the success of these visions. Several governments have pledged to ensure that industry will operate carbon neutrally by 2050; thus, using renewable energy combined with modern manufacturing methods will increase industry resilience in the face of legislative pressure (Guterres, 2020).

4.2.4 The economic context environment

In the economic context environment, organisations need to evaluate their decisions and the impact the operations have in an economic context; this is also often referred to as the economic bottom line. The economic bottom line of sustainability refers to organisations' need to operate profitably in a constant endeavour, ensuring sustainable business operations. The economic bottom line expands beyond organisations' boundaries and includes the sustainable operation of economies in a greater sense and the value individual organisations add to economic growth for future generations (Alhaddi, 2015:8). This is the basis upon which all other dimensions of sustainability are built (Cornelissen, 2020:259).

4.2.5 Linking Industry 4.0 and the economic context environment

Industry 4.0 is an industrial development; thus, there is a special focus on the economic context environment by businesses. Many authors cite Industry 4.0 as a critical element in the manufacturing sector if a business wishes to be economically successful and sustainable in the long term. At its core is the drive of businesses to remain competitive through increased productivity and efficiency whilst lowering operating costs and reducing production wastages. In the economic context, Industry 4.0 is a deep-rooted change in the operations of organisations and the associated supply chains, which also alters the relations between suppliers and customers by altering the bargaining power of a supply chain's members (Goetz & Jankowska, 2020:63).

Particularly, cyber-physical systems hold the potential to increase the long-term viability of manufacturing in high-cost economies. Hellinger and Seeger (2011:23–25) highlight the increasing spectrum of software to control physical machines and the increasing ability to control manufacturing processes remotely as a key aspect and a cornerstone of Industry 4.0 technology. In return, this inevitably leads to a decreased dependence on human workers for select processes. Cobots, a rapidly growing technology, complement human workers and represent a possibility to reduce recurring costs caused by the employment of human workers through a single significant investment in cobots.

In contrast to robots, which are often associated with job losses, it can be argued that cobots can modify this perception by hybridising the manufacturing process. Cobots represent a reduction of operating costs not only through lower labour expenses but also through freeing the human capital for new and more demanding roles (Wallace, 2021:299–309).

Further, the increasing availability of 5G data networks worldwide, as highlighted by Groupe Speciale Mobile Association (2020b), and the availability of augmented reality further decrease the limitations of an organisation to geographic or other physical boundaries.

Additive manufacturing also holds the potential to be harnessed by businesses in the drive to remain economically relevant and sustainable. The additive manufacturing of products can greatly reduce the complexity of manufacturing processes. State-of-the-art processes have reached an advanced state where most materials are printable via 3D printing (Jandyal *et al.*, 2022:36).

Goetz and Jankowska (2020:65) highlight that the use of virtual prototyping and 3D printing can enable businesses to lower stock levels, reduce logistics and warehousing costs and streamline the procurement process. The increased availability of data and the ability to exchange within the supply chain can aid the transparency within a highly integrated supply chain. This is a key enabler to creating new value for customers and harnessing additional value from suppliers by innovating the products and increasing operational efficiency.

However, it must be noted that an argument can be made that the efficiency gains, the increased communication within a supply chain and the associated competitive advantage are only temporal, as these technologies will be expected to become the industry standard. The innovation-driven gains are considered more sustainable and form the basis of any future industrial development of individual organisations and entire economies (Goetz & Jankowska, 2020:65).

Such economic changes do not occur in a vacuum. Unsurprisingly, one can note that Industry 4.0 will not solely impact the ecological and economic environment but also affect the social context environment in numerous dimensions.

4.2.6 <u>The social context environment</u>

The social bottom line of sustainability highlights the impact of organisations on society and the value they create through their operations (Cornelissen, 2020:259). This is partially driven by the moral need for a 'social license to operate'. The social bottom line also includes an organisation's relations with its employees and skills development. The failure to address social development impacts the financial performance of organisations (Alhaddi, 2015:8).

Despite the wide acceptance of the triple bottom line, academics argue that in the context of modern societies, a globalising environment and the re-localisation of businesses and the increasingly deep embedding of business in society lead to business engaging ever closer with society. Beschorner (2013:110) formulates that such close engagement will fundamentally alter the relationship between business and society; the increasing interdependence leads organisations to engage with society and results in a broad spectrum of societal governance.

Engelbrecht and Ungerer (2011:11) echo the need to expand the understanding of the triple context environment into a model of a quadruple bottom line. Such an approach towards a four-dimensional understanding of sustainability changes the temporal dimensions of the model. Financial indicators, particularly their reporting, are regarded as the retrospective view of an organisation's performance. The social and ecological performance of the related indicators reflects the present state of an organisation and includes an indication of the organisation's outlook for up to 10 years.

4.2.7 Linking Industry 4.0 and the social context environment

A key factor that will influence and be influenced by the implementation of Industry 4.0 technology is the execution of labour by human workers in the manufacturing process. In addition to the changing factettes of work, a shift in the age of the population can be witnessed in key economies. The number of persons over 65 will increase between 2019 and 2050 in sub-Saharan Africa by 218% and in North America and Europe by 48%. The latter highlights the increasing age of already senior populations in developed economies. On average, it is expected that the global population of senior citizens over the age of 65 will rise by 120% by 2050 (United Nations Department of Economic and Social Affairs, 2019:5). Such ageing population results in the need to rethink work processes and utilise enablers that aid physically weakened persons to perform work tasks. Industry 4.0 is a potential enabler that changes the focus of human work towards less physically strenuous labour and more mental work that can be performed by older employees (Sallati & Schützer, 2021:810–815).

Low birth rates will expedite the ageing of the working population in developed economies, and the shift towards Industry 4.0 will change communication. This change requires the adaptation of digital novices to perform tasks in this new work environment. The tasks of human workers will become increasingly complex, and work will become increasingly less bound by physical barriers. Whilst face-to-face communication is highlighted as the most favoured type of interaction with work colleagues, an increasingly digital means of communication will become a backbone of social and professional communication due to the increasingly digital work environment. Using cyber-physical systems and collaborative robots may lead to increased inclusivity of physically limited workers if the person has the needed skills to perform the tasks (Schinner *et al.*, 2017:543–545).

Whilst some authors highlight the potential of Industry 4.0 to increase inclusivity in the workplace of physically limited workers, this is highly dependent on the education available in a society. In many economies, there will need to be a transition towards a knowledge-based society, with secondary education focusing on increasing the population's intellectual performance in subjects such as science and mathematics. However, the shift in education is not limited to primary, secondary and tertiary institutions, as the transition towards Industry 4.0 requires lifelong learning of employees and relentless skills development of organisations. This challenge is considered one of the largest and most important challenges faced by society in the context of Industry 4.0 (Menon, 2022:1–10).

On the other hand, some academics argue that Industry 4.0 is a means to eliminate jobs by replacing human labour with automated processes. Particularly low-skilled workers, performing repetitive tasks would face challenges. Assuming that upskilling does not occur, this would lead to increased unemployment, lower government income through taxes and reduced social prosperity. The reduced government income would also impact its ability to provide industry with a competitive infrastructure to foster further growth. In northern Europe and the US, nearly 50% of all jobs are at risk of becoming redundant due to automation, particularly low-skill tasks. Further, economies for which low-skill jobs form the basis are substantially more at risk of high job losses. Southern Europe is highlighted as particularly susceptible to such job losses, with up to 60% of all occupations being at risk. Without increased education and upskilling, it can be argued that such societies will face high and sustained levels of unemployment, as high-skill jobs are reliant on a well-educated workforce and a stable infrastructure (Bonekamp & Sure, 2015:33–40). Menon (2019) highlights that over half of the employees will need some re-skilling, with up to 10% of staff needing skills development that requires over a year of training and 44% of staff needing reskilling that will require less than a year of knowledge transfer to perform their work duties successfully.

The global opportunity inequality and wealth disparity could, as a result of this change in demand for certain skills, increase further because societies need to invest in education and infrastructure. Poorer societies typically lack funds to do so and will therefore experience pressure on working wages or sustained high unemployment (Menon, 2022:1–10). As Min, Kim, Lee, Jang, Kim and Song (2019:405) highlight, because human labour encompasses more than tangible outputs, it is necessary for human, cultural and social development. It is a means to ensure human dignity and self-actualisation.

In developed economies, processes that have been off-shored to avoid high labour costs of low-skill tasks may be re-shored due to Industry 4.0-based automation. Whilst this re-shoring may benefit a limited number of high-skilled labourers, this may nonetheless result in a global net job loss (Federal Ministry of Labour and Social Affairs of Germany, 2017:27).

McKinsey (2017) projects that up to 2.6 billion persons, approximately 14% of the working population, will need to change their occupational category by 2030 to secure employment. The shift is expected to impact particularly the highly developed economies of Germany and the USA, in which an excess of 30% of employees need to find alternative employment by 2030. Unlike societies with limited means to adapt, the US is predicted to offset the job losses with new occupations and accommodate 15 million new workers in its economy. Similarly to the US, Germany is expected to offset the job losses with new occupations. Germany, unlike the US, needs to harness Industry 4.0 automation further to compensate for an expected reduction of its labour force by three million persons by 2030. The economy of mainland China is also expected to cope with the shift in labour demands. It is expected to experience an increase in total labour demand whilst mitigating a shrinking workforce by 2030 through the use of technology.

4.2.8 <u>The governance context environment</u>

The fourth dimension, governance, is the vehicle with which organisations account for the long-term purpose of their existence. This is arguably the representation of the interest of absent stakeholders in the form of future generations that current actions will impact in the long term. An organisation is thus a temporal caretaker of future societal interest. It follows that to fulfil this duty, organisations will need to take a long-term view of the purpose of their being and, crucially, take a proactive, anticipatory approach to organisational actions to succeed in the twenty-first century (Engelbrecht & Ungerer, 2011:11–14). Schwab (2019:2) takes a similar stance to the quadruple bottom line; in his argumentation of stakeholder capitalism, he underlines the role of governance in building an inclusive economy in a drive for sustainable growth. Therefore, a quadruple bottom line could be summarised as ‘people, planet, profit and purpose’.

4.2.9 Linking Industry 4.0 and the governance context environment

Businesses, as previously stated, are facing a need to re-orientate their purpose away from the sole shareholder perspective towards a more inclusive and long-term orientated stakeholder perspective. Whilst the triple bottom line has become part and parcel of many organisations' operations, it can be argued that all of these factors influence the purpose of the operations. As previously discussed, Industry 4.0 heavily influences businesses' relation with natural resources, their impact on the environment and changing social dynamics whilst being a means to adapt to social changes and secure long-term financial sustainability. This changes organisations' purpose, which is reflected by substantial changes in the corporate governance environment. The global community has not managed to fulfil all the millennium development goals and formulated the sustainable sustainability goals, recognising that the successful implementation of initiatives towards these requires the full cooperation of the private sector (United Nations Development Programme, 2022). The sustainable development goals form the basis of government regulation and governance requirements for business conduct, in addition to implicit stakeholder requirements that hold the potential to reshape an organisation's purpose. These 17 goals are illustrated in the following table.

Table 1: Sustainable Development Goals

1	**2**	**3**	**4**	**5**	**6**
Eradicate poverty	Eradicate hunger	Ensure good health and well-being	Quality education	Gender equality	Clean water and sanitation
7	**8**	**9**	**10**	**11**	**12**
Affordable and clean energy	Decent work and economic growth	Industry, innovation and infrastructure	Reduced inequalities amongst nations	Sustainable cities and communities	Responsible consumption and production
13	**14**	**15**	**16**	**17**	
Climate action	Sustain life below water	Sustain life on land	Peace, justice and strong institutions	Strengthen global partnerships for these goals	

Source: United Nations (2022b)

The importance of environmental, social and corporate governance is continually growing in a fast-changing social, environmental and regulatory environment to ensure organisations' continued sustainability. Whilst Industry 4.0 can be identified as a potential driver for social, financial and environmental prosperity, it can only be harnessed if corporate culture, vision, mission and values are based on sustainable governance principles. It is highlighted that Industry 4.0 technologies are enablers for legislation that can lead to the reduction of child labour, environmental pollution and obsolete production methods by offering financial, environmentally and socially acceptable alternative methods of production. This fundamentally changes organisations' production methods and business models towards a balanced approach within the quadruple context environment. Environmental, social and corporate governance is increasingly becoming the basis for investment and divestment in specific organisations and industries and, therefore, investment decisions. Sustainable reporting is expected to include quality factual data that does not constitute greenwashing (Roblek, Thorpe, Bach, Jerman & Meško, 2021:20).

Particular examples that highlight the enabling character of Industry 4.0 in reaching governance goals are the implementation of technologies in situations where physical presence in factories is impossible. During the COVID-19 pandemic, the ability to telecommute and rely on smart manufacturing has increased worker health by avoiding close physical contact and indirectly reduced CO2 emissions by eliminating commuter traffic (Roblek *et al*., 2021:14).

The World Economic Forum (2020) highlights the fourth industrial revolution as a key enabler of sustainability goals, as 70% of all sustainable development goals are directly supported by technological innovation. Technologies that are to be harnessed particularly to reach a positive outcome on financial, social and environmental goals are artificial intelligence and big data.

Short-loop recycling in manufacturing and the harnessing of additive manufacturing may reduce the environmental impact of manufacturers as the additive manufacturing process enables manufacturers to reduce overall wastages. This may enable the automotive industry to fulfil the following Sustainable Development Goals: 3, 6, 8, 9, 11, 12 and 15 (World Economic Forum, 2018).

The introduction of collaborative robots, robotic manufacturing and augmented reality to aid workers with augmented work tools may enable the automobile industry to contribute to the fulfilment of Sustainable Development Goals 3, 4, 5, 6, 8, 9, 11, 12, 14 and 15 (World Economic Forum, 2018).

Beier, Niehoff and Hoffmann (2021) highlight that the most discussed sustainable development goals in the academic literature are Goals 8, 9 and 12. Notably, Goal 8 is discussed more than twice as often as the others. Their research concluded that whilst there is a small but growing amount of literature on the sustainable development goals in the context of Industry 4.0, these frequently reflect hopes and expectations but rarely substantiate these with empirical evidence. This realisation leads the authors to highlight that the introduction of Industry 4.0 will lead to painful dilemmas of the social, environmental and economic aspects that will need to be solved by compromises in the future.

Focusing on the automotive industry, one needs to note that the transition towards e-mobility will likely face challenges in balancing environmental, social and corporate governance. Whilst e-mobility will undoubtedly reduce CO2 emissions when based on sustainable energy sources, it will also represent a major shift in manufacturing supply chains. The less-complex systems are cited as well suited for using Industry 4.0 technologies. Mercedes-Benz plans to lay off 15 thousand employees due to its focus on electrification and the automation of processes. Over 80 thousand jobs will be lost between 2020 and 2023 at Mercedes-Benz (Roblek *et al*., 2021:16).

The less complex propulsion systems will require fewer components and substantially fewer parts suppliers, with up to 30% of all value-added processes at risk of becoming obsolete. Up to 35% of jobs in the automotive sector are at risk of being redundant through the introduction of electric vehicles. Particularly, power-train manufacturing jobs are at risk, with 46% of jobs being at risk without accounting for the efficiency gains through Industry 4.0. When including efficiency gains of Industry 4.0 technologies, up to 62% of power-train manufacturing positions are at risk of being eliminated. In the German context, this is close to 100 thousand jobs. Further, small suppliers of specialised components risk losing key customers through this process (Burkert, 2019:9–13).

In this context, the social impacts need to be considered in the context of the other dimensions of the quadruple context environment to find a socially equitable solution for those whose skills have become superfluous. This is not solely the role of government but rather a collaborative endeavour of businesses and governments. Further, numerous businesses will need to readjust to the new market demands, which often results in organisations having to change industries or markets (Roblek *et al*., 2021:15).

4.3 ALLIANCES TO APPLY INDUSTRY 4.0 TECHNOLOGY

Industry 4.0 is a technological advancement that impacts a plethora of aspects. Following the understanding of stakeholder capitalism and sustainability, one can argue that the application of Industry 4.0 technologies influences and is influenced by the entirety of the quadruple context environment. The interconnectedness of the Industry 4.0 technologies and the globalised nature of modern societies and businesses contribute to the increasing interdependence of organisations. The role of sustainability and stakeholder capitalism facilitates this change and maximises the positive impact; however, this does not take place in silos. Key issues that impact the sustainability of Industry 4.0 and those cited as hindering a swift realisation of the technology include a severe lack of qualified labour and a lack of standardisation of technology. These factors point to a need for heightened cooperation and the consideration of shared value creation to secure sustainability in the quadruple context environment (Horváth & Szabó, 2021:119).

4.3.1 Creating shared value

The creation of shared value is defined as policies and corporate actions that improve a business's competitiveness whilst improving social and environmental conditions and the economic environment as a result of a business's pursuit of sustainable profitability. It is argued that using free-market forces will be a superior mode of co-ordinating the impact of business in modern societies compared to external intervention (Beschorner, 2013:109).

Creating shared value can be regarded as a means to integrate stakeholders and businesses into a combined effort to achieve sustainability goals through close cooperation, action and communication on critical issues (Lòpez & Monfort, 2017:130–132).

The interconnected pillars of stakeholder capitalism should underlie the evaluation of proposed actions and outcomes of corporate efforts (Porter & Kramer, 2011). The redefinition of corporations and society as co-creators of shared value is a key driver of the next wave of innovation and increased productivity in a globally competitive market. Porter and Kramer (2011:7) claim that this creates value in three distinct dimensions. First, it reconceives markets and products, meeting new social needs. Second, it builds supportive industry clusters that improve efficiency and reduce logistics costs whilst centralising competencies. Lastly, and crucially, particularly in efficiency-driven economies, it redefines productivity in the value chain to a wide spectrum of factors.

Moon and Parc (2019:115) echo Crane, Palazzo, Spence and Matten (2014:132–135) and Beschorner (2013:109) in somewhat associating the understanding of creating shared value with corporate social responsibility. Moon and Parc (2019:115) suggest reshaping the perspective towards the aspects of 'creating shared opportunity' as an umbrella term for organisations' engagement with stakeholders to build competitiveness whilst building on corporate strengths to generate mutually beneficial value, leading to an overall positive impact of a business's operations to society.

Kramer and Pfitzer (2016:1–5) suggest that businesses, from a sustainability perspective, are ever more interdependent with an increasing number of stakeholders in the quest to maximise social, economic and environmental progress. When taking an isolationist approach to shared value creation, a business faces barriers that severely limit the impact and negate the value created. Business is constituent to an ecosystem comprising society, nature and business, which are interconnected within the previously stated dimensions. This creates a complex matrix of interdependencies and hubs of skills and knowledge within society and business.

Overcoming certain hindrances or issues may be beyond the scope of a single business, industry or nation. To pursue shared value, multi-sector coalitions form to address issues. These coalitions of non-governmental organisations, governments, community members and businesses form objective-driven networks in pursuit of a common goal (Kramer & Pfitzer, 2016:4–5). The case-by-case composition of these coalitions highlights the dynamics they develop when addressing issues. The role of all stakeholders will evolve, and the relation between the members will differ in every coalition.

Kramer and Pfitzer (2016:4) refer to these networks as a means to achieve collective impact. Through collective impact alliances, businesses will advance social developments that otherwise would, if not addressed, pose threats to a business's sustainability. Further, as a consequence of addressing such threats, stakeholders will benefit by creating value. The underlying understanding of common impact is that social problems result from complex and interrelated issues caused by various societal actors. Due to this complexity, single entities are ill-equipped to address these and therefore need to form alliances to address these complex issues in a holistic manner (Kramer & Pfitzer, 2016:6).

4.3.2 Networks for skills development

When exploring Industry 4.0 in the work environment, it becomes clear that there is a substantial shift in the skills demanded to work in a manufacturing setting. The role of the traditional factory worker is reshaped substantially as the use of novel technology alters their tasks and tools – this reshaped demand for select skills. Industry 4.0 is contingent on efficient skills development of the workforce. Many parties have a viable interest in enabling this transition and reshaping the workforce's skill set.

Ninan, Roy and Thomas (2019:782–786) argue that skills development should be in the interest of the individual worker and the manufacturing organisation. On the one hand, it is argued that the individual worker is interested in obtaining as much knowledge as possible to obtain a competitive advantage over the relevant peers and potential Industry 4.0 technologies that may substitute human labour. On the other hand, the organisation should view skills development as an investment in increased productivity and worker retention rather than a cost. Further, governments have a vested interest in ensuring that the labour market is not negatively affected by Industry 4.0 technology.

Three key elements to be developed are workers' skills in occupational abilities and skills and employee knowledge (Ninan *et al.*, 2019:782–787). Considering the profound change in demands for worker skills, as highlighted by the changing requirement of Industry 4.0

enabled manufacturing facilities, it is clear that skills development is crucial for workers and employers. The upskilling of current workers and the preparation of the future workforce can be seen as being facilitated in several ways. These ways range from state-sponsored education programmes to initiatives of private organisations to upskill staff.

Maisiri, Darwish and van Dyk (2019:94) state that the fast-paced development of Industry 4.0 necessitates the workforce to develop skills over the entire period of professional activity. This is also known as lifelong learning. Further, the increasingly technical work environment that Industry 4.0 creates the need and the environment for close cooperation between industry and educational institutions.

Industry’s significant role in the training and reskilling of workers includes cooperation with educational institutions in providing onsite training opportunities for students and insight on educational shortcomings and future industry needs. The investment in vocational training and labour market support of many developed nations has been declining in relation to GDP, indicating a shrinking role of formal vocational training and labour market support by governments. To mitigate this reduced investment, the cooperation of private businesses to upskill persons collaboratively is on the increase (Manyika *et al.*, 2017b:17–108).

Whilst there are numerous opportunities for the workforce to reskill and develop existing skills to address future needs, it must be recognised that communication with stakeholders in a value-creating network is a vital element that enables private organisations and public institutions to coordinate and cooperate in skills development. In the context of the changing skills demanded by industry, it is in the interest of manufacturing organisations, governments and factory workers to address this as a coalition.

4.3.3 Networks to install Industry 4.0 technologies

The technologies that comprise Industry 4.0 are highly complex and represent a substantial cost to develop and implement. Therefore, these technologies are being introduced through various means, including business-to-business and private enterprise cooperation with state institutions. Examples of national initiatives that aim to foster the rollout of Industry 4.0 technology include the German ‘Platform 4.0’ and the Slovak ‘Inteligentný priemysel pre

Slovensko' (Klitou, Conrads, Rasmussen, Probst & Pedersen, 2018:3; Klitou *et al.*, 2017a:3). These initiatives focus heavily on industry and government co-operation on aspects such as skills development of citizens and the fostering of supportive infrastructure. The alliance to provide infrastructure for Industry 4.0 includes the national introduction of mobile technologies, such as 5G networking and adapting the national legislature to accommodate the changes in the industrial landscape.

On an operational level, businesses that introduce Industry 4.0 technologies rarely develop these themselves but use readily available solutions that technology suppliers customise to fit the respective application. The interconnected nature of Industry 4.0 is a further factor that enhances the need for the universality of technology not to be limited by the bounds of a single organisation or technological standard (Chen, Wan, Shu, Li, Mukherjee & Yin, 2018:6505–6519).

Whilst exploring the application of the internet of things, it has become apparent that some businesses in a supply chain do not have the required technology or have technology that is not compatible with organisations outside their direct fields of influence. This lack of compatibility is regarded as a substantial hindrance to operations and the sustainability of the organisation's cooperation (Nagy *et al.*, 2018:14). This is a strong argument for industry to standardise its approach to technology and the use of standardised products from supplies. Leading suppliers of Industry 4.0 technologies include telecommunication network providers and well-known IT businesses. Industry analysts highlight the role of Microsoft as a supplier of augmented reality solutions and a key software supplier to industry. Other key suppliers supporting the installation of Industry 4.0 technologies are Siemens, Bosch, General Electric and ABB. These companies will likely actively cooperate with customers during the implementation phase of new technology (Wopata, 2019).

4.4 CONCLUSION

The illustration and discussion of literature in chapters 2, 3 and 4 aims to provide the reader with a structured overview of academic discourses of relevance to the exploration of employee perceptions of the implementation of Industry 4.0. Whist Industry 4.0 is a novel phenomenon and thusly little literature on the implementation process is available, there is sufficient literature on the factors shaping the implementation and communication of Industry 4.0. It is in the nature of exploratory research that literature needs to reflect an integration of academic literature with practical considerations that societies and businesses are facing. The interconnectedness of stakeholders, Industry 4.0 and sustainability in context of an industrial revolution poses numerous aspects where communication is central to a successful execution of a change towards Industry 4.0. Rather than solely highlighting an abstract approach to literature on the subject, the literature chapters of this study aim to integrate academic knowledge with explicit consequences for stakeholders due to the introduction of Industry 4.0. Having provided the reader with such information, the next chapter of this study will present the methodological approach followed in order to address the research problem and research question.

CHAPTER 5

5 RESEARCH METHODOLOGY

5.1 INTRODUCTION

In chapter five the rationale for the choice of research methodology choice is presented. This is done by highlighting the attributes of the qualitative and quantitative research methods. The qualitative research approach is detailed. Additionally, the study population is outlined, the sampling procedures are illustrated and the data collection process is explained. In the final section of this chapter, the data analysis method employed in this study is discussed.

5.2 RESEARCH APPROACH

The first uncertainty in research design is whether a qualitative or quantitative approach should be followed. This is addressed by analysing the phenomena at hand, the availability of established research on the topic and, crucially, the nature of the planned exploration. Du Plooy (2011:16) states that all research traditions that guide research are based on certain defined assumptions that characterise the approach to the phenomenon being investigated, the related theoretical background and the selection of data gathering techniques.

In addition, research design is based on a set of assumptions that guide the research endeavour to the appropriate approach to ultimately gain insight into the research questions or research hypothesis.

Ontological assumption is the descriptive term for what can be explained in simple terms as the beliefs of the researcher with respect to the nature of the phenomenon being investigated (Du Plooy, 2011:20).

Epistemological assumption is the descriptive term for the endeavour to choose the scientifically appropriate approach to investigate the identified phenomenon (Du Plooy, 2011:20).

Theoretical assumption is the descriptive term for the theory or the generalised reason or justification given for an action or belief that would explain the highly specific phenomenon being researched (Du Plooy, 2011:20).

Finally, Du Plooy (2011:20) highlights that methodological assumption is the descriptive term for all reasoning related to creating a suitable approach to practically investigate a phenomenon sensibly and rationally.

Having discussed the above assumptions, it needs to be clear that none of these assumptions is to be addressed or analysed individually, but rather, the research approach should be deemed suitable or unsuitable as a result of a holistic analysis of the ontological, epistemological, theoretical and methodological assumptions and the related approaches to address these assumptions and investigate the phenomenon. As all four assumptions are interdependent, they influence all related selections (Du Plooy, 2011:21).

There are two distinct approaches to research: qualitative and quantitative. Quantitative research has been practised since the 17th century and is based on a data system for experiences that does not allow for speculation. It is driven by a need to quantify all findings and solely accounts for quantifiable results. Du Plooy (2011:22–30) highlights an ontological trait typically exemplified by the quantitative approach to research in that one of the key ontological assumptions is the approach to and understanding of reality.

This assumption is that when researching reality, there is arguably only a single reality to be investigated, and this reality is objective and free of any value concerning the investigative goals or targets. In addition, communication, which forms part of the social sciences, can be investigated and measured (quantified) with complete objectivity.

Further, reality can be explained by universal laws; the associated generalisations, and, as a result, the hypothesis in question, can be accepted or rejected solely based on objective findings. Such findings are based on empirical observations that, in line with experiments and quantifiable observations, are regarded as the sole sources of knowledge. The methodology is exemplified by the assumption that the hypothesis can control and predict what is at the core of the study (Du Plooy, 2011:30).

5.3 QUALITATIVE RESEARCH

The qualitative approach goes by many names, such as the anti-positivist approach, critical research, field research, naturalism, the interpretive approach and constructivism (Du Plooy, 2011:30). It is an umbrella description for any type of research approach and method that studies natural social life (Saldaña, 2011:3). It can be argued that a detailed account of established features of qualitative research is still lacking in the literature. Aspers and Corte (2019:139–144) argue that many authors have intimate knowledge of what constitutes qualitative research but most fail to provide a coherent definition. Nonetheless, there are numerous commonalities in the definitions available, and by using eminent authors of qualitative research, these will be highlighted in the following discussion.

Unlike quantitative research, qualitative research accounts for the subjects' experiences and various contexts of being and, as a result, regards reality as comprising subjective truths. This ontological assumption allows for different understandings of a phenomenon and the role of context in building a reality that may not be shared by all in the understanding. Particularly when exploring the role of communication, insights are evaluated in the context of the social world and are derived from a subject's perspective. The research process can be regarded as being based on inductive reasoning compared to the deductive reasoning of the quantitative approach to research design (Du Plooy, 2011:35).

From an epistemological standpoint, qualitative research is highly focused on extracting knowledge from meaning that people attach to experiences such as communicating. The subjective nature of understanding the subject allows for the accommodation of multiple sources of truth and the use of these to explore, understand and interpret a subjective setting. The subjective nature of the qualitative approach to research must, under no circumstances, be understood as less methodical or scientific than the quantitative approach. To enable a meticulous and organised approach to data analysis, qualitative themes and categories should be developed based on the data gathered to explore and describe meaning in distinct contexts. Contrary to a quantitative hypothesis, a qualitative study's research questions can be used to guide observations, which are made to satisfactorily provide answers to these questions (Du Plooy, 2011:35). Scientifically valuable and acceptable results of a research endeavour are universally dependent on a systematic approach to inquiry and the systematic application of research methods (Chun-Tie, Birks & Francis, 2019:1).

Even though qualitative research does not rely on well-established statistical methodological protocols, it is, as previously stated, a systematic and rational approach to gathering insight. When exploring reasoning in a qualitative setting, there are three principal approaches: deductive, inductive and abductive reasoning. Drawing conclusions from reasoning based on established evidence that is based on fact is called deductive reasoning. Abductive reasoning is the process of summarising the evidence and forming a conclusion based on what is to be considered the most likely explanation. The third method of reasoning, inductive reasoning, is the process of inferring the transferability of a particular phenomenon from the specific into the general based on experience and gathered evidence (Saldaña, 2011:95).

Several key differences between the qualitative and quantitative approaches to conducting social research can be distilled into key advantages and disadvantages when seeking insight into a phenomenon. The key differentiator, possibly the most obvious, is that the quantitative approach seeks insight through the use of numbers that represent trends and the results of research, whereas qualitative research relies mostly on the interpretation of text and observations that are non-numerical. The sampling approach is a further differentiator between the two research techniques. Quantitative researchers typically select participants using random or probability sampling, whereas qualitative research allows for purposefully selecting individuals based on individual criteria (Keyton, 2011:71).

It can also be argued that qualitative research and the results of such research endeavours account for the contextualisation of the process, the research results and the interpretation of those results. However, in contrast to qualitative research, quantitative research excludes context from the results and their interpretation, as an important factor in successful quantitative research is the elimination of external factors (for example, in experiments) (Keyton, 2011:72). The respective advantages of qualitative and quantitative approaches are summarised in the following table.

Table 2: Strengths and weaknesses of qualitative and quantitative research

	Qualitative approach	**Quantitative approach**
Strengths	Enables the comprehension of meaning and behaviour in a social context	Isolates variables and enables the exploration of relationships between variables
	Highlighting interactions between factors in real contexts	Simple comparison of participant responses due to standardised data collection across all subjects and controlled environment
	Interaction and environment (context) are the core of the data collection process	Researcher controls interaction environment and limits external variables
	Optimal for the discovery of unknown or new phenomena	Optimal for ensured validation and replication
Weaknesses	Rarely appropriate to test predictions	An approach that is too narrow may lead to the neglecting of elements or influences on results
	Highly demanding on the researcher in respect to time and resources used	A weak comprehension of subjects' interpretations of reality
	High degree of difficulty to generalise findings in certain settings	Weak approach to discovering new phenomena

Source: Keyton (2011:72)

5.3.1 <u>Select qualitative approaches</u>

Similar to quantitative research, there are numerous subgenres of qualitative research. These are distinct in the approach to data gathering, the style of enquiry, the use of data to represent results and the subsequent presentation of the results. Of the numerous research genres, some are notable for this study, and their selection or non-selection as a possible research approach is relevant. Ethnography, the study through observation and documentation of a society's life in an effort to understand a specific group's culture, often involves long-term fieldwork close to the subject of interest and the presentation of the final written results. This type of study was initially primarily used by anthropologists in an effort to gain an understanding of foreign people about whom little or no previous academic knowledge had been gathered. This genre of qualitative study has since been substantially widened to include multidisciplinary applications to explore cultures in organisational settings, such as companies, online communities or schools. Culture itself is a highly contested term with many definitions and underlying understandings (Saldaña, 2011:5). It can be argued that the accounts of the distinctive features that would clearly identify qualitative research are complex, and the numerous authors who have contributed to the field have divergent interpretations of the constituent characteristics of qualitative research. This issue is particularly eminent in the field of ethnography (Hemmersley, 2018:1–17).

In the context of this research, the ethnographic approach has several limitations, even if one should only follow a relatively superficial analysis of ethnography. This study was intended to be concluded in a defined and relatively short timeframe. This is because this study was self-funded with limited resources and a partnering company highlighted that the running operations of its factories were to be disturbed as little as possible. Nonetheless, it could reasonably be assumed that these limitations could have been addressed. The unique timing of the research, with the outbreak of the global COVID-19 pandemic, the resultant physical distancing within entire societies, the ultimate closing of borders and the grounding of flight operations for months and years made the above considerations mute. As a result, an ethnographic approach was deemed unsuitable for this study not only for the above reasons but also in light of other, more suitable approaches in the context of the research aims and the contextual limitations in terms of travel and access to the specified factories and their relevant employees. Furthermore, the cultural aspect of this global study is only one aspect of the research, which addresses several contexts and constructs.

Phenomenology is another approach to qualitative research. It is the study of the nature of things or the meaning of a phenomenon's essence. Saldaña (2011:7–8) highlights this approach's historical background in philosophy and the interpretation of texts to understand the underlying meanings. In the modern context, this approach is often selected to explore events, concepts and life experiences. The aim of this approach can be summarised as exploring commonalities among the experiences of individual subjects through gathering information from individuals and extracting common essential themes or constructs. Phenomenological research has no specific data analysis method, as the method is guided by the subjects and the appropriate data sources. The researcher mainly needs to ensure that the data can be distilled to the essence of the experiences of all the subjects who provide the data (Saldaña, 2011:7–9).

This approach, as stipulated by Saldaña (2011:7–9), is highly focused on distilling commonalities between subjects, and while a suitable instrument for data gathering may be found, there are still several reasons to object to using this qualitative research approach for this study. Primarily, this study seeks to find commonalities between the employees and management of 'The Company' at four regional facilities; however, a crucial factor in this study is the divergent experiences of these groups concerning the experience of change due to the introduction of Industry 4.0 technology. While commonalities between the groups are to be expected and welcome, the study aims to find differences and communication possibilities resulting from this novel phenomenon. Additionally, even though there is ample literature on change management and communication, the industry is relatively novel, and the literature is still being established. Finally, although phenomenological research offers the researcher a high degree of flexibility in selecting data sources, this advantage cannot be fully utilised due to the lack of literature on this highly specialised field of study.

Content analysis is also highlighted as a possible method for conducting this study. It involves the use of textual and visual data to analyse the latent meanings of the data. Content analysis can be qualitative and quantitative, as analysing the frequency of an occurrence can be regarded as a quantitative research approach, and the interpretation of the underlying meaning of the data is considered qualitative (Saldaña, 2011:10). However, due to the previously mentioned limitations in the literature and the need to gather primary data to satisfactorily answer the research questions, this research approach was ruled out for this study. This study is conducted with a single organisation that has multiple manufacturing facilities in various global settings. Whilst not following a case study approach, this study does follow a case approach of an explorative nature. The following sections of this chapter will guide the reader through the research methodological choices made for this research endeavour.

5.3.2 Credibility and trustworthiness

Nieuwenhuis and Smit (2012:137) argue that in qualitative research, one should refer to credibility and trustworthiness rather than reliability and validity. This rationale was followed in the present research. Yin (2016:88) states that ensuring the validity (trustworthiness) of qualitative research is paramount when designing a study and engaging in data collection and data analysis. Ensuring the validity (trustworthiness) of a qualitative study maximises the credibility of its description of the phenomenon under study and the conclusions drawn and ensures the transparency of the interpretation and explanations. In ensuring the credibility of a study, the literature suggests steps to consider in the design and execution of a qualitative research study.

Additionally, an in-depth understanding of the situation to be explored and the context in which the data is collected is needed. This is ensured through the intensive and long-term involvement of the researcher in the subject matter and the data collection process (Yin, 2016:89). The researcher dedicated extensive time and effort to the study's design and several months to the data collection process.

Data richness must be ensured. To gain sufficient insight into a phenomenon, sufficient data is required to be the source of detailed and varied data for later analysis and interpretation (Yin, 2016:89). As a result, a total of 50 interviews were conducted and transcribed from participants in four distinct regional contexts at a managerial and non-managerial level in a globally operating organisation to ensure data richness on the explored phenomenon.

Yin (2016:89) and Nieuwenhuis and Smit (2012:138) highlight the importance of triangulation, which is the process of collecting evidence from various sources and cross-validating interviewees' assertions. This study utilised an extensive literature review and semi-structured interviews with two distinct sets of items for management and non-management staff on a single phenomenon.

To ensure validity and trustworthiness, the literature encourages the use of numbers, where appropriate, rather than adjectives in presenting and analysing qualitative data (Yin, 2016:89). Owing to the extensive quantity of data collected and analysed in this study, data presented in the following chapter extensively relies on the use of tabulations of results, using numbers to highlight the measures of statements made relating to the developed data analysis codes. Further, the use of numbers in the presentation of code co-occurrence in the respective case regions is noted.

Finally, Yin (2016:89) illustrates that ensuring trustworthiness can include a comparison across settings, events and groups. In executing this study, the phenomenon was explored in four distinct regional contexts: Germany, the United States of America, Slovakia and China. Further, this study considered two distinct perspectives on the phenomenon to be explored by seeking input from the case organisation's management and non-management staff.

5.3.3 Limitations of qualitative research

The literature highlights the qualitative research approach, like the quantitative research approach, as having distinct advantages. While the advantages of using qualitative research in this study have been discussed, there are also possible limitations.

Qualitative research, compared to quantitative research, is highly time intensive. For example, the research process, particularly the data collection through interviews and data analysis, is cited as being time intensive (Queirós, Faria & Almeida, 2017:378). This limitation was addressed by allowing sufficient time for the research process, accepting the time needed to conduct the research and not giving in to possible time pressure.

Qualitative research is often only focused on participants' experiences (Rahman, 2017:104–105). This research endeavours to explore the perception of a phenomenon and, therefore, requires data on the participants' experiences to address the research questions and problem statement highlighted in Chapter One.

5.4 ETHICAL CONSIDERATIONS

Ethics are a key element in a research endeavour. Keyton (2010:81) states that communication researchers, irrespective of the research method, need to follow the five elements that guide the endeavour. These guidelines were followed.

First, integrity needs to be maintained throughout the research process to ensure that the goal to generate knowledge for the academic community and public on a phenomenon is met. Second, confidentiality between the researcher and the subjects needs to be ensured to protect all research participants. Third, researchers must maintain professional responsibility, which encompasses compliance with all legal and institutional requirements during the research and the processing of the data (Keyton, 2010:83). Ethical clearance from the University of Pretoria is attached to this document as Appendix B. The cooperation agreement with 'The Company' is also attached. Please see Appendix I.

Fourth, honesty and openness are required when conducting communication research. The researcher must obtain informed consent from all research participants, including the interviewees, the case organisation and the case facility. The details supplied to participants in the informed consent form should include the identities of the principal researcher and the sponsoring organisation. Informed consent should include the main features of the research design and what kind of data will be collected. The duration of the interaction with the participant needs to be indicated, and, most importantly, participants can only give informed consent based on their accurate knowledge of the research endeavour's confidentiality (Keyton, 2010:84).

Further, as part of the research process, deception is to be avoided. All sources and citations used to substantiate theoretical claims are to be acknowledged in the discussion of the literature. The research results must be disclosed irrespective of the outcome. Data is not to be falsified or presented in a misleading manner. In addition, all financial interests and support for the researcher, should there be any, must be disclosed. Ethical research also requires that all financial relationships, should there be any, between the researcher and the people and institutions related to the research, must be declared. Finally, the researcher needs to ensure that social responsibilities are honoured. Social responsibilities include respect for the human subjects involved in the research process and the need for the researcher to honour all commitments made during the research process (Keyton, 2010:84).

5.5 STUDY POPULATION

A research's population is the sum of all possible units of analysis or in simple terms, all sources that could provide data in line with the selected methodology in a specific context. A population can consist of people but may also include organisations, objects or groups. The first step in selecting a sample type is to determine the population parameters, as this forms the basis of all the following steps (Keyton, 2011:122).

This study's population consists of all staff employed at the automotive supplier, 'The Company', during the data collection period at a facility using or introducing Industry 4.0 technology. These employees can be considered the target population. A research endeavour aims to provide generalisable results for the target population (Du Plooy, 2011:109).

These employees need to be directly employed by the automotive business unit in the production facilities in Berlin, Germany; Nové Zámky, Slovakia; Foshan, China and Hillsboro, New Hampshire, the United States of America, where Industry 4.0 technology was being used or introduced during the time of data collection. Du Plooy (2011:109) defines such a population as the accessible population, as these are the employees where internal and external factors make it feasible to conduct research in a scientific manner. These units of analysis form part of the target population but are distinct due to their plausible accessibility.

These facilities have introduced Industry 4.0 technologies and represent a diverse population with respect to culture, geographic location, product portfolio and economic background. Initially, a production site in northern Italy (Treviso) was also identified but had to be excluded from the accessible population due to operational restrictions outlined in the sampling size section of this document. While 'The Company' did not state the number of employees at the individual factories, it did state having a total of 30,000 employees and 5 billion euros in revenue at the time of conducting the interviews ('The Company', 2021). It is important to note that 'The Company' does not have automotive production facilities in Africa or South America.

5.6 SAMPLE SIZE AND SAMPLING PROCEDURE

Sampling is the stringent and rigorous selection process of analysis units from an identified population.

5.6.1 <u>Sample size</u>

The sample size was determined after careful consideration and close coordination with 'The Company's' senior management and the dedicated staff who focus on implementing Industry 4.0 technology globally and in the respective facilities. After considering operational limitations and the need for tangible quantities with respect to the total sample size for the facilitators, a total goal of 50 interviews was selected. This was broken down into 25 management and 25 non-management staff, of which management and non-management staff were approached until five interviews could be arranged per group. All regions facilitated 10 interviews in total, except the Berlin factory, whose leadership kindly agreed to facilitate 10 non-management and 10 management interviews. The reason for this departure from the otherwise well-balanced sampling approach is twofold. First, a manufacturing facility that introduced Industry 4.0 technology in northern Italy was permitted by the company's global leadership, but no agreement on several key elements of the research process could be made with local management.

Second, in an attempt to avoid hostilities with local management that could negatively influence the interviews at other sites, undermining the assertion that these interviews were completely voluntary and anonymous, no individual interviews were held at this location. The key points that could not be agreed on were the one-on-one nature of the interviews to ensure interviewee confidentiality and the timeframe in which the interviews would be conducted. Consequently, no sample was drawn from this location. Whilst this is regrettable, no contextual link to particular positive or negative attitudes towards Industry 4.0 can be made at this location. The main driving force of this lack of cooperation can be linked to other points of friction between the Italian facility management and global management.

After exploring the production facilities that were open to interviews, the Berlin facility, which is one of 'The Company's' largest facilities, offered the researcher the opportunity to explore the sole production line where employees had not yet seen upgrades of existing technologies to 4.0 standards but rather joined a dedicated new Industry 4.0 production line.

Table 3: Overview of research regions and the sample

Facility	Country	Geographic Region	Sample size Management	Sample size Non-Management	Product	Type of line
Berlin1	Germany	Central Europe	10	5	Xenon Bulbs	Upgraded Line
Berlin 2	Germany	Central Europe	0	5	Laser Light	New Line
Nové Zámky	Slovakia	Eastern Europe	5	5	Aux Bulbs	Upgraded Line
Hillsboro	USA	North-East North America	5	5	Halogen and LED Lighting	Upgraded Line
Foshan	China	East Asia	5	5	Halogen and LED Light	Upgraded Line

5.6.2 Sampling procedure

The literature distinguishes between two prevalent types of sampling procedures followed in scientific research. Probability sampling is a method through which a sample is selected while ensuring that all constituents of a population have an equal likelihood of being selected to represent the research population. This is achieved using a simple random sample, where a constituent of the population is randomly selected using an unbiased selection process, such as a computerised random selection or a lottery method. A quota or stratified sample is another possible approach to probability sampling. This method is used when population subgroups are assigned specific quotas when selecting the probability sample in an effort to ensure that the subgroups' representation in the study mirror those in the population. While this is still a probability sample, this gives the researcher greater control over ensuring that the sample is not only representative of the high-level view of the population but also the stratified constituent groups that form part of the population (Du Plooy, 2011:117). The simplest way to understand probability sampling is to analyse the population's chance of being selected. Should the chance of non-selection be non-zero for all population members, then it can be seen as a probability sampling method (Keyton, 2011:124).

A probability sample has meritorious properties, as it eliminates sample bias if applied correctly. This unbiased sampling method enables the researcher to obtain a representative sample from the population and allows the findings to be generalised across the population. However, this comes at a cost, primarily in the form of a time-consuming draw of candidates and the compilation of the entire population based on the smallest possible unit of account (Du Plooy, 2011:117–120).

Further, in light of data collection through interviews, it is vital to highlight that interviewees may choose to decline to participate. This may cause problems in selecting substitute participants or create a risk of a low participation rate. In addition, the approach of randomly selecting interviewees, who may decline, could be very time-consuming and increase the research cost for the participant company in the form of lost employee time. The time is lost because it was spent without producing a tangible result for the researcher or the company due to the interviewee declining the interview, resulting in a de facto financial loss. Whilst one needs to be cognisant of such factors, they may not be a limiting factor to the research project. In the case of this research, the researcher is cognisant of the possible cost of the research to the business, but agreement was found that employees may participate during working-hours. Financial considerations may not and have not impacted academic rationale in selecting the appropriate means of data collection.

Quasi-probability sampling poses a viable alternative to such shortcomings. It may take the form of a systematic random sample or a cluster random sample. The former selects the sample from the population using a predetermined interval, which is determined to fulfil the predetermined number of desired samples. This, however, does not address the above-mentioned practical limitations. It is time-consuming and, in the case of a low participation rate, costly. This is particularly true when considering that, in this case, the sample needs to be drawn from a working and highly interlinked production environment (Du Plooy, 2011:117–120).

The stratified random sample accommodates such a production environment to a degree. Instead of including all clusters when sampling, only a predetermined percentage of clusters is used to draw the sample at random. The advantage is that the selection of clusters and samples is still largely unbiased, but the logistics of conducting the data collection can be simplified, as the size of the population is reduced because the random selection (or exclusion) of clusters reduces the population from which a sample is drawn. A key shortcoming of this method is that (similar to the simple random sample) the sample may not be representative of the clusters, as no quota on any properties is enforced when selecting the clusters to draw the sample, which is also free of quotas (Keyton, 2011:127).

The above discussion leads to non-probability sampling. These sampling methods do not compromise or limit the equality of the population in regard to their selection to form part of the sample. Despite this disadvantage, it can be argued that this sampling approach has distinct merits in particular fields. Du Plooy (2011:122) highlights communication management researchers as a group that would often be put into positions where a non-probability approach is best suited or, at times, the only viable approach to collect data from a sample. Particularly, when engaging in exploratory research, one may be faced with the need to select a non-probability sampling strategy.

The most well-known non-probability sampling method is the convenience sampling method. This method describes an approach where the units of analysis are drawn from a sample population based on the researcher's ability to access the units. No quota is enforced; therefore, the convenience sampling method does not account for specific attributes of the desired units of analysis but rather solely on availability and convenience for the researcher. This method can be applied to interviews and artefacts as units of analysis. Two perspectives exist on the use of convenience sampling: some researchers consider this a legitimate research approach under certain circumstances and when resources make using other sampling methods impossible. Another view expressed on convenience sampling is that it is an appropriate sampling method should there be no need for the results to be generalisable (Keyton, 2011:129).

This approach was, however, not selected for this study. While resources were limited, this limitation did not prohibit the selection of a suitable and widely accepted sampling method. A volunteer sample may be a viable approach to sample selection. In this case, a sample would be drawn based on instruments of analysis, such as participants offering their cooperation voluntarily. This voluntarism is often based on close knowledge of the researcher or sympathy towards the research aims. This highlights a crucial flaw in the approach, as prior relationships with the participants may introduce bias into the research. Further, social backgrounds, such as education and participation motivation, may lead to a substantial underrepresentation of target populations (Du Plooy, 2011:124).

Snowball sampling was identified as a possible approach to selecting units of analysis for this qualitative research. The name of the method alludes to a snowball rolling down a hill and collecting additional material during its rolling motion down the proverbial hill in order to identify the units of analysis or 'additional snow'. For example, persons of interest are contacted, or they contact the researcher, and they are invited to participate in the data collection process by becoming a constituent of the sample. These units of analysis (persons) would then be recruited to refer other possible interview candidates that form part of the population for the researcher to approach for inclusion in the research. This process is repeated until sufficient units of analysis are gathered to ensure data saturation (Wagner *et al.*, 2012:92).

When conducting purposive sampling, the researcher selects specific units of analysis that best represent the typical population of the study. This selection is made based on the predetermined criteria from the study's aims. This choice is based on the judgement of the criteria by the researcher and is influenced by the criteria, the researcher's knowledge of the most important characteristics of a population and the selection process. To minimise bias in the selection process, the researcher needs to possess intimate knowledge of the desired selection criteria and the members of the population to select the sample in a well-informed and unbiased manner (Keyton, 2011:132).

5.6.3 Approaching the interviewees

For this study, the initial step was identifying gatekeepers, who were able and willing to assist in the study, find other participants and serve as possible motivators for participants to join the study. As Keyton (2011:132) highlights, purposive sampling may be used for identifying and approaching gatekeepers to possibly transition into other sampling methods. The present study followed this approach. Once gatekeepers were identified and approached, they were interviewed. After the interviews, they were asked if they would name other possible candidates from the shop floor or colleagues in management. These gatekeepers were identified with assistance from ‘The Company’s’ Industry 4.0 team, utilising their relationships and knowledge of the managers and staff who are knowledgeable, in a relevant role and likely to participate and aid in the identification of further candidates. Once this process took place, the sampling method followed a snowball sampling method, with several criteria for inclusion. To ensure absolute anonymity, the persons who referred other candidates were not informed if the person declined or accepted to participate. The English introduction email template reads as follows:

Dear [Insert title and name],
My name is Dominique Pröbstl, I’m a PhD student at the University of Pretoria in South Africa. Currently, I am conducting interviews to examine the attitudes of various interest groups towards Industry 4.0. I would greatly appreciate it if I could hold an interview with you as part of my research. A one-page introduction and a letter of consent are attached to this email for your information.
The interview takes the form of a relaxed conversation on Industry 4.0. The aim is to explore the experiences and evaluations of people who are already working with this technology. I am holding interviews around the world with the goal of getting information on regional attitudes towards Industry 4.0. At the beginning of the interview, I have a few pre-determined questions prepared, which will be followed by an open conversation.
The interview takes place via Microsoft Teams. The conversation will be recorded, transcribed and pooled with all other interviews. This ensures absolute anonymity and objectivity in the evaluation of the interview responses. For this purpose, I need your signed statement of consent via email before the start of our conversation.
Could you please suggest 3 dates, that would suit you best (60 minutes each)? I will then send you a Microsoft Teams invitation from my “interview account” for one of these dates. So far, this has proven to be the simplest and almost failsafe date-setting procedure.

I’m looking forward to talking to you. If you have any questions, please do not hesitate to contact me.

Sincerely,
Dominique Pröbstl

The emails were professionally translated into the relevant languages, and an offer to conduct the interview in English, German or the interviewee's home language with the aid of an interpreter was added to all non-English and non-German emails. The initial interviewees approached were contacted via the University of Pretoria's email address, but 'The Company's' email rules resulted in the emails being classified as spam. To rectify this, 'The Company' provided a temporary email address to the researcher, highlighting him as an external partner of the company. This positively impacted the response rate, as it identified the interviewer as approved by 'The Company' and ensured that the initial engagement emails were not classified as junk mail. In addition, the researcher was given access to a remote desktop and 'The Company's' intranet from October 2020 until the last day of September 2021.

The German manufacturing facility in Berlin stipulated that approval of the 'Betriebsrat', the representation of unionised labourers, is a legal requirement before contacting any of the case organisation's employees. The 'Betriebsrat' was approached, and an online meeting was held where the study's purpose and the questions for the interviewees were presented and approved by the labour representatives. This meeting was facilitated by 'The Company's' management. No other locations required union approval for the research to commence.

5.7 DATA COLLECTION

5.7.1 <u>Interviews</u>

From December 2020 to June 2021, a total of 50 interviews were conducted with 25 management and 25 non-management staff employed by the participating company located in Berlin, Germany; Nové Zámky, Slovakia; Foshan, China; and Hillsboro, the United States of America. The interviews were conducted via electronic means and followed the semi-structured interview methodology.

As stated by Nieuwenhuis and Smit (2012:133) all interviewees must be well informed of the purpose of the research they are participating in and aware of their rights concerning the research and the use of the data. To comply with this requirement, all interviewees were provided with a research summary and were informed, in their native language, of the following:

- their rights
- the recording of the interview for later analysis
- the voluntary nature of their participation

Appendices E, F, G and H contain the introductory text and summary of the research project that were presented to all interview candidates. In addition, Appendices J, K, L and M contain the consent documents that outline the interviewees' rights and the interview process details in the native languages of the regions. All non-English documents were translated by professional translators using the English template provided by the University of Pretoria.

5.7.2 <u>Virtual semi-structured interviews</u>

An interview is a data-gathering method based on a purpose-driven, two-way conversation between the interviewer and the interviewee. The interviewer is the person seeking to gather insight into a relevant phenomenon, and the interviewee is the vessel of knowledge who shares their insights with the researcher through the interview process (Nieuwenhuis & Smit, 2012:133–135).

Physical restrictions due to COVID-19 necessitated using electronic means to communicate with the potential interviewees and liaison staff at the participating company. All interviews were conducted using the following electronic meeting applications:

- Google Meet
- Microsoft Teams
- Apple FaceTime
- Meta WhatsApp (solely for communication with the liaison staff of the participating staff)

The years 2020 and 2021 were marked by a sudden and unexpected transition toward digital work communication due to COVID-19 travel restrictions. The interviews were conducted in the context of fast-evolving information technology (I.T.) infrastructure and the frequent adaptation of the participating company's I.T. security policy. Initial interviews were conducted via Google Meet, but updated I.T. policies necessitated the transition to Microsoft Teams for the remaining interviews. Once approved by the participating company's management, the researcher was provided with an external partner Microsoft Teams account that enabled the researcher to interact with all interviewees without I.T. limitations.

5.7.3 Interview engagement guide

Nieuwenhuis and Smit (2012:133) outline interview guidelines followed by the researcher to develop the interview schedule and conduct the online interviews.

When questioning the interviewee, leading questions and formulations that evoke yes or no answers with no further need for engagement must be avoided. The questions posed to the interviewee should be short and precise, as long and complex formulations may limit the usefulness of the answer because the interviewee may solely focus on a singular aspect of the question and ignore the other aspects of the long question. The interview must be as short as possible to limit inconvenience to the interviewee and ensure they remain focused. In addition, trivial questions must be avoided. The interviewer needs to be a careful listener and avoid sounding confrontational or accusatory when asking follow-up questions (Nieuwenhuis & Smit, 2012:133).

When inviting potential interviewees to participate in research, the researcher needs to ensure that all interviewees hold information that the research endeavour is designed to explore. All interviewees need to give their informed consent prior to participating and be informed of the purpose of the research. The informed consent and information documents provided to the interviewees can be found in Annexes 5, 6, 7, 8, 9, 12, 13, 14 and 15. The interviewer should not impose their ideas and values upon the interviewees or criticise the interviewee, as this can limit interviewee cooperation. This would undermine the purpose of the research, which is to understand a phenomenon. Developing rapport and gaining the interviewees' trust is also vital for extracting all available data from the interviewees (Nieuwenhuis & Smit, 2012:133).

Saldaña (2011:39) suggests always remaining courteous and sympathetic during the interview process. The interviewer should also give the interviewee some insight into the logistics of the research process and share some personal background to demystify the research process and the interviewer. This was done throughout the interview series.

5.7.4 <u>Data collection instrument</u>

The interview schedule for the management staff consisted of 26 items, followed by the opportunity for follow-up questions on statements made by the interviewee, situational conversation and the termination of the interview. For non-management staff, the interview schedule consisted of 30 items, followed by the opportunity for follow-up questions on statements made by the interviewee, situational conversation and the termination of the interview. Both schedules were available in English and German. Interviews conducted in other languages were performed with the services of a live translator. For further information, please see the language section of this document. All items related to the primary research question and secondary research questions, as shown in the following tables.

Of the seven secondary research questions, Research Question 1 and Research Question 6 are associated with items developed solely for and presented to the management staff interviewees. While management staff and non-management staff perceptions are explored by Research Questions 3, 4 and 5, it is paramount to note that some items vary between the two interviewee groups and, therefore, all items presented to interviewees will be presented separately for the respective sample groups. In the following tables, the relevant research questions and items for the management staff sample of this research are presented:

Table 4: Research Question 1 and the associated interview items

Research Question 1	Items
How is the implementation of Industry 4.0 being perceived from a management perspective?	What is Industry 4.0 in your opinion?
	To what degree have elements of Industry 4.0 been introduced in your environment?
	What changes do you expect as a result of introducing Industry 4.0?
	What changes do you expect on production cost?
	What changes do you expect of quality?
	What changes do you expect of the speed of product development?
	How will the number of autonomous robots change in future at your facility?

Table 5: Research Question 3 and the associated interview items

Research Question 3	Items
How is Industry 4.0 altering the role of stakeholders of the organisation?	Which stakeholders do you believe will be most affected by Industry 4.0?
	Who are the most affected employee groups of Industry 4.0?
	How do you expect Industry 4.0 to affect the relations within supply chains?
	To what extent have outside institutions influenced the implementation of Industry 4.0 in your region?

Table 6: Research Question 4 and the associated interview items

Research Question 4	Items
How is Industry 4.0 altering the role of stakeholders of the organisation?	Which stakeholders do you believe will be most affected by Industry 4.0?
	Who are the most affected employee groups of Industry 4.0?
	How do you expect Industry 4.0 to affect the relations within supply chains?
	To what extent have outside institutions influenced the implementation of Industry 4.0 in your region?
	To what degree do you believe that factory work from home will be possible in future?

Table 7: Research Question 5 and the associated interview items

Research Question 5	Items
How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?	In your opinion, to what degree has the shift towards Industry 4.0 been a gradual or fast transition in your organisation?
	What are, in your opinion, current and future drivers of the change towards Industry 4.0?
	What disruptions within the organisation do you expect from Industry 4.0?
	Would you consider the 4^{th} industrial revolution to be an enabler or barrier towards increased innovation within the organisation?
	In light of 3D printing do you believe that there will be a need for factories in the future or will the consumer become the manufacturer of his/her own goods?

Table 8: Research Question 6 and the associated interview items

Research Question 6	Items
To what extent do managerial staff link the introduction of Industry 4.0 with elements of sustainability?	To what extent do you think the transition towards Industry 4.0 will impact the use of resources of your organisation?
	What are the links between the introduction of Industry 4.0 and financial sustainability?
	Do you believe Industry 4.0 will change the societal role of your business?
	Your organisation has experienced change in the past years; how do you assess the role of Industry 4.0 in reshaping your organisation's purpose?
	In your opinion, will factories without negative impact on the environment be possible in future?

In addition to the above research questions presented to management staff, the items of Research Questions 2, 3, 4, 5 and 7 were presented to non-management staff at the case facilities. The respective research questions and items developed for non-management staff are presented in the following tables:

Table 9: Research Question 2 and the associated interview items

Research Question 2	Items
How is the implementation of Industry 4.0 being perceived from a non-management perspective?	Have you heard of Industry 4.0?
	What is Industry 4.0 in your opinion?
	Has the amount of autonomous machinery changed?
	Are you using more digital and physical means to achieve your production tasks?
	What changes do you expect as a result of introducing Industry 4.0?
	What changes in respect of product quality have you witnessed?
	Have you witnessed a change of pace of product development?
	Do you believe that the amount of autonomous robots will change in future?

Table 10: Research Question 3 and the associated interview items

Research Question 3	Items
How is Industry 4.0 altering the role of stakeholders of the organisation?	Which group of persons will be most affected by this change to Industry 4.0?
	Who are the most affected employee groups of Industry 4.0?
	Is Industry 4.0 a tool for you to widen your responsibilities to extend beyond your own organisation?
	To what extent have outside institutions influenced the implementation of Industry 4.0 in your region?
	When Industry 4.0 was introduced, what outside groups participated in the introduction?
	Do you expect pushback from employees to the implementation of Industry 4.0?

Table 11: Research Question 4 and the associated interview items

Research Question 4	Items
How can change management programmes facilitate the implementation of Industry 4.0 on non-managerial level?	In your opinion, to what degree has the shift towards Industry 4.0 been a gradual or fast transition in your organisation?
	Who or what, from your perspective, is driving the implementation of Industry 4.0?
	Can you describe dramatic changes in your work and your environment as a result of the change towards Industry 4.0?
	How do the Industry 4.0 tools that you use enable you to innovate your work processes without outside input?
	Will there be a need for factories in their current form in future or will at consumers become the manufacturers of goods (using 3D printing for example)?

Table 12: Research Question 5 and the associated interview items

Research Question 5	Items
How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?	How were the changes of Industry 4.0 introduced to you?
	How did your managers communicate this change to you?
	Do you believe that the way in which you communicate with colleagues and managers will change as a result of Industry 4.0?
	How will Industry 4.0 bring you closer to your managers and colleagues or make it more difficult to communicate with them?
	To what degree do you believe that factory work from home will be possible in future?

Table 13: Research Question 7 and the associated interview items

Research Question 7	Items
To what extend do non-managerial staff link the introduction of Industry 4.0 with elements of sustainability?	Has the introduction of Industry 4.0 reduced wastages in production?
	Do you believe that Industry 4.0 makes operations more efficient?
	Do you think Industry 4.0 reduces production costs?
	In your opinion, what is the role of private organisations in addressing possible societal effects of the 4th industrial revolution?
	The company has seen change in the past years; can you describe these and relate them to Industry 4.0?
	In your opinion, will factories without negative impact on the environment be possible in the future?
	Note: Opportunity for open conversation with interviewee and to follow-up on statements made before concluding interview.

5.7.5 Language

A key element in the interview process is the language in which the interview is conducted. In this research, interviews were held in English and German without a translator with all interviewees who indicated that they wished to participate in the interview in one of these languages. The services of a translator were used in all interviews conducted with participants who indicated their desire to communicate in a language other than English or German. The majority of interviewees were native English or German speakers. The need for live translator services was limited to some interviews with Chinese and Slovak interviewees, as highlighted in Tables 15 and Table 16.

Saldaña (2021:54–55) states that using interpreters to facilitate the interview process is an advantageous choice if the researcher is not fluent in the interviewees' language of choice. It can facilitate clear communication with the interviewee. The translator also serves as a medium familiar with the interviewees' culture to ensure that intercultural miscommunication is avoided. In their role as facilitators of communication between parties who do not share a common language, and, often, a common culture, translators serve as analysts of language and culture in relation to the final analysis language (Saldaña, 2021:54–55).

For the 50 interviews, two live translators were contracted to act as facilitators for the exchange. Translator 1 was a native Slovak with extensive translation experience in live translations of Slovak to English and vice versa. A further factor that led to the selection of this particular translator was their ability to facilitate the interviews online within a two-hour notice period. The short notice availability was an important attribute, as the interviews with the non-management staff were conducted during working hours in a factory. Translator 2 was a Hong Kong-based translator with translation experience in live translations of Chinese to English and vice versa. The interviews in China were in Foshan; therefore, a regional peculiarity influenced the selection of a translator for the Chinese interviews. The Foshan region is on the border of Mandarin Chinese- and Cantonese Chinese-dominant regions; as a result, a translator fluent in both Chinese languages was of paramount importance.

The translators were contacted, interviewed and contracted using the services of Upwork, an e-commerce freelancing platform with a large pool of freelance service providers. The freelance staff selection was grounded in the need for close cooperation with the live translators during all relevant interviews, which is best negotiated directly with the freelance staff. The physical limitations during the interview period due to COVID-19 restrictions made the online service the most feasible choice to contract translators without the need for in-person meetings and cross-border travel.

5.7.6 Recording and transcription of data

All 50 interviews were recorded using the screen recording feature of the Apple Mac. This was done with the interviewees' consent, as stipulated in the consent form. It was necessary to record the interviews to facilitate the later transcription of the interviews. This is the preferred method of documenting interviews for later analysis, as recording audio and video captures sufficient aspects of the exchange between the interviewer and interviewee, unlike other methods, such as note taking (Saldaña, 2011:34–39).

Further, while Saldaña (2011:39) states that the presence of recording equipment may cause some interviewees discomfort, it can be argued that using digital platforms to conduct interviews can reduce this discomfort, as the recording process is substantially less intrusive when compared with analogue recording equipment. The transcripts serve as the source documents for coding the raw data.

All interviews were transcribed by native speakers of the respective languages. The transcription and translation of the original responses of the interviews that were conducted with the aid of live translators were outsourced to the respective translators who facilitated the interviews. Translator 1 transcribed and translated all Slovak language interviews. Translator 2 transcribed and translated all Mandarin and Cantonese Chinese language interviews. Where possible, the researcher checked the accuracy of the transcription of the interviews at least twice by listening to the recordings while reading along with the transcripts and rectifying any human errors. All interviews were transcribed by humans, because artificial intelligence transcription technology cannot pick up on the nuances of accents and variations in sound quality in recordings, it is unacceptable for academic purposes (Saldaña, 2011:34–39).

5.7.7 Interview timeline

The first interviews were held with employees who volunteered in December 2020, and the interview series concluded in June 2021.

Table 14: Interview code, timeline and interview language in Germany

Interview Code	Language	Interview Date
Interview DE 1 Management	DE	18.12.2020
Interview DE 2 Management	DE	23.11.2020
Interview DE 3 Management	DE	18.01.2021
Interview DE 4 Management	DE	23.12.2020
Interview DE 5 Management	DE	07.01.2021
Interview DE 6 Management	DE	27.01.2021
Interview DE 7 Management	DE	11.02.2021
Interview DE 8 Management	DE	17.02.2021
Interview DE 9 Management	DE	12.04.2021
Interview DE 10 Management	DE	03.06.2021
Interview DE 1 Non-Management	DE	3.12.2020
Interview DE 2 Non-Management	DE	09.02.2021
Interview DE 3 Non-Management	DE	09.02.2021
Interview DE 5 Non-Management	DE	19.04.2021
Interview DE 4 Non-Management	DE	18.02.2021
Interview DE 8 Non-Management	DE	21.04.2021
Interview DE 9 Non-Management	DE	22.04.2021
Interview DE 7 Non-Management	DE	21.04.2021
Interview DE 6 Non-Management	DE	20.04.2021
Interview DE 10 Non-Management	DE	03.05.2021

Table 15: Interview code, timeline and interview language in Slovakia

Interview Code	Language	Interview Date
Interview SK 2 Management	DE	28.01.2021
Interview SK 1 Management	EN	12.01.2021
Interview SK 5 Management	DE	05.05.2021
Interview SK 4 Management	EN	02.03.2021
Interview SK 3 Management	SK-EN	25.02.2021
Interview SK 1 Non-Management	EN	18.03.2021
Interview SK 4 Non-Management	EN	08.04.2021
Interview SK 2 Non-Management	SK-EN	24.03.2021
Interview SK 3 Non-Management	SK-EN	15.04.2021
Interview SK 5 Non-Management	EN	22.04.2021

Table 16: Interview code, timeline and interview language in China

Interview Code	Language	Interview Date
Interview CN 1 Management	EN	12.03.2021
Interview CN 3 Management	EN	30.04.2021
Interview CN 4 Management	EN	17.05.2021
Interview CN 5 Management	CN-EN	19.05.2021
Interview CN 2 Non-Management	CN-EN	01.04.2021
Interview CN 1 Non-Management	EN	30.03.2021
Interview CN 3 Non-Management	CN-EN	28.04.2021
Interview CN 5 Non-Management	EN	20.05.2021
Interview CN 4 Non-Management	CN-EN	18.05.2021
Interview CN 2 Management	EN	22.04.2021

Table 17: Interview code, timeline and interview language in the USA

Interview Code	Language	Interview Date
Interview US 3 Management	EN	21.04.2021
Interview US 4 Management	EN	12.05.2021
Interview US 2 Management	EN	02.04.2021
Interview US 5 Management	EN	26.05.2021
Interview US 1 Management	EN	01.04.2021
Interview US 4 Non-Management	EN	25.05.2021
Interview US 2 Non-Management	EN	18.05.2021
Interview US 3 Non-Management	EN	21.05.2021
Interview US 1 Non-Management	EN	20.04.2021
Interview US 5 Non-Management	EN	08.06.2021

5.8 METHOD OF DATA ANALYSIS

5.8.1 Themes and categories

The coding process for this research project followed the guidelines outlined by Saldaña (2021) in '*The coding manual for qualitative researchers*'. Coding is the analytical process in qualitative research of assigning a phrase or summative word that accurately captures the attributes of a statement in a document or recording. The code is the phrase or summative word that captures the attributes of the source document or recording. This is done to aid the systematic process of turning input data from the source documents into information that informs the research questions of the research project (Saldaña, 2021:51).

Codes are said to be a group of interpretations of the raw data used to symbolise the meaning of the raw data for later pattern detection or to create support themes, categories or theories (Saldaña, 2021:51–52).

While it is suggested that coding in the original language of the interview is preferred, numerous academics have found suitable approaches to code translated content in a single language. In cases where it is impossible to code in all the original interview languages, as in this research project, it is suggested to use a single language for the coding processes (Saldańa, 2021:53–55).

This approach was followed, and all codes were developed in English, and all transcripts were coded in English. Some interviews were conducted in languages the researcher does not speak and, therefore, the researcher needed to use the English transcripts of all the interviews.

Saldaña (2021:87–94) suggests that the first coding cycle is the initial act of assigning high-level codes to the data in the source document in units ranging from single words to entire paragraphs or statements. During the second coding cycle, the researcher addresses the codes assigned in the first round of coding to create further nuanced segregation and synthesis of meaning that lead to the insights needed to address the research questions in the social and cultural contexts. A list of all codes applied to the 50 interview transcripts can be found in Appendix N.

The codes for the initial coding cycle were predetermined and informed by the literature review. This type of coding is known as a priori coding. This approach to coding is a well-established method of extracting meaning from data for research driven by theory and aims to target defined phenomena and experiences that are certain to be contained in the data being analysed (Saldaña, 2021:98).

For the second coding cycle, informed changes may be made based on insights gained from the first coding cycle. This would lead to the maximisation of utility for the data analysis.

5.8.2 Computer-assisted qualitative data analysis software

All transcribed and translated (where applicable) interview transcripts were systematised using the ATLAS.ti 9 software for Mac. ATLAS.ti is a computer-assisted qualitative data analysis software that aids in the data systematisation process for qualitative research. The program automatically updates the code list of all documents in real time without any action needed from the researcher other than creating the codes in the document. The software offers an auto-coding feature that was not used due to the various input languages in the 50 source interview transcripts and the resultant lack of language commonality (Saldaña, 2021:50–53).

All data in MS Word format was segmented in Atlas.ti 9 into management and non-management staff and by the interview participants' geographical locations. Each MS Word file contained a single interview transcript. All data was arranged by participant rather than by question in the interview schedule. All interview transcript files were labelled to highlight the most crucial attributes of the interview. The format was as follows: The term 'Interview' was followed by the chronological number of the interview in the region and the corporate hierarchy, followed by the geographical identifier and the interviewees' position in the corporate hierarchy. The regional identifiers were:

- All interviews of employees in Germany were labelled DE
- All interviews of employees in Slovakia were labelled SK
- All interviews of employees in the USA were labelled US
- All interviews of employees in China were labelled CN

The interviewees' position in the organisational hierarchy was labelled as 'management' for all staff identified by the company as members of management, and 'non-management' for all employees that formed part of the company's non-management staff. All interview transcripts were grouped into the following document groups in Atlas.ti 9 for the purposes of data systematisation:

- 'Management' contains all management interview documents.
- 'Non-management' contains all non-management interview documents.
- 'Germany management' contains all management interview documents from Germany.
- 'Germany non-management' contains all non-management interview documents from Germany.

- ‘Slovakia management’ contains all management interview documents from Slovakia.
- ‘Slovakia non-management’ contains all non-management interview documents from Slovakia.
- ‘USA management’ contains all management interview documents from the United States of America.
- ‘USA Non-management’ contains all non-management interview documents from the United States of America.
- ‘China management’ contains all management interview documents from China.
- ‘China non-management’ contains all non-management interview documents from China.

5.9 CONCLUSION

The above sections discussed the methodology this study followed and highlighted the detailed steps taken to follow an ethical research approach. Undoubtedly, a rational approach to research design and disciplined execution of the methodological plan formulated are vital elements of any study. In this chapter, the rationale for the choices made in the research design was presented and formed the basis of the data collection method followed. The choices made include the selection of the qualitative research approach for this exploratory research study. Using snowball sampling interview partners at facilities of “The Company” have been identified and approached until a total of 50 interviews have been conducted. The data collection is conducted using semi structured interviews in manufacturing sites in Germany, Slovakia, the US and China. In the next chapter, the findings obtained through the analysis of the 50 interviews held in 2020 and 2021 are presented in a structured manner.

CHAPTER 6

6 PRESENTATION OF FINDINGS

6.1 INTRODUCTION

In the following chapter, the findings of the 50 semi-structured interviews held with staff experiencing the introduction of Industry 4.0 at their respective manufacturing facilities are presented. To ensure the comparability of data obtained at the respective locations, this section is heavily reliant on the use of tables. All tables follow the same format for each respective region. The final section of this chapter presents the combined data of all four facilities.

A total of 14 distinct themes have been identified in the data. All codes developed for the analysis of the data with the aid of Atlas.ti. have been grouped into these themes. The themes of this study are as follows:

- Theme 1: Employees associating Industry 4.0 with specific technologies
- Theme 2: Factors affecting the implementation of Industry 4.0
- Theme 3: Future implementation of Industry 4.0
- Theme 4: Industry 4.0 affecting the social context environment
- Theme 5: Industry 4.0 affecting the environmental context environment
- Theme 6: Industry 4.0 affecting the financial context environment
- Theme 7: Industry 4.0 affecting the purpose context environment
- Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders
- Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affecting some stakeholders
- Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform
- Theme 11: Employee experience of implementation of Industry 4.0
- Theme 12: Industry 4.0 is introduced through the use of change communication
- Theme 13: Changes in internal communication are experienced by staff
- Theme 14: Employees are perceiving a change towards the virtual workplace

The themes of this research project have further been segregated into categories which summarise the relevant codes applied to the raw data in the source documents. The categories of theme 1 are as follows:

Category 1: Industry 4.0 can be defined through Industry 4.0 constituent technologies
Category 2: Proprietary technologies identified by staff as Industry 4.0 technologies
Category 3: Generic technologies identified by staff as Industry 4.0 technologies

Theme 2 consists of a total of four categories that address the factors affecting the implementation of Industry 4.0, which are as follows:

Category 1: Machine compatibility with Industry 4.0 technologies
Category 2: Labour resources affecting the implementation of Industry 4.0 technology
Category 3: Availability of corporate resources to the implementation process of Industry 4.0 technology
Category 4: Expected future changes of Industry 4.0 technologies

Theme 3 is made up of two categories relating to interviewees' expectation towards the future introduction of Industry 4.0. These categories are:

Category 1: Expected future changes of Industry 4.0 technologies
Category 2: No expected future changes of Industry 4.0 technologies

Theme 4 is made up of five categories relating to the social context environment in relation to Industry 4.0. These categories are:

Category 1: Industry 4.0 alters the scope of workers' responsibilities
Category 2: Industry 4.0 is associated with a change in workers' tools
Category 3: Industry 4.0 is associated with a change in the independence of their work activities
Category 4: Industry 4.0 is associated with a change the degree of worker cooperation
Category 5: Industry 4.0 impacts workers' safety

Theme 5 is made up of three categories relating to the environmental context environment in relation to the introduction of Industry 4.0. These categories are:

Category 1: Constructive correlation between Industry 4.0 and environmental sustainability
Category 2: Non-constructive correlation between Industry 4.0 and environmental sustainability
Category 3: No correlation between Industry 4.0 and environmental sustainability is identifiable

Theme 6 is made up of seven categories relating to the financial context environment in relation to Industry 4.0. These categories are:

Category 1: Industry 4.0 has a link to the company's financial position
Category 2: Industry 4.0 has a link to innovation
Category 3: Industry 4.0 has a link to product development
Category 4: Industry 4.0 has a link to product quality
Category 5: Industry 4.0 has a link to the supply chain
Category 6: Industry 4.0 influences organisational efficiency
Category 7: Industry 4.0 influences operational competitiveness

Theme 7 is made up of four categories relating to the purpose context environment in relation to Industry 4.0. These categories are:

Category 1: Corporate responsibility to upskill the workforce in context of Industry 4.0
Category 2: Industry 4.0 impacts the societal purpose of the case organisation
Category 3: Industry 4.0 influences the case organisation's region
Category 4: Change in manufacturing sites due to Industry 4.0 technology

Theme 8 is made up of four categories relating to Industry 4.0 and a beneficial change for stakeholders. These categories are:

Category 1: The workforce is positively affected by Industry 4.0 based on skill
Category 2: The workforce is positively affected by Industry 4.0 based on age
Category 3: The workforce is positively affected by Industry 4.0 based on adaptability

Category 4: Various stakeholders are affected positively by the implementation of Industry 4.0

Theme 9 is made up of four categories relating to Industry 4.0 and a negative change for stakeholders. These categories are:

Category 1: The workforce is negatively affected by Industry 4.0 based on skill
Category 2: The workforce is negatively affected by Industry 4.0 based on age
Category 3: The workforce is negatively affected by Industry 4.0 based on adaptability
Category 4: Various stakeholders are affected negatively by the implementation of Industry 4.0

Theme 10 is made up of three categories relating to the pace of implementation of Industry 4.0. These categories are:

Category 1: Fast-paced implementation of Industry 4.0
Category 2: Slow-paced implementation of Industry 4.0
Category 3: The rate of implementation of Industry 4.0 is not identifiable

Theme 11 is made up of three categories relating to the introduction of Industry 4.0. These categories are:

Category 1: Entities associated with the implementation of Industry 4.0
Category 2: Change in the organisation is identifiable
Category 3: Resistance to the change toward Industry 4.0

Theme 12 is made up of three categories relating to the role of communication in the introduction of Industry 4.0. These categories are:

Category 1: A variety of communication channels are utilised to communicate the changes associated with the introduction of Industry 4.0
Category 2: Messaging towards staff during the introduction of Industry 4.0
Category 3: Identified shortcomings of communicating the introduction of Industry 4.0

Theme 13 is made up of five categories relating to the change in communication due to the introduction of Industry 4.0. These categories are:

Category 1: Human communication is shaped by the introduction of Industry 4.0
Category 2: Digital communication has affected the accessibility of co-workers in the work environment
Category 3: Digital communication has affected the formality of communication at the workplace
Category 4: Digital communication has changed the internal communication
Category 5: Digital communication has influenced the transparency of data

Theme 14 is made up of four categories relating to the role of the home office in the introduction of Industry 4.0. These categories are:

Category 1: Experience with the home office
Category 2: Expectation towards the future implementation of home office work
Category 3: Employee experience of home office work
Category 4: Employee attitude towards home office work

In the following section, the data of the entire study, in all four regions, is presented. First, data from the German case facility is presented. Second, data from the Slovakian case facility is presented. Third, data from the United States case facility is presented. Fourth, data from the Chinese case facility is presented.

Atlas ti was utilised to systematise the raw data collected for the data analysis process of the data generated through the interview process and the transcription of these interviews. Patterns in the data are highlighted using Atlas ti software and these are presented in this chapter in the form of tables. The following chapter heavily relies on tables for the presentation of findings in an effort to maximise data transparency and uniformity of the presentation of findings. The first column of the tables in this chapter relates to the code used to systemise the data. This code represents the essence of all statements associated with the specific code in the respective region. The second column highlights the most frequent co-occurrences of specific codes in statements of management and non-management staff in the respective sub-columns. The total number of co-occurring codes in statements are highlighted by a number in brackets that corresponds to the total co-occurrence of specific codes in the relevant region. Using Atlas ti to systemise data for ease of analysis, the sum of a specific code in a cluster of documents can be illustrated. The total number of statements in a region that are associated with a specific code are highlighted in the third column of the tables of this section. The total number of statements is separated into management and non-management statements. The separation of codes for management and non-management staff eases the identification of commonalities and divergences in attitudes between management and non-management staff.

This format is followed throughout this chapter except for section 6.2. As discussed in Chapter 5, the German facility has two constituent sub facilities from which non-management interviewees were drawn. Sub-columns marked as ‘Non-management 1’ or ‘NM 1’ refer to findings from data generated through interviews with non-management staff of a manufacturing line that has been upgraded to Industry 4.0 standard. Sub-columns marked as ‘Non-management 2’ or ‘NM 2’ refer to findings from data generated through interviews with non-management staff of a manufacturing line that incorporates Industry 4.0 technologies form the time it has been installed.

6.2 FIELDSTUDY 1 (GERMANY)

In the following section findings from the German case facility are presented based on the 14 themes identified for data analysis.

6.2.1 Theme 1: Employees associating Industry 4.0 with specific technologies

The number of statements associated to the individual codes that highlight the employees’ association of Industry 4.0 with specific technologies are set out in the following tables. In addition, the most frequent co-occurrence of statements throughout the interviews at the German facility are highlighted below. Industry 4.0 is an amalgamation of several technologies and can be identified through the use of generic terminology or proprietary technologies. German management staff show a strong familiarity with the term Industry 4.0 and statements made by management staff demonstrate a link of autonomous machinery and the expectations of quality improvements at the respective facility. Non-management staff statements share this association of Industry 4.0 with autonomous machinery at the facility which has been upgraded to Industry 4.0 standard. The strong association of Industry 4.0 and autonomous machinery cannot be linked with statements made by non-management staff at the facility that was introduced with Industry 4.0 technology from its conception. Both management and non-management staff often cite the TicketManager technology. Management and non-management staff statements indicate a link of the TicketManager to changes in communication and change communication.

The number of statements associated to the individual codes that highlight the employees' association from the German case facility of Industry 4.0 with specific technologies are set out in the following three tables. In addition, the most frequent co-occurrence of statements throughout the interviews in Germany are highlighted below. First, the data highlighting the perceived initial understanding of constituent technologies of Industry 4.0 from a management and non-management perspective is presented in Table 18.

Table 18: Industry 4.0 can be defined through Industry 4.0 constituent technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Initial understanding of Industry 4.0	Autonomous machinery, Positive impact of Industry 4.0 on product quality (4)	Autonomous machinery (4)		17	6	4
Employee knows of Industry 4.0				0	5	5
Employee does not know of Industry 4.0				0	0	0

Table 19 illustrates the proprietary technologies identified by management and non-management staff of the German facility.

Table 19: Proprietary technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Camline				0	0	0
Camstar			TicketManager (3)	1	0	10
HoloLens	Use of digital communication means (4)		Increased collaboration of workers due to Industry 4.0 technologies (3)	12	0	4
My QI				0	0	0
QRQC				0	0	0
TicketManager	Machine–human cooperation, Resistance to the introduction of Industry 4.0 (8), Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations, Use of digital communication means (5)	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (5), Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations, Negative impact of Industry 4.0 on product quality (4)	Channels utilised to communicate changes, Communication of Industry 4.0 related changes (8), Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (4)	34	20	21

Technology can be referred to with reference to specific brand names or through the use of generic terms of technology. Table 20 illustrates the identified generic technologies and statements with high co-occurrence to these technologies at the German case facility.

Table 20: Generic technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
3D printing	Expected changes to the form of factories (5)	No expected changes to the form of factories (3)	No expected changes to the form of factories (3)	14	5	7
5G	Supportive external influencers on the implementation of Industry 4.0 (2)			6	1	0
Augmented reality	Use of digital communication means (3)			6	0	0
Autonomous machinery	Initial understanding of Industry 4.0, Machine learning / artificial intelligence (4)	Initial understanding of Industry 4.0 (4)	Big Data (3)	15	20	8
Big Data	Increased transparency of data due to digital communication, Machine learning / artificial intelligence, Positive effect on product development, Positive impact of Industry 4.0 on product quality (2)	Initial understanding of Industry 4.0 (2)	Autonomous machinery (3)	11	4	10
Machine learning / artificial intelligence	Autonomous machinery, Positive impact of Industry 4.0 on product quality (4)	Autonomous machinery (2)		10	3	1
Machine–human cooperation	TicketManager (8)	TicketManager (3)		11	5	4
MES systems				1	0	3
Cloud computing				3	0	1
Cobots	Negative impact on work safety, Supportive external influencers on the implementation of Industry 4.0 (2)			7	0	1

Internet of Things				0	0	0
Cyber-physical systems				0	0	0

6.2.2 Theme 2: Factors affecting the implementation of Industry 4.0

Theme 2 consists of codes which highlight all statements made by staff of the German facility, that feature specific factors that are perceived to affect the implementation of Industry 4.0 at the facilities. Statements of German management and non-management staff do not show a consensus on the upgradability of machinery as a similar number of statements indicate scepticism or optimism towards this issue. Statements on factors that affect the implementation of Industry 4.0 are sparse in respect to labour resources. A crucial element to the implementation of Industry 4.0 are resources. On the one hand, management and non-management staff statements show, with a narrow majority of statements, a lack of resources to implement further technologies. On the other hand, it needs to be noted that management staff statements indicate that the dedication of resources is strongly linked to financial gains.

Table 21 illustrates the perceived compatibility of existing machinery at the facility with Industry 4.0 technology and the codes with the highest co-occurrence with such statements.

Table 21: Machine compatibility with Industry 4.0 technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Old machinery is upgradable to Industry 4.0				3	2	1
Old machinery is not upgradable to Industry 4.0				2	2	0

Table 22 highlights the link between the availability or lack of labour and the labour cost for the implementation of Industry 4.0. The co-occurrence of such statements with other statements of staff of the facility in Germany is also highlighted.

Table 22: Labour resources affecting the implementation of Industry 4.0 technology

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Lack of labour availability				0	0	1
High labour costs				2	1	1
Low labour costs				0	0	0
IT literacy of stakeholder				1	0	1

The implementation of Industry 4.0 represents a high capital expense to business. The perception of resource availability and association to this is highlighted below in table 23.

Table 23: Availability of corporate resources to the implementation process of Industry 4.0 technology

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Dedicated resources for Industry 4.0	Positive financial impact of Industry 4.0 (3)			8	0	0
Lack of resources to implement Industry 4.0	No change expected of Industry 4.0 technologies at facility (2)			9	3	3

6.2.3 Theme 3: Future implementation of Industry 4.0

In Tables 24 and 25, the data that highlights the staff's expectations regarding future developments of Industry 4.0 technologies at the facilities is presented. In addition, the co-occurrence of other codes at the German facility with these statements is illustrated. Staff statements, particularly at management and non-management level at the second German facility, indicate an expectation of increased Industry 4.0 technologies in future. Some statements indicate that this increased role of technology is linked to corporate responsibility to upskill its staff to cope with the change in technology, but also that such an introduction of Industry 4.0 is associated with a possible negative impact on some staff at the facility. It is important to note that no German staff statements indicate any expectation of a decreasing role of Industry 4.0 at the facility.

Table 24: Expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Expected increase of Industry 4.0 technologies at facility	'The Company' has a responsibility to upskill its workforce, Negative impact of Industry 4.0 on undefined workforce (2)			5	1	7
Expected decrease of Industry 4.0 technologies at facility				0	0	0

Table 25: No expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
No change expected of Industry 4.0 technologies at facility	Lack of resources to implement Industry 4.0 (2)			2	1	3
No reply / No opinion on changes of Industry 4.0 technology at facility				0	0	0

6.2.4 Theme 4: Industry 4.0 affecting the social context environment

Following Schwab (2021:171), the quadruple context environment consists of the social, the natural, the economic and the governance or purpose context environment. In Tables 26 to 30, the data relating to the social context environment is presented. It can be found that many non-management staff are already experiencing a change in work tools as a result of the introduction with a minority of statements indicating contrary findings. Management staff statements demonstrate an expectation of the increased scope of workers' responsibilities due to Industry 4.0 to result in negative consequences for less-skilled staff. The TicketManager is foregrounded as a technology that is a change in work tools for staff and the HoloLens is a means to increase collaboration using Industry 4.0 technology.

Table 26 highlights the German interviewees' perceptions of the changing responsibilities of staff at the facilities due to the introduction of Industry 4.0.

Table 26: Industry 4.0 alters the scope of workers' responsibilities

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Workers experience an increased scope of responsibilities due to Industry 4.0 technologies		Negative impact of Industry 4.0 on less-skilled workforce (3)	Increased collaboration of workers due to Industry 4.0 technologies (3)	1	10	6
Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies				0	6	2

The perceptions of management and non-management staff of the German facility in regard to changing work tools due to Industry 4.0 are presented in Table 27 The frequency of code co-occurrences is also illustrated.

Table 27: Industry 4.0 is associated with a change in workers' tools

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Exposure to changes of work tools		TicketManager (4)	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations, TicketManager (3)	3	16	17

Table 28 sets out the changes in the perceived ability of workers to perform work tasks independently.

Table 28: Industry 4.0 is associated with a change in the independence of their work activities

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Increased independent work due to Industry 4.0 technologies				1	1	2
Decreased independent work due to Industry 4.0 technologies				0	0	0
No change in the degree of independent work				0	0	0

The perceived changes in workers' ability for work collaborations in the German facility are highlighted in Table 29.

Table 29: Industry 4.0 is associated with a change the degree of worker cooperation

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Increased collaboration of workers due to Industry 4.0 technologies	HoloLens, Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations, Use of digital communication means (2)		Workers experience an increased scope of responsibilities due to Industry 4.0 technologies, Increased transparency of data due to digital communication (3)	4	1	5
Decreased collaboration of workers due to Industry 4.0 technologies				0	1	1

Worker safety and the perceived change that Industry 4.0 has on this is illustrated in Table 30. The frequent code co-occurrences are also presented.

Table 30: Industry 4.0 impacts workers' safety

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact on work safety		Autonomous machinery (2)		0	2	1
Negative impact on work safety	Cobots (2)			2	1	0

6.2.5 Theme 5: Industry 4.0 affecting the environmental context environment

The environmental or natural context environment is a further element of the quadruple context environment. Staff statements' sentiment is that, whilst environmental neutrality of the manufacturing site through the use of Industry 4.0 technology is unlikely, the technology is nonetheless associated with an improvement in the manufacturing site's impact on the environment. Management staff statements on positive environmental outcomes of Industry 4.0 are often linked to improvements in the financial position of the organisation and improvements in the product quality.

In Table 31, below, the number of statements from staff of the German facility that are coded as indicating a positive correlation between Industry 4.0 and the natural context environment are highlighted. Frequent co-occurring codes are also displayed.

Table 31: Constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 has improved the factory's environmental footprint	Positive financial impact of Industry 4.0 (6), Positive impact of Industry 4.0 on product quality (5)	Factories cannot have 0 impact on the environment (2)	Positive financial impact of Industry 4.0 (4)	13	9	10
Factories can have 0 impact on the environment	Industry 4.0 has improved the factory's environmental footprint (2)			4	0	0

In Table 32, the number of statements coded as indicating a negative correlation between Industry 4.0 and the natural context environment are shown. Frequent co-occurring codes are also highlighted.

Table 32: Non-constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 has not improved the factory's environmental footprint				4	3	2
Factories cannot have 0 impact on the environment		Industry 4.0 has improved the factory's environmental footprint (2)	Industry 4.0 has improved the factory's environmental footprint (2)	4	4	3

A small number of statements indicated that no response was given to the question regarding the natural environment in connection with Industry 4.0, or an interviewee indicated no opinion on the topic. This is represented in Table 33.

Table 33: No correlation between Industry 4.0 and environmental sustainability is identifiabl

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
No Response / No opinion on Industry 4.0's impact on the environment				0	0	2

6.2.6 <u>Theme 6: Industry 4.0 affecting the financial context environment</u>

The financial context environment is a further element of the quadruple context environment. Tables 34 to 40 highlight the data gained through interviews at the German facility in relation to staff linking Industry 4.0 with the financial context environment. The table below illustrates the data linking staff statements on their perception of Industry 4.0 and the organisation's financial position. It is found that the vast majority of findings in Germany are of a positive nature. This applies to statements from management and non-management staff in

Germany. The financial repercussions of Industry 4.0 at the German facility are of particular note. A very large number of statements by management staff indicate positive experiences or expectations in relation to the organisation's financial performance as a result of increased efficiencies in the manufacturing process and improved quality of the product. At the German facility that is upgraded to Industry 4.0 standard, it needs to be highlighted that the improved financial performance of the organisation due to Industry 4.0 is linked by some management and non-management staff to a negative career development for some staff. Product development, product quality and the supply chain are regarded as a beneficiary of the introduction of Industry 4.0 in Germany.

Table 34: Industry 4.0 has a link to 'The Company's' financial position

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive financial impact of Industry 4.0	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (12), Negative impact of Industry 4.0 on undefined workforce (9), Positive impact of Industry 4.0 on product quality (8)	Negative impact of Industry 4.0 on undefined workforce (5)	Industry 4.0 has improved the factory's environmental footprint (4)	42	10	7
Negative financial impact of Industry 4.0	Dedicated resources for Industry 4.0, Positive financial impact of Industry 4.0			4	3	1
No financial Impact				1	0	0
No Response / No opinion on Industry 4.0's impact on				0	0	0

financial sustainability						

Table 35 presents the findings of statements that highlight Industry 4.0 as a driver of innovation or as a hindrance.

Table 35: Industry 4.0 has a link to innovation

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 is a driver of innovation				9	0	0
Industry 4.0 is a hindrance for innovation				0	0	0
Industry 4.0 is neither a driver nor a hindrance to innovation				1	0	0

The product is at the core of a manufacturing facility's reason of being. Table 36 highlights the findings of statements that link Industry 4.0 to a change in product development.

Table 36: Industry 4.0 has a link to product development

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive effect on product development	Big Data (2)			8	1	1
Negative effect on product development				2	0	1
No change to product development				2	3	1

Continuing from Table 36, Table 37 highlights the perceived relation of the introduction of Industry 4.0 to the quality of the product that the respective facilities produce.

Table 37: Industry 4.0 has a link to product quality

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on product quality	Positive financial impact of Industry 4.0 (8)		Camstar (2)	24	3	5
Negative impact of Industry 4.0 on product quality		Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations, TicketManager (4)		1	8	0
No change to product quality		Resistance to the introduction of Industry 4.0 (2)		2	3	0

Industry 4.0 is regarded as changing the dynamics in supply chains. In Table 38, the perceptions of the introduction of Industry 4.0 and the links to changes in the supply chain are highlighted.

Table 38: Industry 4.0 has a link to the supply chain

CODE	Frequent co-occurrence		Grounded			
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on the supply chain	Willingness to share data within the supplychain (4)			11	1	0
Negative impact of Industry 4.0 on the supply chain				1	0	0
Industry 4.0 has no impact on the supply chain				2	0	0

One of many factors which determines the financial performance of an organisation is organisational efficiency. The findings of perceived links between Industry 4.0 and organisational efficiency are illustrated in Table 39.

Table 39: Industry 4.0 influences organisational efficiency

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.	Positive financial impact of Industry 4.0 (12)	TicketManager (5)	TicketManager (4)	34	11	16
Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations	Resistance to the introduction of Industry 4.0, TicketManager (2)	Negative impact of Industry 4.0 on product quality, TicketManager (4)		4	8	1

In most economies organisations are driven by competition in their respective market, but manufacturing facilities are also experiencing competition amongst each other within a single organisation. The table below presents the findings on the perceived link between the introduction of Industry 4.0 and operational competitiveness.

Table 40: Industry 4.0 influences operational competitiveness

	Frequent co-occurrence		Grounded		
CODE	**Management**	**Non-management**	**M**	**N-M I**	**N-M II**
Improved competitiveness of facility due to Industry 4.0			**0**	**0**	**1**

6.2.7 Theme 7: Industry 4.0 affecting the purpose context environment

The final dimension of the quadruple context environment is the purpose or governance environment. It is of note that a substantial proportion of statements by German management and non-management staff indicate a corporate responsibility towards upskilling staff to cope with Industry 4.0 technologies. A sole statement of a non-management staff differs from this consensus. Whilst some management staff do expect the form of factories to be reshaped by the advent of additive manufacturing, non-management staff do not share this assessment.

In Tables 41 to 44, the links between the context environment and the introduction of Industry 4.0 are presented. Below, the responses to the perceived responsibility of the organisation to upskill its workers in light of the implementation of Industry 4.0 are presented.

Table 41: Corporate responsibility to upskill workforce in context of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
'The Company' has a responsibility to upskill its workforce	Resistance to the introduction of Industry 4.0 (3), TicketManager, Expected increase of Industry 4.0 technologies at facility (2)	Communication of Industry 4.0 related changes, Resistance to the introduction of Industry 4.0 (2)		6	3	5
'The Company' has no responsibility to upskill its workforce				0	1	0

Table 42 shows the perceived change or lack or change in the societal purpose of the organisation due to the implementation of Industry 4.0.

Table 42: Industry 4.0 impacts the societal purpose of the case organisation

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 has changed the purpose of 'The Company'				3	0	0
Industry 4.0 has not changed the purpose of 'The Company'				0	0	0
Positive change in the societal role of 'The Company'				1	0	1
Negative change in the societal role of 'The Company'				2	1	2
No reply / No opinion on the societal role of 'The Company'				0	0	0

All statements made at the German facility that relate to the perceived influence that the implementation of Industry 4.0 will have on the German case facilities' region are presented in Table 43 below.

Table 43: Industry 4.0 influences the case organisation's region

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Impact of Industry 4.0 on the region				1	0	0

Table 44 highlights the expected change to the manufacturing sites due to the implementation of Industry 4.0. A particularly strong co-occurrence with additive manufacturing techniques is noted.

Table 44: Change in manufacturing sites due to Industry 4.0 technology

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Expected changes to the form of factories	3D printing (5)			11	0	1
No expected changes to the form of factories	3D printing (2)	3D printing (3)	3D printing (3)	4	3	3

6.2.8 Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders

The introduction of Industry 4.0 will affect the stakeholders of the organisation. The data on the altering of stakeholder roles due to the introduction of Industry 4.0 is presented in the following tables with a particular focus on those stakeholders whose roles are positively altered by the introduction of Industry 4.0. In relation to positive expectations or experiences of management and non-management staff at the German case facility, it is of note that the main benefactors of staff are those that are regarded as highly skilled. Some management staff statements also list the TicketManager as a possible means to benefit less skilled staff to perform work tasks previously beyond their means. In Table 45, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 45: The workforce is positively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on skilled workforce	Negative impact of Industry 4.0 on less-skilled workforce (4)			12	3	5
Positive impact of Industry 4.0 on	Industry 4.0 has or will have a positive effect on the efficiency of			4	1	2

less-skilled workforce	the organisation's operations, TicketManager					

In Table 46, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on age group.

Table 46: The workforce is positively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on old-aged employees				0	0	0
Positive impact of Industry 4.0 on young-aged employees				0	0	2

In Table 47, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based perceived adaptability.

Table 47: The workforce is positively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on persons who are willing to accept change				0	0	0

Statements with no clear stakeholder identification but highlighting a positive impact on stakeholder are presented in Table 48.

Table 48: Various Stakeholder are affected positively by the implementation of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive impact of Industry 4.0 on undefined workforce			Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (2)	2	0	6
Positive impact of Industry 4.0 on other stakeholders				2	0	0
No negative impact on stakeholders				1	2	0
No reply / No opinion on the impact of Industry 4.0 on stakeholders				0	0	0

6.2.9 Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affects some stakeholders

As previously stated, the introduction of Industry 4.0 will affect the stakeholders of the organisation. This can be positive for some stakeholders but could be negative for others. Having presented the perceived internal stakeholders that will benefit from the introduction of Industry 4.0, those that are perceived to be less well-off will now be presented. The data that presents the statements of perceptions of stakeholder roles that will be negatively affected by the introduction of Industry 4.0 is presented in the following tables. A clear trend of statements that indicate a negative experience or expectation for the less skilled staff at the German case facility. In addition to the expectation of negative impacts on those who are seen as less skilled, statements are often linked with those that highlight the positive impact that Industry 4.0 has on the skilled group of staff.

In Table 49, the staff groups that are negatively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 49: The workforce is negatively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Negative impact of Industry 4.0 on skilled workforce				3	0	0
Negative impact of Industry 4.0 on less-skilled workforce	Positive impact of Industry 4.0 on skilled workforce (4)	Resistance to the introduction of Industry 4.0 (6)		20	16	6

Table 50 presents, based on age, the staff groups that are negatively affected by the introduction of Industry 4.0.

Table 50: The workforce is negatively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Negative impact of Industry 4.0 on old-aged employees				0	0	3
Negative impact of Industry 4.0 on young-aged employees				0	0	0

In Table 51, the staff groups that are negatively impacted by the introduction of Industry 4.0 are presented based on perceived adaptability.

Table 51: The workforce is negatively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Negative impact of Industry 4.0 on persons who are not willing to accept change				0	0	0

Not all statements in the interviews make direct reference to stakeholder groups but instead highlight negative implications on stakeholders. These are presented in Table 52.

Table 52: Various Stakeholder are affected negatively by the implementation of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Negative impact of Industry 4.0 on undefined workforce	Positive financial impact of Industry 4.0 (9)	Positive financial impact of Industry 4.0, Resistance to the introduction of Industry 4.0 (5)		16	15	3
Negative impact of Industry 4.0 on other stakeholders				1	0	0

6.2.10 <u>Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform</u>

Tables 53 to 55 present the codes and respective frequency of statements and co-occurrence of statements relating to the perceived pace of the implementation of Industry 4.0 technology at the German facility of this study. Whilst no clear consensus is found in the statements of management and non-management staff, it can be concluded that the majority of all staff statements are of the opinion that the implementation was fast paced. The majority of management staff consider the implementation of Industry 4.0 to be of a slow nature. Table 53 shows the data for the perception of a fast implementation.

Table 53: Fast paced implementation of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Implementation of Industry 4.0 was fast				4	4	2

In Table 54, statements that are contrary to the assertions of Table 53 are shown.

Table 54: Slow paced implementation of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Implementation of Industry 4.0 was slow				5	1	1

Some statements may not conform to the requirements of Tables 53 or 54. Statements that indicate no knowledge of the pace of implementation or statements that indicate an interviewee declines to comment on this are presented in Table 55.

Table 55: The rate of implementation of Industry 4.0 is not identifiable

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
No reply / No opinion on the rate of change				0	0	0

6.2.11 <u>Theme 11: Employee experience of implementation of Industry 4.0</u>

In the following section, employee experience of the implementation of Industry 4.0 is presented. This relates to the association of the implementation of Industry 4.0 in the German facility and outside organisations, the link of organisational change and the introduction of Industry 4.0 and possible resistance to the implementation of Industry 4.0. The experience of management and non-management staff at the German case facility is strongly shaped by the resistance of staff to the introduction of change at the facility. From a communication perspective it is of note that statements on the resistance to the introduction of Industry 4.0 are closely linked to the manner in which such changes are communicated towards the workforce. A further factor of note is that statements indicating the perception of a resistance towards the change to Industry 4.0 are most prevalent amongst non-management staff at the upgraded German facility. Management and non-management staff statements indicate that most external influences of Industry 4.0 are regarded as being of a supportive nature. Table 56 presents statements which identify outside organisations.

Table 56: Entities associated with the implementation of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Drivers of change towards Industry 4.0		Positive financial impact of Industry 4.0 (2)		14	6	6
Supportive external influencers on the implementation of Industry 4.0	TicketManager (3), Cobots, 5G (2)		Non-supportive external influencers on the implementation of Industry 4.0 (2)	14	9	10
Non-supportive external influencers on the implementation of Industry 4.0			Supportive external influencers on the implementation of Industry 4.0 (2)	3	0	2
No reply / No opinion on external influencers of the implementation of Industry 4.0				0	0	0

Statements on the perceived change within the case organisation and the case facility are presented in Table 57. A differentiation is made between statements that link such changes with the implementation of Industry 4.0, and those that do not.

Table 57: Change in the organisation is identifiable

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Experience of organisational change with a link to Industry 4.0		Resistance to the introduction of Industry 4.0 (4)		8	5	4
Experience of organisational change with no link to Industry 4.0				11	6	2

Table 58 is of note in this study. It presents the number of statements and the co-occurrence of statements in the case facility that indicate that a resistance to the introduction of Industry 4.0 is perceived or not perceived.

Table 58: Resistance to the change towards Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Resistance to the introduction of Industry 4.0	TicketManager (8), Communication of Industry 4.0 related changes (6)	Communication of Industry 4.0 related changes (19)		25	29	3
No resistance to the introduction of Industry 4.0				1	0	0
No reply / No opinion on				0	0	0

possible resistance to change						

6.2.12 Theme 12: Industry 4.0 is introduced through the use of change communication

This section presents the data that is linked to the implementation of Industry 4.0 and the communication perceived to facilitate this process. All staff groups at the German facility have been able to identify the communication messages and channels used to introduce Industry 4.0 at the facility. Of particular importance is the link of statements that discuss the communication of change with statements that indicate a resistance towards the introduction of Industry 4.0 amongst non-management staff at the German facility that is undergoing an upgrade process to facilitate Industry 4.0. Interestingly, management staff statements do not indicate perceived communication shortcomings; non-management staff statements indicate otherwise.

In Table 59, the number of statements relating to the use of communication channels in the communication of the implementation of Industry 4.0 are presented.

Table 59: A variety of communication channels are utilized to communicate the changes associated with the introduction of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Channels utilised to communicate changes	Communication of Industry 4.0 related changes (40)	Communication of Industry 4.0 related changes (26), Resistance to the introduction of Industry 4.0 (12)	Communication of Industry 4.0 related changes (23)	42	23	23

Table 60 presents the statements and co-occurrence of statements relating to the communication of change.

Table 60: Messaging towards staff during the introduction of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Communication of Industry 4.0 related changes	Channels utilised to communicate change (40)	Channels utilised to communicate change (26), Resistance to the introduction of Industry 4.0 (19)	Channels utilised to communicate change (23)	46	28	23

Several statements are identified that highlight perceived communication shortcomings of the introduction of Industry 4.0. Such statements are grouped in Table 61 and presented with the respective co-occurrence of statements.

Table 61: Identified shortcomings of communicating the introduction of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Perceived change communication shortcomings		Communication of Industry 4.0 related changes (5)	Channels utilised to communicate change (5), Communication of Industry 4.0 related changes (5)	0	7	7

6.2.13 <u>Theme 13: Changes in internal communication are experienced by staff</u>

Communication is used to facilitate the implementation of Industry 4.0, but this research shows that the perception of the introduction of Industry 4.0 is also linked to the change in communication due to the introduction of the novel technology at the German case facility. Undoubtably, communication has changed as a result of the introduction of Industry 4.0. Whereas management staff experience the change in communication due to the introduction of the HoloLens, the TicketManager and digital communication means, non-management staff statements at the upgraded Industry 4.0 facility in Germany highlight the decreasing role of face-to-face communication. Management staff statements also indicate a decreasing formality in communication practices and increased transparency. The latter is also asserted by non-management staff statements. Across all hierarchical levels one can assert that statements indicate an increasing reliance on digital communication means. Table 62 highlights the perception in change of face-to-face conversation, the increased use of communication means and other changes in internal communications due to increased digitalisation of the workplace.

Table 62: Human communication is shaped by the introduction of Industry 4.0

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Face-to-face communication	Outlook on the future of home office (4)		Use of digital communication means (5)	5	1	8
Use of digital communication means	TicketManager (5), HoloLens (4)		Face-to-face communication (3)	18	4	16
Change in communication as a result of digitalisation	Use of digital communication means (3)		Use of digital communication means (3)	21	6	7

A further change to be addressed in the presentation of data is the changing availability of co-workers and superiors and the change in access to these persons due to Industry 4.0. This is presented in Table 63.

Table 63: Digital communication has affected the accessibility of co-workers in the work environment

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Increased accessibility of co-workers due to digital communication			Use of digital communication means (3)	0	2	5
Decreased accessibility of co-workers due to digital communication				0	3	1

The perceived change in the formality of communication at the German case facility is presented below in Table 64.

Table 64: Digital communication has affected the formality of communication at the workplace

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Increased formality in communication due to digitalisation				1	0	0
Decreased formality in communication due to digitalisation	Positive experience with home office (3)			7	1	1
No change in formality of communication due to digitalisation				0	1	1

Table 65 presents the number of statements and the co-occurrence of statements that relate to the change in internal communication due to digital communication at the German case facility.

Table 65: Digital communication has changed the internal communication

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Industry 4.0 has a positive effect on communication			Positive experience with home office, Use of digital communication means (2)	1	0	4
Industry 4.0 has a negative effect on communication			Change in communication as a result of digitalisation, Use of digital communication means (2)	0	0	4

Data transparency is a critical element of Industry 4.0. Below, Table 66 presents the codes and co-occurrences of changes in the transparency of data within the organisation and its supply chain due to the introduction of Industry 4.0.

Table 66: Digital communication has influenced the transparency of data

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Increased transparency of data due to digital communication	Big Data, Positive impact of Industry 4.0 on the supply chain, Use of digital communication means (2)			7	3	6
Decreased transparency of data due to digital communication				0	0	1
Willingness to share data within the supply chain	Positive impact of Industry 4.0 on the supply chain (4)			7	0	0

6.2.14 Theme 14: Employees are perceiving a change towards the virtual workplace

The interviews were conducted in 2020 and 2021, during a time when travel and physical presence at the workplace was difficult for some workers. Many interviewees have worked from home, but not all. The German case facility is one in which home office has been applied to most management roles and some non-management roles. Statements from the majority of staff that have experienced home office work indicate a positive experience. This includes a perception of decreased formality amongst staff. The outlook of staff towards the future of home office work varies. Some statements indicate a continuation of such practices, whereas some expect the scope of home office to be reduced in a post Covid-19 setting.

Below, in Table 67, the data on positive and negative experiences of interviewees at the German facility in regard to the home office is presented.

Table 67: Experience with home-office

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive experience with home office	Decreased formality in communication due to digitalisation, Interviewee has been in home office, Outlook on the future of home office (3)			16	4	5
Negative experience with home office				4	0	2

Industry 4.0 is expected to change the manner in which work is performed. In Table 68, the frequent co-occurrence of codes that highlight the possibility or the impossibility of home office work for factory staff is presented along with the relevant codes.

Table 68: Expectation towards the future implementation of home-office

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Positive outlook on the possibility of home office for production staff				3	4	7
Negative outlook on the possibility of home office for production staff				9	1	1
Outlook on the future of home office	Face-to-face communication (4)			17	4	7

Table 69 highlights the statements that indicate whether an interviewee has been in the home office or not.

Table 69: Employee experience of home-office work

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Interviewee has been in home office	Positive experience with home office (3)			5	0	4
Interviewee has not been in home office				1	4	3

Last, Table 70 illustrates the interviewees desire to perform their work tasks from a home office setting or if the interviewees of the German case facility prefer an office in a traditional setting.

Table 70: Employee attitude towards home-office work

CODE	Frequent co-occurrence			Grounded		
	Management	**Non-management I**	**Non-management II**	**M**	**N-M I**	**N-M II**
Interviewee wants to work from home				1	1	5
Interviewee does not want to work from home				1	1	5

6.3 FIELD STUDY 2 (SLOVAKIA)

In the following section findings from the Slovak case facility are presented based on the 14 themes identified for data analysis.

6.3.1 Theme 1: Employees associating Industry 4.0 with specific technologies

Similar to the German management, Slovak staff show a strong familiarity with the term Industry 4.0, non-management staff statements are less familiar with the term and its concepts with a single non-management staff statement indicating unfamiliarity with the term. Both management and non-management staff often cite the TicketManager, but these are not the most common statements on technology at the Slovak location. Non-management staff most frequently highlight the Camstar technology as a core technology of Industry 4.0, they also highlight additive manufacturing and Big Data. Management staff statements highlight the centrality of Big Data to the introduction of Industry 4.0. Non-management staff indicate a strong expectation of novel Industry 4.0 technologies to be linked to autonomous machinery at the Slovak facility.

The number of statements associated to the individual codes that highlight the employees' association of Industry 4.0 with specific technologies are set out in the following three tables. In addition, the most frequent co-occurrence of statements throughout the interviews at the Slovak facility are highlighted below. First, the data highlighting the perceived initial understanding of constituent technologies of Industry 4.0 from a management and non-management perspective is presented in Table 71.

Table 71: Industry 4.0 can be defined through Industry 4.0 constituent technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Initial understanding of Industry 4.0	Drivers of change towards Industry 4.0 (1)	Big Data (2)	4	4
Employee knows of Industry 4.0	N/A		0	4
Employee does not know of Industry 4.0	N/A		0	1

Table 72 illustrates the proprietary technologies identified by management and non-management staff in the Slovak region of study.

Table 72: Proprietary technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Camline	Positive impact of Industry 4.0 on product quality (2)		3	0
Camstar	Big Data (2)	Expected increase of Industry 4.0 technologies at facility (2)	4	12
HoloLens	Increased collaboration of workers due to Industry 4.0 technologies (5)		7	3
My QI			0	0
QRQC			0	0
TicketManager	Machine–human cooperation (3)		10	6

Technology can be referred to with reference to specific brand names or through the use of generic terms of technology. Table 73 illustrates the identified generic technologies and statements with high co-occurrence to these technologies.

Table 73: Generic technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
3D printing	Positive effect on product development (2)	Positive effect on product development (3)	7	9
5G			0	0
Augmented reality	Positive effect on product development (2)		1	2
Autonomous machinery	Machine learning / artificial intelligence (3)	Expected increase of Industry 4.0 technologies at facility (3)	10	8
Big Data	Initial understanding of Industry 4.0, Positive impact of Industry 4.0 on product quality (3)	Exposure to changes of work tools, Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations., Initial understanding of Industry 4.0, Use of digital communication means (2)	11	9
Machine learning / artificial intelligence	Autonomous machinery (3)		4	0
Machine–human cooperation	TicketManager, Increased transparency of data due to digital communication, Increased transparency of data due to digital communication (3)	Increased transparency of data due to digital communication, Increased transparency of data due to digital communication, TicketManager (3)	7	0
MES systems			0	8
Cloud computing			0	0
Cobots			4	0
Internet of Things			0	0
Cyber-physical systems			0	0

6.3.2 Theme 2: Factors affecting the implementation of Industry 4.0

Theme 2 consists of codes which highlight all statements made by staff at the Slovak facility, that feature specific factors that are perceived to affect the implementation of Industry 4.0 at the facility. Few statements of staff of the Slovak case facility can be identified that highlight factors that affect the implementation of Industry 4.0. Of those statements made by management staff it is clear that low labour costs make the introduction of Industry 4.0 less attractive than in higher cost regions. In cases where investments in Industry 4.0 are secured management staff statement indicate that these technologies propose a manner in which the Slovak facility can improve its financial position, also in context of low labour costs.

Table 74 illustrates the perceived compatibility of existing machinery at the facility with Industry 4.0 technology and the codes with the highest co-occurrence with such statements.

Table 74: Machine compatibility with Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Old machinery is upgradable to Industry 4.0			1	2
Old machinery is not upgradable to Industry 4.0			0	1

Table 75 highlights the link between the availability or lack of labour and the labour cost for the implementation of Industry 4.0. The co-occurrence of such statements with other statements is also highlighted.

Table 75: Labour resources affecting the implementation of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Lack of labour availability			0	1
High labour costs			0	0
Low labour costs			3	0
IT literacy of stakeholder			0	3

The implementation of Industry 4.0 represents a high capital expense to business. The perception of resource availability and association to this is highlighted below in table 76.

Table 76: Availability of corporate resources to the implementation process of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Dedicated resources for Industry 4.0	Positive financial impact of Industry 4.0 (3)		7	1
Lack of resources to implement Industry 4.0			1	1

6.3.3 <u>Theme 3: Future implementation of Industry 4.0</u>

At the Slovak case facility statements of staff on a management level can be identified that indicate an expectation of more technologies associated with Industry 4.0 at the facility. Whilst more non-management staff statements are identified that echo an increased level of Industry 4.0 technologies at the facility, it is of note that there are also voices that are of the opinion that no further expansion of Industry 4.0 technologies are expected. In Tables 77 and 78, the data that highlights the staff’s expectations regarding future developments of

Industry 4.0 technologies at the Slovak facility is presented. In addition, the co-occurrence of other codes with these statements is illustrated.

Table 77: Expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected increase of Industry 4.0 technologies at facility	Autonomous machinery (2)	Autonomous machinery (3)	3	9
Expected decrease of Industry 4.0 technologies at facility			0	0

Table 78: No expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No change expected of Industry 4.0 technologies at facility			0	2
No reply / No opinion on changes of Industry 4.0 technology at facility			0	3

6.3.4 Theme 4: Industry 4.0 affecting the social context environment

The quadruple context environment consists of the social, the natural, the economic and the governance or purpose context environment. The following section and the associated tables illustrate the findings related to the social context environment. A key realisation in this context is the changing role of the non-management worker. Non-management staff statements indicate that these staff are experiencing a change in the tools that are used to perform the relevant work tasks. Whereas management discussions on this topic are linked to the utilisation of digital communication means, one can note that non-management staff link the novel tools to an increase in the Slovak organisation's operational efficiency. Management staff statements also highlight the role of Industry 4.0 as a means to alter an organisation's responsibility for the safety of workers. In Tables 79 to 83, the data relating to the social context environment is presented. Table 79 highlights the interviewees' perceptions of the changing responsibilities of staff at the Slovak facility due to the introduction of Industry 4.0.

Table 79: Industry 4.0 alters the scope of workers' responsibilities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Workers experience an increased scope of responsibilities due to Industry 4.0 technologies			0	2
Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies			0	1

The perceptions of management and non-management staff of the Slovak facility in regard to changing work tools due to Industry 4.0 are presented in Table 80. The frequency of code co-occurrences is also illustrated.

Table 80: Industry 4.0 is associated with a change in workers' tools

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Exposure to changes of work tools	Use of digital communication means (2)	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (4)	2	13

Table 81 sets out the changes in the perceived ability of workers to perform work tasks independently.

Table 81: Industry 4.0 is associated with a change in the independence of their work activities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased independent work due to Industry 4.0 technologies			0	2
Decreased independent work due to Industry 4.0 technologies			0	0
No change in the degree of independent work			0	1

The perceived changes in workers' ability for work collaborations in the Slovak facility are highlighted in Table 82.

Table 82: Industry 4.0 is associated with a change the degree of worker cooperation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased collaboration of workers due to Industry 4.0 technologies	HoloLens (5)		7	4
Decreased collaboration of workers due to Industry 4.0 technologies			0	0

Worker safety and the perceived change that Industry 4.0 has on this is illustrated in Table 83. The frequent code co-occurrences are also presented.

Table 83: Industry 4.0 impacts workers' safety

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact on work safety			5	0
Negative impact on work safety			0	0

6.3.5 Theme 5: Industry 4.0 affecting the environmental context environment

The findings in respect to statements relating to the role of Industry 4.0 in the environmental context are clear. The majority of statements made by management and non-management staff indicate that Industry 4.0 can (or has) improved the facility's environmental performance. Slovak managers are amongst a small group where statements are identified that show a belief that factories can be environmentally neutral. A minority of non-management statements show a belief there is no environmental benefit in the Industry 4.0 technology.

In Table 84, below, the number of statements that are coded as indicating a positive correlation between Industry 4.0 and the natural context environment are highlighted. Frequent co-occurring codes are also displayed.

Table 84: Constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has improved the factory's environmental footprint	Positive financial impact of Industry 4.0 (4)	Positive financial impact of Industry 4.0 (2)	11	7
Factories can have 0 impact on the environment			2	0

In Table 85, the number of statements coded as indicating a negative correlation between Industry 4.0 and the natural context environment are shown. Frequent co-occurring codes are also highlighted.

Table 85: Non-constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has not improved the factory's environmental footprint			0	2
Factories cannot have 0 impact on the environment	Industry 4.0 has improved the factory's environmental footprint (2)		3	3

A small number of statements indicated that no response was given to the question regarding the natural environment in connection with Industry 4.0, or an interviewee indicated no opinion on the topic. This is represented in Table 86.

Table 86: No correlation between Industry 4.0 and environmental sustainability is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No Response / No opinion on Industry 4.0's impact on the environment			0	1

6.3.6 Theme 6: Industry 4.0 affecting the financial context environment

The financial context environment is a further element of the quadruple context environment and one often at the centre of a business' rational. Management and non-management staff statements demonstrate the close link of the introduction of Industry 4.0 and the need to be financially sustainable. Statements highlighting the role of operational efficiency, optimised supply chains, improved product quality and the resulting financial benefits are amongst the most quoted drivers of the implementation of Industry 4.0 amongst management staff of the Slovak case facility. Interestingly, non-management staff discussions of the financial factors that affect the implementation of Industry 4.0 are closely linked to the factors that are considered beneficial to the natural environment. Tables 87 to 93 highlight the data gained through interviews at the Slovak facility in relation to staff linking Industry 4.0 with the financial context environment. The table below illustrates the data linking staff statements on their perception of Industry 4.0 and the organisation's financial position.

Table 87: Industry 4.0 has a link to 'The Company's' financial position

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive financial impact of Industry 4.0	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (5)	Industry 4.0 has improved the factory's environmental footprint (2)	19	7
Negative financial impact of Industry 4.0			0	0
No financial Impact			0	0
No Response / No opinion on Industry 4.0's impact on financial sustainability			0	0

Table 88 presents the findings of statements that highlight Industry 4.0 as a driver of innovation or as a hindrance.

Table 88: Industry 4.0 has a link to innovation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 is a driver of innovation			5	0
Industry 4.0 is a hindrance for innovation			0	0
Industry 4.0 is neither a driver nor a hindrance to innovation			0	0

The product is at the core of a manufacturing facility's reason of being. Table 89 highlights the findings of statements that link Industry 4.0 to a change in product development.

Table 89: Industry 4.0 has a link to product development

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive effect on product development	Positive effect on product development (2)	Positive effect on product development (3)	7	4
Negative effect on product development			0	0
No change to product development			1	3

Continuing from Table 89, Table 90 highlights the perceived relation of the introduction of Industry 4.0 to the quality of the product that the Slovak facility produces.

Table 90: Industry 4.0 has a link to product quality

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on product quality	Positive financial impact of Industry 4.0, Big Data (3)	MES systems (2)	10	4
Negative impact of Industry 4.0 on product quality			0	0
No change to product quality			0	2

Industry 4.0 is regarded as changing the dynamics in supply chains. In Table 91, the perceptions of the introduction of Industry 4.0 and the links to changes in the supply chain are highlighted.

Table 91: Industry 4.0 has a link to the supply chain

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on the supply chain	Positive financial impact of Industry 4.0, Willingness to share data within the supplychain (2)		7	0
Negative impact of Industry 4.0 on the supply chain			1	0
Industry 4.0 has no impact on the supply chain			0	0

One of many factors which determines the financial performance of an organisation is organisational efficiency. The findings of perceived links between Industry 4.0 and organisational efficiency are illustrated in Table 92.

Table 92: Industry 4.0 influences organisational efficiency

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.	Positive financial impact of Industry 4.0 (5)	Exposure to changes of work tools (4)	12	10
Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations			2	0

Organisations are driven by competition in their respective market, but manufacturing facilities are also experiencing competition amongst each other within a single organisation. The table below presents the findings on the perceived link between the introduction of Industry 4.0 and operational competitiveness.

Table 93: Industry 4.0 influences operational competitiveness

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Improved competitiveness of facility due to Industry 4.0	Dedicated resources for Industry 4.0, Positive financial impact of Industry 4.0 (2)		7	1

6.3.7 <u>Theme 7: Industry 4.0 affecting the purpose context environment</u>

The final dimension of the quadruple context environment is the purpose or governance environment.

In Tables 94 to 97, the links between the context environment and the introduction of Industry 4.0 are presented. Below, the responses to the perceived responsibility of the organisation to upskill its workers in light of the implementation of Industry 4.0 are presented.

Table 94: Corporate responsibility to upskill workforce in context of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
'The Company' has a responsibility to upskill its workforce			1	2
'The Company' has no responsibility to upskill its workforce			0	0

Table 95 shows the perceived change or lack or change in the societal purpose of the organisation due to the implementation of Industry 4.0.

Table 95: Industry 4.0 impacts the societal purpose of the case organisation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has changed the purpose of 'The Company'			1	0
Industry 4.0 has not changed the purpose of 'The Company'			0	0
Positive change in the societal role of 'The Company'			1	0
Negative change in the societal role of 'The Company'			0	0
No reply / No opinion on the societal role of 'The Company'			0	0

All statements that relate to the perceived influence that the implementation of Industry 4.0 will have on the case facility's region are presented in Table 96 below.

Table 96: Industry 4.0 influences the case organisation's region

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Impact of Industry 4.0 on the region			1	0

Table 97 highlights the expected change to the manufacturing sites due to the implementation of Industry 4.0. A particularly strong co-occurrence with additive manufacturing techniques is noted.

Table 97: Change in manufacturing sites due to Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected changes to the form of factories			2	1
No expected changes to the form of factories			2	1

6.3.8 Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders

The introduction of Industry 4.0 will affect the stakeholders of the organisation, particularly the staff at the facilities. The data on the altering of stakeholder roles due to the introduction of Industry 4.0 is presented in the following tables, with a particular focus on those stakeholders whose roles are positively altered by the introduction of Industry 4.0. Statements of management and non-management staff that illustrate the most benefited stakeholders of the Slovak facility are those who are considered highly skilled. Statements of the staff at the Slovak case facility do however also demonstrate an understanding that the introduction of Industry 4.0 technology can benefit less skilled staff. A key benefit to less skilled staff is that laborious tasks are simplified or that novel work tasks emerge for such staff as a result of the application of Industry 4.0 technology. In Table 98, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 98: The workforce is positively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on skilled workforce	Positive impact of Industry 4.0 on skilled workforce (2)		6	2
Positive impact of Industry 4.0 on less-skilled workforce	Positive impact of Industry 4.0 on skilled workforce (2)		4	2

In Table 99, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on age group.

Table 99: The workforce is positively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on old-aged employees			0	0
Positive impact of Industry 4.0 on young-aged employees			1	0

In Table 100, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based perceived adaptability.

Table 100: The workforce is positively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on persons who are willing to accept change			1	0

Statements with no clear stakeholder identification but highlighting a positive impact on stakeholder are presented in Table 101.

Table 101: Various Stakeholder are affected positively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on undefined workforce			1	2
Positive impact of Industry 4.0 on other stakeholders			5	2
No negative impact on stakeholders			0	1
No reply / No opinion on the impact of Industry 4.0 on stakeholders			0	2

6.3.9 Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affects some stakeholders

The introduction of Industry 4.0 will affect the stakeholders of the organisation. This can be positive for some stakeholders but could be negative for others. Having presented the perceived internal stakeholders that will benefit from the introduction of Industry 4.0, those that are perceived to be less well-off will now be presented. In general, statements indicate that the less skilled staff group at the Slovak case facility are perceived to be impacted negatively. Whilst some statements indicate that less skilled staff can benefit from the introduction of Industry 4.0 it needs to be stressed that those that state the contrary to this positive outlook outnumber the optimists in respect to the effect of Industry 4.0 on less skilled staff. The data that presents the statements of perceptions of stakeholder roles that will be negatively affected by the introduction of Industry 4.0 is presented in the following tables. In Table 102, the staff groups that are negatively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 102: The workforce is negatively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on skilled workforce			1	2
Negative impact of Industry 4.0 on less-skilled workforce	Positive impact of Industry 4.0 on product quality, Resistance to the introduction of Industry 4.0 (2)		8	3

Table 103 presents, based on age, the staff groups that are negatively affected by the introduction of Industry 4.0.

Table 103: The workforce is negatively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**

Negative impact of Industry 4.0 on old-aged employees			2	0
Negative impact of Industry 4.0 on young-aged employees			0	0

In Table 104, the staff groups that are negatively impacted by the introduction of Industry 4.0 are presented based on perceived adaptability.

Table 104: The workforce is negatively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on persons who are not willing to accept change			0	0

Not all statements in the interviews make direct reference to stakeholder groups but instead highlight negative implications on stakeholders. These are presented in Table 105.

Table 105: Various Stakeholder are affected negatively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on undefined workforce	Positive financial impact of Industry 4.0 (3)		5	1
Negative impact of Industry 4.0 on other stakeholders			1	0

6.3.10 <u>Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform</u>

The perceived pace of the implementation of Industry 4.0 varies between case facilities. The Slovak case facility has less implemented Industry 4.0 technologies compared to high-cost facilities such as Berlin or Hillsboro. Statements by staff at the Slovak case facility generally indicate a perceived slow-paced implementation of Industry 4.0 technologies. Tables 106 to 108 present the codes and respective frequency of statements and co-occurrence of statements relating to the perceived pace of the implementation of Industry 4.0 technology at the respective facility of this study. Table 106 shows the data for the perception of a fast implementation.

Table 106: Fast paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was fast			1	1

In Table 107, statements that are contrary to the assertions of Table 106 are shown.

Table 107: Slow paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was slow			4	3

Some statements may not conform to the requirements of Tables 106 or 107. Statements that indicate no knowledge of the pace of implementation or statements that indicate an interviewee declines to comment on this are presented in Table 108.

Table 108: The rate of implementation of Industry 4.0 is not identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No reply / No opinion on the rate of change			0	2

6.3.11 Theme 11: Employee experience of implementation of Industry 4.0

In the following section, employee experience of the implementation of Industry 4.0 is presented. This relates to the association of the implementation of Industry 4.0 at the Slovak facility and outside organisations, the link of organisational change and the introduction of Industry 4.0 and possible resistance to the implementation of Industry 4.0. A regional specificity of the Slovak case facility is the perceived role of governmental institutions as non-supportive external influences on the implementation of Industry 4.0. Whilst staff do experience change at the case facility and the case organisation, this experience is not overshadowed by the introduction of Industry 4.0. Further, the resistance to the implementation is evident in statements made by management and non-management staff, such statements are not as dominant as in other regions. Several statements also indicate that no resistance has been experienced or is not expected. Table 109 illustrates statements which identify outside organisations.

Table 109: Entities associated with the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Drivers of change towards Industry 4.0	Positive financial impact of Industry 4.0 (4)		11	6
Supportive external influencers on the implementation of Industry 4.0			3	2
Non-supportive external influencers on the implementation of Industry 4.0			7	4
No reply / No opinion on external influencers of the implementation of Industry 4.0			0	3

Statements on the perceived change within the case organisation and the Slovak case facility are presented in Table 110. A differentiation is made between statements that link such changes with the implementation of Industry 4.0, and those that do not.

Table 110: Change in the organisation is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Experience of organisational change with a link to Industry 4.0			3	2
Experience of organisational change with no link to Industry 4.0			4	3

Table 111 is of note in this study. It presents the number of statements and the co-occurrence of statements by staff of the Slovak case facility that indicate that a resistance to the introduction of Industry 4.0 is perceived or not perceived.

Table 111: Resistance to the change towards Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Resistance to the introduction of Industry 4.0	Negative impact of Industry 4.0 on less-skilled workforce (2)		4	2
No resistance to the introduction of Industry 4.0			3	2
No reply / No opinion on possible resistance to change			0	1

6.3.12 Theme 12: Industry 4.0 is introduced through the use of change communication

Here the data that is linked to the implementation of Industry 4.0 and the communication perceived to facilitate this process are presented. All interviewees of the Slovak facility identify the role of communication in the introduction of Industry 4.0 at the facility. Means of communications used to introduce the technology to staff include personal communications as well as group meetings and digital communication means such as e-mail. In Table 112, the prevalence of statements that indicate the use of communication channels in the communication of the implementation of Industry 4.0 are presented.

Table 112: A variety of communication channels are utilized to communicate the changes associated with the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Channels utilised to communicate changes	Communication of Industry 4.0 related changes (11)	Communication of Industry 4.0 related changes (7)	11	7

Table 113 presents the statements and co-occurrence of statements relating to the communication of change.

Table 113: Messaging towards staff during the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Communication of Industry 4.0 related changes	Channels utilised to communicate changes (11)	Channels utilised to communicate changes (7)	11	7

Several statements are identified that highlight perceived communication shortcomings of the introduction of Industry 4.0. Such statements are grouped in Table 114 and presented with the respective co-occurrence of statements.

Table 114: Identified shortcomings of communicating the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Perceived change communication shortcomings			0	2

6.3.13 Theme 13: Changes in internal communication are experienced by staff

Communication is used to facilitate the implementation of Industry 4.0, but this research shows that the perception of the introduction of Industry 4.0 is also linked to the change in communication due to the introduction of the novel technology at the facility in Slovakia. Face-to-face communication is a primary form of communication that has changed for management staff. This mode of communication is substituted by digital communication means. Several statements of management staff link the change towards digital communication due to the introduction of Industry 4.0 to increased transparency and accessibility of data. Table 115 highlights the perception in change of face-to-face conversation, the increased use of communication means and other changes in internal communications due to increased digitalisation of the workplace.

Table 115: Human communication is shaped by the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Face-to-face communication	Use of digital communication means (3)		6	4
Use of digital communication means	Change in communication as a result of digitalisation (5)	Big Data, Change in communication as a result of digitalisation, Exposure to changes of work tools (2)	12	6
Change in communication as a result of digitalisation	Use of digital communication means (5)	Use of digital communication means (2)	7	11

A further change to be addressed in the presentation of data is the changing availability of co-workers and superiors and the change in access to these persons due to Industry 4.0. This is presented in Table 116.

Table 116: Digital communication has affected the accessibility of co-workers in the work environment

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased accessibility of co-workers due to digital communication			2	1
Decreased accessibility of co-workers due to digital communication			1	1

The perceived change in the formality of communication at the Slovak facility is presented below in Table 117.

Table 117: Digital communication has affected the formality of communication at the workplace

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased formality in communication due to digitalisation			0	0
Decreased formality in communication due to digitalisation			3	0
No change in formality of communication due to digitalisation			2	0

Table 118 presents the number of statements and the co-occurrence of statements that relate to the change in internal communication due to digital communication at the case facility.

Table 118: Digital communication has changed the internal communication

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has a positive effect on communication			0	0
Industry 4.0 has a negative effect on communication			1	0

Data transparency is a critical element of Industry 4.0. Below, Table 119 presents the codes and co-occurrences of changes in the transparency of data within the organisation and its supply chain due to the introduction of Industry 4.0.

Table 119: Digital communication has influenced the transparency of data

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased transparency of data due to digital communication	Machine–human cooperation (3)		8	2
Decreased transparency of data due to digital communication			0	0
Willingness to share data within the supply chain	Positive impact of Industry 4.0 on the supply chain (2)		3	0

6.3.14 Theme 14: Employees are perceiving a change towards the virtual workplace

During 2020 and 2021 the interviews were conducted, a time when travel and physical presence at the workplace was difficult for some. Many interviewees have worked from home, but not all. Few staff at the Slovak facility discuss experiences with home office work. Those statements that include home office work by management and non-management staff are positive. Management staff statements do not share the consensus of non-management staff statements that indicate an increasingly positive development of home office work at the case facility. Below, in Table 120, the data on positive and negative experiences of interviewees at the Slovak facility in regard to the home office is presented.

Table 120: Experience with home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive experience with home office			4	2
Negative experience with home office			0	0

Industry 4.0 is expected to change the manner in which work is performed. In Table 121, the frequent co-occurrence of codes that highlight the possibility or the impossibility of home office work for factory staff is presented along with the relevant codes.

Table 121: Expectation towards the future implementation of home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive outlook on the possibility of home office for production staff			2	4
Negative outlook on the possibility of home office for production staff	Outlook on the future of home office (2)		3	3
Outlook on the future of home office	Change in communication as a result of digitalisation, Negative outlook on the possibility of home office for production staff, Use of digital communication means (2)		10	5

Table 122 highlights the statements that indicate whether an interviewee has been in the home office or not.

Table 122: Employee experience of home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee has been in home office			3	4
Interviewee has not been in home office			0	2

Last, Table 123 illustrates the interviewees desire to perform their work tasks from a home office setting or if the interviewees of the Slovak facility prefer an office in a traditional setting.

Table 123: Employee attitude towards home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee wants to work from home			0	4
Interviewee does not want to work from home			0	1

6.4 FIELD STUDY 3 (USA)

In the following section findings from the US case facility are presented based on the 14 themes identified for data analysis.

6.4.1 Theme 1: Employees associating Industry 4.0 with specific technologies

The number of statements associated to the individual codes that highlight the employees' association of Industry 4.0 with specific technologies are set out in the following tables. In addition, the most frequent co-occurrence of statements throughout the interviews at the US facility are highlighted below. First, the data highlighting the perceived initial understanding of constituent technologies of Industry 4.0 from a management and non-management perspective is presented in Table 124. US management staff show a strong familiarity with the term Industry 4.0 and statements made by management staff demonstrate a link with the gathering and application of Big Data. Non-management staff statements indicate a familiarity with Industry 4.0 amongst most staff. A single non-management staff statement indicates little or no familiarity with the term 'Industry 4.0'. Both management and non-management staff often cite technologies that are enablers of human-machine cooperation. The frequent occurrence of statements on the application of collaborative robots at the US case facility underline this region's focus on aspects of Industry 4.0 of a physical nature that compliment cyber technologies such as the frequently named use of Big Data. A link between the physical and cyber technologies at the US case facility is highlighted by the frequent co-occurrence of statements by management staff regarding collaborative robots and the MES system 'Camstar'.

Table 124: Industry 4.0 can be defined through Industry 4.0 constituent technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Initial understanding of Industry 4.0	Big Data (5)		5	4
Employee knows of Industry 4.0			0	4
Employee does not know of Industry 4.0			0	1

Table 125 illustrates the proprietary technologies identified by management and non-management staff in the US region of study.

Table 125: Proprietary technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Camline			0	0
Camstar	Big Data (4)	Cobots (4)	13	11
HoloLens	Increased collaboration of workers due to Industry 4.0 technologies (3)		4	1
My QI			0	0
QRQC			2	1
TicketManager	Camstar, Machine–human cooperation, Negative financial impact of Industry 4.0 (2)		4	0

Technology can be referred to with reference to specific brand names or through the use of generic terms of technology. Table 126 illustrates the identified generic technologies and statements with high co-occurrence to these technologies.

Table 126: Generic technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
3D printing	Positive effect on product development (4)		7	4
5G			0	0
Augmented reality	Big Data (3)		4	5
Autonomous machinery	Cobots, Machine–human cooperation (3)		4	3
Big Data	Machine–human cooperation (6)	Camstar, Machine–human cooperation (3)	21	5
Machine learning / artificial intelligence	Big Data (4)		5	2
Machine–human cooperation	Cobots (10)	Exposure to changes of work tools (5)	21	18
MES systems	Big Data (7), Machine–human cooperation (5)		**7**	0
Cloud computing			0	0
Cobots	Machine–human cooperation, Positive financial impact of Industry 4.0 (10)	Camstar (4)	31	17
Internet of Things			0	0
Cyber-physical systems			0	0

6.4.2 Theme 2: Factors affecting the implementation of Industry 4.0

Theme 2 consists of codes which highlight all statements made by staff at the US facility, that feature specific factors that are perceived to affect the implementation of Industry 4.0 at the facility. It is of importance to note that statements of management and non-management staff highlight the role of cobots in addressing the perceived labour shortages that the case facility has encountered. Statements indicate that interviewees opinions on the effectiveness in addressing labour shortages by introducing cobots vary greatly. Management staff statements indicate that the limited resources available have been used to introduce cobots at the facility. Further, management staff indicate that the lack of further resources to introduce Industry 4.0 is associated with the general perception of a slow implementation of elements of Industry 4.0 that are not linked to MES systems, Big Data and cobots. In relation to the introduction of cobots at the case facility, it can be stated that indications can be found of non-management staff support for upskilling of staff to utilise the technologies. Table 127 illustrates the perceived compatibility of existing machinery at the facility with Industry 4.0 technology and the codes with the highest co-occurrence with such statements.

Table 127: Machine compatibility with Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Old machinery is upgradable to Industry 4.0			1	0
Old machinery is not upgradable to Industry 4.0			2	0

Table 128 highlights the link between the availability or lack of labour and the labour cost for the implementation of Industry 4.0. The co-occurrence of such statements with other statements is also highlighted.

Table 128: Labour resources affecting the implementation of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Lack of labour availability	Cobots (2)	'The Company' has a responsibility to upskill its workforce (2)	3	4
High labour costs			0	0
Low labour costs			0	0
IT literacy of stakeholder			1	0

The implementation of Industry 4.0 represents a high capital expense to business. The perception of resource availability and association to this is highlighted below in Table 129.

Table 129: Availability of corporate resources to the implementation process of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Dedicated resources for Industry 4.0	Cobots (3)		5	1
Lack of resources to implement Industry 4.0	Big Data, Implementation of Industry 4.0 was slow		11	0

6.4.3 Theme 3: Future implementation of Industry 4.0

A small number of statements can be identified that highlight staff impressions on the likelihood of future implementations of Industry 4.0 technologies at the US case facility. It is of note, the non-management staff statements indicate that this group of employees unanimously expect an increase of Industry 4.0 technologies at the US case facility. In Tables 130 and 131, the data that highlights the staff's expectations regarding future developments of Industry 4.0 technologies at the US facility is presented. In addition, the co-occurrence of other codes with these statements is illustrated.

Table 130: Expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected increase of Industry 4.0 technologies at facility			0	4
Expected decrease of Industry 4.0 technologies at facility			0	0

Table 131: No expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No change expected of Industry 4.0 technologies at facility			1	0
No reply / No opinion on changes of Industry 4.0 technology at facility			0	0

6.4.4 Theme 4: Industry 4.0 affecting the social context environment

The quadruple context environment consists of the social, the natural, the economic and the governance or purpose context environment. Statements indicate that the role of the employees and the manner in which work is performed at the US case facility has changed due to the introduction of Industry 4.0. Non-management staff at the case facility state that work tools have changed due to the introduction of Industry 4.0 technologies. A particularly strong link of statements in regard to changes in work tools can be made to statements on the introduction of technological means that facilitate human-machine cooperation. Cooperation amongst management staff is highlighted in management staff statements that can often be linked to the HoloLens technology. In Tables 132 to 136, the data relating to the social context environment is presented. Table 132 highlights the interviewees' perceptions of the changing responsibilities of staff at the US facility due to the introduction of Industry 4.0.

Table 132: Industry 4.0 alters the scope of workers' responsibilities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Workers experience an increased scope of responsibilities due to Industry 4.0 technologies			0	2
Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies			0	1

The perceptions of management and non-management staff of the US facility in regard to changing work tools due to Industry 4.0 are presented in Table 133. The frequency of code co-occurrences is also illustrated.

Table 133: Industry 4.0 is associated with a change in workers' tools

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Exposure to changes of work tools		Machine–human cooperation (5)	0	13

Table 134 sets out the changes in the perceived ability of workers to perform work tasks independently.

Table 134: Industry 4.0 is associated with a change in the independence of their work activities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased independent work due to Industry 4.0 technologies			0	3
Decreased independent work due to Industry 4.0 technologies			0	0
No change in the degree of independent work			0	0

The perceived changes in workers' ability for work collaborations in the US facility are highlighted in Table 135.

Table 135: Industry 4.0 is associated with a change the degree of worker cooperation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased collaboration of workers due to Industry 4.0 technologies	HoloLens (3)		3	0
Decreased collaboration of workers due to Industry 4.0 technologies			0	0

Worker safety and the perceived change that Industry 4.0 has on this is illustrated in Table 136. The frequent code co-occurrences are also presented.

Table 136: Industry 4.0 impacts workers' safety

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact on work safety			1	2
Negative impact on work safety			0	0

6.4.5 Theme 5: Industry 4.0 affecting the environmental context environment

The environmental or natural context environment is a further element of the quadruple context environment. Statements at the US case facility indicate that management staff unanimously do not believe that manufacturing facilities can be environmental neutral, but a majority of statements show a belief that the use of Industry 4.0 technology can improve the environmental impact of the case facility in the context of the natural environment. Statements made by non-management staff at the US case facility are less clear. Whilst many statements indicate that Industry 4.0 has or can improve the environmental footprint of the case facility, some statements also assert that technologies do not further environmental improvements at the case facility.

In Table 137, below, the number of statements that are coded as indicating a positive correlation between Industry 4.0 and the natural context environment are highlighted. Frequent co-occurring codes are also displayed.

Table 137: Constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has improved the factory's environmental footprint	Factories cannot have 0 impact on the environment (2)		4	3
Factories can have 0 impact on the environment			0	2

In Table 138, the number of statements coded as indicating a negative correlation between Industry 4.0 and the natural context environment are shown. Frequent co-occurring codes are also highlighted.

Table 138: Non-constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has not improved the factory's environmental footprint			1	2
Factories cannot have 0 impact on the environment	Industry 4.0 has improved the factory's environmental footprint (2)		4	1

A small number of statements indicated that no response was given to the question regarding the natural environment in connection with Industry 4.0, or an interviewee indicated no opinion on the topic. This is represented in Table 139.

Table 139: No correlation between Industry 4.0 and environmental sustainability is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No Response / No opinion on Industry 4.0's impact on the environment			1	2

6.4.6 Theme 6: Industry 4.0 affecting the financial context environment

The financial context environment is a further element of the quadruple context environment. Statements that highlight the positive role of Industry 4.0 in improving the financial position of the case facility are strongly linked to statements that make reference to the use of cobots. This link between positive financial impact of Industry 4.0 and cobots can be found amongst management and non-management statements made at the US case facility. Management staff at the US case facility expect Industry 4.0 to improve the competitive position of the facility particularly in context of high labour costs and low labour availability. Discussions of the use of additive manufacturing are particularly clearly linked to statements linked to improvements in the development of products at the case facility. Tables 140 to 146 highlight the data gained through interviews at the US facility in relation to staff linking Industry 4.0 with the financial position of the US case facility. The table below illustrates the data linking staff statements on their perception of Industry 4.0 and the organisation’s financial position.

Table 140: Industry 4.0 has a link to ‘The Company’s’ financial position

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive financial impact of Industry 4.0	Cobots (10)	Cobots (3)	20	5
Negative financial impact of Industry 4.0	Machine–human cooperation (3)		4	0
No financial Impact			0	0
No Response / No opinion on Industry 4.0's impact on financial sustainability			2	1

Table 141 presents the findings of statements that highlight Industry 4.0 as a driver of innovation or as a hindrance.

Table 141: Industry 4.0 has a link to innovation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 is a driver of innovation			4	0
Industry 4.0 is a hindrance for innovation			1	0
Industry 4.0 is neither a driver nor a hindrance to innovation			0	0

The product is at the core of a manufacturing facility's reason of being. Table 142 highlights the findings of statements that link Industry 4.0 to a change in product development.

Table 142: Industry 4.0 has a link to product development

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive effect on product development	3D printing (4)		9	1
Negative effect on product development			0	0
No change to product development			0	2

Continuing from Table 142, Table 143 highlights the perceived relation of the introduction of Industry 4.0 to the quality of the product that the US facility produces.

Table 143: Industry 4.0 has a link to product quality

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on product quality	Positive financial impact of Industry 4.0 (5)		10	3
Negative impact of Industry 4.0 on product quality			0	0
No change to product quality			0	3

Industry 4.0 is regarded as changing the dynamics in supply chains. In Table 144, the perceptions of the introduction of Industry 4.0 and the links to changes in the supply chain are highlighted.

Table 144: Industry 4.0 has a link to the supply chain

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on the supply chain	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations (2)		5	1
Negative impact of Industry 4.0 on the supply chain			1	0
Industry 4.0 has no impact on the supply chain			0	0

One of many factors which determines the financial performance of an organisation is organisational efficiency. The findings of perceived links between Industry 4.0 and organisational efficiency are illustrated in Table 145.

Table 145: Industry 4.0 influences organisational efficiency

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.	Positive financial impact of Industry 4.0 (5)		12	7
Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations			1	3

The table below presents the findings on the perceived link between the introduction of Industry 4.0 and operational competitiveness.

Table 146: Industry 4.0 influences operational competitiveness

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Improved competitiveness of facility due to Industry 4.0	Cobots (5)		8	0

6.4.7 Theme 7: Industry 4.0 affecting the purpose context environment

The final dimension of the quadruple context environment is the purpose or governance environment. In Tables 147 to 150, the links between the context environment and the introduction of Industry 4.0 are presented. Statements by non-management staff at the US case facility highlight that most non-management staff are of the opinion that staff can expect the case organisation to upskill its staff to cope with the transition towards a work environment that is cantered on Industry 4.0 technologies. Statements further indicate that staff regard such upskilling to be in the interest of the staff and in the interest of the case organisation. Management staff statements demonstrate that this group of staff expect the advent of Industry 4.0 to reshape the role of the case facility in its rural setting, affecting its suppliers, the labour market and infrastructure. Below, the responses to the perceived responsibility of the organisation to upskill its workers in light of the implementation of Industry 4.0 are presented.

Table 147: Corporate responsibility to upskill workforce in context of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
'The Company' has a responsibility to upskill its workforce		Lack of labour availability (2)	0	5
'The Company' has no responsibility to upskill its workforce			0	1

Table 148 shows the perceived change or lack or change in the societal purpose of the organisation due to the implementation of Industry 4.0.

Table 148: Industry 4.0 impacts the societal purpose of the case organisation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has changed the purpose of 'The Company'			0	0
Industry 4.0 has not changed the purpose of 'The Company'			1	0
Positive change in the societal role of 'The Company'			0	0
Negative change in the societal role of 'The Company'			0	0
No reply / No opinion on the societal role of 'The Company'			0	0

All statements that relate to the perceived influence that the implementation of Industry 4.0 will have on the case facility's region are presented in Table 149 below.

Table 149: Industry 4.0 influences the case organisation's region

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Impact of Industry 4.0 on the region			4	3

Table 150 highlights the expected change to the manufacturing sites due to the implementation of Industry 4.0. A particularly strong co-occurrence with additive manufacturing techniques is noted.

Table 150: Change in manufacturing sites due to Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected changes to the form of factories			1	2
No expected changes to the form of factories			2	4

6.4.8 Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders

The introduction of Industry 4.0 will affect the stakeholders of the organisation. The data on the altering of stakeholder roles due to the introduction of Industry 4.0 is presented in the following tables, with a particular focus on those stakeholders whose roles are positively altered by the introduction of Industry 4.0. It can be highlighted that management and non-management staff statements demonstrate that the majority of staff regard the persons to be most advantaged by the introduction of Industry 4.0 to be skilled staff. Such statements made by management and non-management staff often co-occur with statements highlighting possible negative effects on the less skilled workforce. Almost half of statements made by non-management staff, that highlight positive effects on staff, highlight a possible positive effect on less skilled workers. In Table 151, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 151: The workforce is positively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on skilled workforce	Negative impact of Industry 4.0 on less-skilled workforce (4)	Negative impact of Industry 4.0 on less-skilled workforce (3)	9	4
Positive impact of Industry 4.0 on less-skilled workforce			2	3

In Table 152, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on age group.

Table 152: The workforce is positively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on old-aged employees			0	0
Positive impact of Industry 4.0 on young-aged employees			0	2

In Table 153, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based perceived adaptability.

Table 153: The workforce is positively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on persons who are willing to accept change			0	1

Statements with no clear stakeholder identification but highlighting a positive impact on stakeholder are presented in Table 154.

Table 154: Various Stakeholder are affected positively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on undefined workforce			1	1
Positive impact of Industry 4.0 on other stakeholders	Positive financial impact of Industry 4.0, Positive impact of Industry 4.0 on skilled workforce (2)		2	0
No negative impact on stakeholders			0	0

No reply / No opinion on the impact of Industry 4.0 on stakeholders			1	1

6.4.9 Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affects some stakeholders

As previously stated, the introduction of Industry 4.0 will affect the stakeholders of the organisation. This can be positive for some stakeholders but could be negative for others. Having presented the perceived internal stakeholders that will benefit from the introduction of Industry 4.0, those that are perceived to be less well-off will now be presented. The data that presents the statements of perceptions of stakeholder roles that will be negatively affected by the introduction of Industry 4.0 is presented in the following tables. Most notable are the statements made by management and non-management staff in regard to the less skilled workforce. Whilst some statements in section 6.4.8 can be identified that highlight possible benefits of Industry 4.0 for the less skilled workforce, it needs to be stressed that these statements are dwarfed by a high volume of statements that assert the contrary. Many statements are identified that mark the less skilled workforce as being amongst those that are negatively affected by the introduction of Industry 4.0.

In Table 155, the staff groups that are negatively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 155: The workforce is negatively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on skilled workforce			1	0
Negative impact of Industry 4.0 on less-skilled workforce	Cobots, Positive impact of Industry 4.0 on skilled workforce (4)	Positive impact of Industry 4.0 on skilled workforce (3)	10	4

Table 156 presents, based on age, the staff groups that are negatively affected by the introduction of Industry 4.0.

Table 156: The workforce is negatively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on old-aged employees			1	3
Negative impact of Industry 4.0 on young-aged employees			0	0

In Table 157, the staff groups that are negatively impacted by the introduction of Industry 4.0 are presented based on perceived adaptability.

Table 157: The workforce is negatively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on persons who are not willing to accept change			0	1

Not all statements in the interviews make direct reference to stakeholder groups but instead highlight negative implications on stakeholders. These are presented in Table 158.

Table 158: Various Stakeholder are affected negatively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on undefined workforce	Positive financial impact of Industry 4.0, Cobots (2)	Machine–human cooperation (3)	4	4
Negative impact of Industry 4.0 on other stakeholders			0	0

6.4.10 Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform

Tables 159 to 161 present the codes and respective frequency of statements and co-occurrence of statements relating to the perceived pace of the implementation of Industry 4.0 technology at the respective facility of this study. Table 159 shows the data for the perception of a fast implementation. The majority of statements indicate a perception of the implementation of Industry 4.0 as rather slow than fast at the US case facility.

Table 159: Fast paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was fast			2	1

In Table 160, statements that are contrary to the assertions of Table 159 are shown.

Table 160: Slow paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was slow			4	3

Some statements may not conform to the requirements of Tables 159 or 160. Statements that indicate no knowledge of the pace of implementation or statements that indicate an interviewee declines to comment on this are presented in Table 161.

Table 161: The rate of implementation of Industry 4.0 is not identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No reply / No opinion on the rate of change			0	1

6.4.11 Theme 11: Employee experience of implementation of Industry 4.0

In the following section, employee experience of the implementation of Industry 4.0 is presented. This relates to the association of the implementation of Industry 4.0 at the respective facility and outside organisations, the link of organisational change and the introduction of Industry 4.0 and possible resistance to the implementation of Industry 4.0. Whilst non-management staff do not demonstrate a clear opinion on external influences on the implementation of Industry 4.0, management staff do identify supportive external influencers. The technology is identified by both management - and non-management staff as a driver of change at the case facility. Staffs' experience of change at the case facility is dominated by the introduction of Industry 4.0, as statements that link Industry 4.0 outnumber those that do not link change with Industry 4.0. Non-management staff statements indicate experience of resistance to the introduction of Industry 4.0 at the case facility. Not all statements by management staff indicate an experience of resistance towards changes as a result of the introduction of Industry 4.0. Table 162 presents statements which identify outside organisations.

Table 162: Entities associated with the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Drivers of change towards Industry 4.0			6	5
Supportive external influencers on the implementation of Industry 4.0			5	2
Non-supportive external influencers on the implementation of Industry 4.0			2	1

No reply / No opinion on external influencers of the implementation of Industry 4.0			0	4

Statements on the perceived change within the case organisation and the US case facility are presented in Table 163. A differentiation is made between statements that link such changes with the implementation of Industry 4.0, and those that do not.

Table 163: Change in the organisation is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Experience of organisational change with a link to Industry 4.0			5	8
Experience of organisational change with no link to Industry 4.0			2	3

Table 164 is of note in this study. It presents the number of statements and the co-occurrence of statements by staff of the US case facility that indicate that a resistance to the introduction of Industry 4.0 is perceived or not perceived.

Table 164: Resistance to the change towards Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Resistance to the introduction of Industry 4.0	Communication of Industry 4.0 related changes (3)		7	7
No resistance to the introduction of Industry 4.0			3	0
No reply / No opinion on possible resistance to change			0	0

6.4.12 Theme 12: Industry 4.0 is introduced through the use of change communication

This section presents the findings that are linked to the implementation of Industry 4.0 and the communication perceived to facilitate this process. In Table 165, the prevalence of statements that indicate the use of communication channels in the communication of the implementation of Industry 4.0 are presented. Management staff's statements on the use of communication during the introduction of Industry 4.0 are plentiful and of a high variety. Managers highlight the channels used to communicate towards their staff, including the use of a cobot on a shopfloor level to familiarise non-management staff with the presence of such technology at the US case facility. Non-management staff statements centre on the means that have reached them in conveying the implementation of Industry 4.0. This includes the proactive research of some on the topic rather than solely relying on management communications.

Table 165: A variety of communication channels are utilized to communicate the changes associated with the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Channels utilised to communicate changes	Communication of Industry 4.0 related changes (8)	Communication of Industry 4.0 related changes (8)	9	8

Table 166 presents the statements and co-occurrence of statements relating to the communication of change.

Table 166: Messaging towards staff during the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Communication of Industry 4.0 related changes	Channels utilised to communicate changes (8)	Channels utilised to communicate changes (8)	20	14

Several statements are identified that highlight perceived communication shortcomings of the introduction of Industry 4.0. Such statements are grouped in Table 167 and presented with the respective co-occurrence of statements.

Table 167: Identified shortcomings of communicating the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Perceived change communication shortcomings			0	4

6.4.13 Theme 13: Changes in internal communication are experienced by staff

Communication is used to facilitate the implementation of Industry 4.0, but this research shows that the perception of the introduction of Industry 4.0 is also linked to the change in communication due to the introduction of the novel technology at the facility in the US. Statements indicate that US management staffs' perception of change in communication due to Industry 4.0 are more present than those statements made by non-management staff on this topic. Statements by both staff groups indicate a transition towards increased digital communication at the workplace. A further change in communication due to Industry 4.0 identified by management staff is the increased transparency of data at the case facility; this is particularly linked to the application of Big Data.

Table 168 highlights the perception in change of face-to-face conversation, the increased use of communication means and other changes in internal communications due to increased digitalisation of the workplace.

Table 168: Human communication is shaped by the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Face-to-face communication			3	1

Use of digital communication means			7	7
Change in communication as a result of digitalisation			6	2

A further change to be addressed in the presentation of data is the changing availability of co-workers and superiors and the change in access to these persons due to Industry 4.0. This is presented in Table 169.

Table 169: Digital communication has affected the accessibility of co-workers in the work environment

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased accessibility of co-workers due to digital communication			1	5
Decreased accessibility of co-workers due to digital communication			0	0

The perceived change in the formality of communication at the US facility is presented below in Table 170.

Table 170: Digital communication has affected the formality of communication at the workplace

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased formality in communication due to digitalisation			0	0
Decreased formality in communication due to digitalisation			1	0
No change in formality of communication due to digitalisation			1	0

Table 171 presents the number of statements and the co-occurrence of statements that relate to the change in internal communication due to digital communication at the case facility.

Table 171: Digital communication has changed the internal communication

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has a positive effect on communication			0	0
Industry 4.0 has a negative effect on communication			0	1

Data transparency is a critical element of Industry 4.0. Below, Table 172 presents the codes and co-occurrences of changes in the transparency of data within the organisation and its supply chain due to the introduction of Industry 4.0.

Table 172: Digital communication has influenced the transparency of data

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased transparency of data due to digital communication	Big Data (2)		8	1
Decreased transparency of data due to digital communication			1	0
Willingness to share data within the supply chain			4	0

6.4.14 Theme 14: Employees are perceiving a change towards the virtual workplace

The interviews were conducted in 2020 and 2021, during a time when travel and physical presence at the workplace was difficult for some. Many interviewees have worked from home, but not all. Whilst most statements by management staff show a positive experience with home office, no statement indicates that non-management staff have worked from a home office setting. Statements focusing on the future of home office, made by management and non-management staff, show that supportive and non-supportive statements occur similarly often. Below, in Table 173, the data on positive and negative experiences of interviewees at the US facility in regard to the home office is presented.

Table 173: Experience with home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive experience with home office	Negative experience with home office (2)		6	0
Negative experience with home office	Positive experience with home office (2)		3	0

Industry 4.0 is expected to change the manner in which work is performed. In Table 174, the frequent co-occurrence of codes that highlight the possibility or the impossibility of home office work for factory staff is presented along with the relevant codes.

Table 174: Expectation towards the future implementation of home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive outlook on the possibility of home office for production staff			3	4
Negative outlook on the possibility of home office for production staff			2	3
Outlook on the future of home office			0	2

Table 175 highlights the statements that indicate whether an interviewee has been in the home office or not.

Table 175: Employee experience of home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee has been in home office			1	0
Interviewee has not been in home office			1	5

Last, Table 176 illustrates the interviewees desire to perform their work tasks from a home office setting or if the interviewees of the US facility prefer an office in a traditional setting.

Table 176: Employee attitude towards home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee wants to work from home			0	1
Interviewee does not want to work from home			0	2

6.5 FIELD STUDY 4 (CHINA)

The following section of this chapter contains the presentation of findings obtained through interviews at the Chinese facility.

6.5.1 Theme 1: Employees associating Industry 4.0 with specific technologies

Statements of management and non-management staff at the Chinese case facility indicate that the interviewees show a familiarity with the term Industry 4.0 and its technologies. Non-management staff statements indicating the interviewees initial understanding of Industry 4.0 link to the increased use of autonomous machinery. The data highlighting the perceived initial understanding of constituent technologies of Industry 4.0 from a management and non-management perspective is presented in Table 177.

Table 177: Industry 4.0 can be defined through Industry 4.0 constituent technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Initial understanding of Industry 4.0		Autonomous machinery (2)	5	4
Employee knows of Industry 4.0			0	5
Employee does not know of Industry 4.0			0	0

Statements of staff at the Chinese case facility indicate that, similarly to statements made by staff at the German case facility, often focus on the introduction and use of the

TicketManager technology. Statements indicate a thorough understanding of the interlinked nature of Industry 4.0, as high co-occurrences of various technologies are evident in the identification of the various Industry 4.0 technologies. Details on the many co-occurrences of statements on generic and proprietary technologies can be found in Tables 178 and 179.

Table 178 illustrates the proprietary technologies identified by management and non-management staff in the facility in China.

Table 178: Proprietary technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Camline		My QI (2)	0	3
Camstar	TicketManager (7)	TicketManager (6)	14	9
HoloLens		Increased collaboration of workers due to Industry 4.0 technologies, Use of digital communication means(4)	2	6
My QI		Camline, TicketManager (2)	2	4
QRQC			0	0
TicketManager	Camstar (7)	Autonomous machinery, Camstar (6)	15	19

Technology can be referred to with reference to specific brand names or through the use of generic terms of technology. Table 179 illustrates the identified generic technologies and statements with high co-occurrence to these technologies.

Table 179: Generic technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
3D printing		Expected changes to the form of factories (2)	5	5
5G			2	0
Augmented reality		HoloLens, Increased collaboration of workers due to Industry 4.0 technologies, Use of digital communication means (3)	2	3
Autonomous machinery	Exposure to changes of work tools (2)	TicketManager (16)	4	16
Big Data	Positive impact of Industry 4.0 on product quality (4)	TicketManager, Positive impact of Industry 4.0 on product quality, Increased transparency of data due to digital communication (3)	6	9
Machine learning / artificial intelligence		Autonomous machinery (2)	1	2
Machine–human cooperation	TicketManager (2)	Autonomous machinery, TicketManager (4)	3	5
MES systems			0	0
Cloud computing			0	0
Cobots	Positive financial impact of Industry 4.0, TicketManager (3)	Expected increase of Industry 4.0 technologies at facility, Positive impact of Industry 4.0 on undefined workforce (3)	6	8
Internet of Things			0	0
Cyber-physical systems			0	0

6.5.2 Theme 2: Factors affecting the implementation of Industry 4.0

Theme 2 consists of codes which highlight all statements made by staff at the Chinese facility, that feature specific factors that are perceived to affect the implementation of Industry 4.0 at the facility. A noteworthy factor identified in statements of management staff is the perceived high labour cost which the Chinese case facility is facing. Statements made by managers show that Industry 4.0 is regarded as a means of improving the financial performance of the case facility through increased operational performance harnessed through the use of Industry 4.0. Statements highlighting the dedication of resources to implement Industry 4.0 technology outweigh those that address a lack of resources to implement Industry 4.0 technologies. Table 180 illustrates the perceived compatibility of existing machinery at the facility with Industry 4.0 technology and the codes with the highest co-occurrence with such statements.

Table 180: Machine compatibility with Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Old machinery is upgradable to Industry 4.0			0	1
Old machinery is not upgradable to Industry 4.0			1	1

Table 181 highlights the link between the availability or lack of labour and the labour cost for the implementation of Industry 4.0. The co-occurrence of such statements with other statements is also highlighted.

Table 181: Labour resources affecting the implementation of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Lack of labour availability			2	0
High labour costs	Positive financial impact of Industry 4.0 (2)		3	2
Low labour costs			0	0
IT literacy of stakeholder			0	0

The implementation of Industry 4.0 represents a high capital expense to business. The perception of resource availability and association to this is highlighted below in table 182.

Table 182: Availability of corporate resources to the implementation process of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Dedicated resources for Industry 4.0	Positive financial impact of Industry 4.0, TicketManager (3)		12	5
Lack of resources to implement Industry 4.0			2	3

6.5.3 Theme 3: Future implementation of Industry 4.0

In Tables 183 and 184, the data that highlights the staff's expectations regarding future developments of Industry 4.0 technologies at the Chinese facility is presented. In addition, the co-occurrence of other codes with these statements is illustrated. Whilst management staff statements highlight a degree of scepticism of further expansions of Industry 4.0 technologies at the Chinese case facility, non-management statements demonstrate an expectation of increased use of Industry 4.0 technologies at the facility.

Table 183: Expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected increase of Industry 4.0 technologies at facility		Cobots (3)	1	9
Expected decrease of Industry 4.0 technologies at facility			1	0

Table 184: No expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No change expected of Industry 4.0 technologies at facility			1	0
No reply / No opinion on changes of Industry 4.0 technology at facility			0	0

6.5.4 <u>Theme 4: Industry 4.0 affecting the social context environment</u>

Theme 4 centres on statements that focus on changes in the social context environment associated to the introduction of Industry 4.0. Statements that highlight a change in work tools can be identified amongst management and non-management staff. Statements of management staff indicate that a key change in work tools is the expanded use of autonomous machinery and non-management associate a change in work tools with the TicketManager.

In Tables 185 to 189, the data relating to the social context environment is presented. Table 185 highlights the interviewees' perceptions of the changing responsibilities of staff at the Chinese facility due to the introduction of Industry 4.0.

Table 185: Industry 4.0 alters the scope of workers' responsibilities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Workers experience an increased scope of responsibilities due to Industry 4.0 technologies			1	3
Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies			1	0

The perceptions of management and non-management staff of the Chinese facility in regard to changing work tools due to Industry 4.0 are presented in Table 186. The frequency of code co-occurrences is also illustrated.

Table 186: Industry 4.0 is associated with a change in workers' tools

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Exposure to changes of work tools	Autonomous machinery (2)	TicketManager (4)	4	16

Table 187 sets out the changes in the perceived ability of workers to perform work tasks independently.

Table 187: Industry 4.0 is associated with a change in the independence of their work activities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased independent work due to Industry 4.0 technologies			0	3
Decreased independent work due to Industry 4.0 technologies			0	1
No change in the degree of independent work			0	1

The perceived changes in workers' ability for work collaborations in the Chinese facility are highlighted in Table 188 below.

Table 188: Industry 4.0 is associated with a change the degree of worker cooperation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased collaboration of workers due to Industry 4.0 technologies		Use of digital communication means (5)	2	6
Decreased collaboration of workers due to Industry 4.0 technologies			0	0

Worker safety and the perceived change that Industry 4.0 has on this is illustrated in Table 189. The frequent code co-occurrences are also presented.

Table 189: Industry 4.0 impacts workers' safety

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact on work safety		Cobots, Positive impact of Industry 4.0 on undefined workforce (2)	1	2
Negative impact on work safety			0	0

6.5.5 <u>Theme 5: Industry 4.0 affecting the environmental context environment</u>

The theory of sustainability contains elements that can be grouped under the headlining of the quadruple context environment. While the majority of statements indicate a perception of Industry 4.0 as a means to improve the environmental footprint of the Chinese case facility, it can be highlighted that substantially more non-management staff statements than management staff statements indicate a belief in an improved environmental footprint of the case facility due to the introduction of Industry 4.0.

In Table 190, below, the number of statements that are coded as indicating a positive correlation between Industry 4.0 and the natural context environment are highlighted. Frequent co-occurring codes are also displayed.

Table 190: Constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has improved the factory's environmental footprint		Autonomous machinery (3)	3	11
Factories can have 0 impact on the environment			1	1

In Table 191, the number of statements coded as indicating a negative correlation between Industry 4.0 and the natural context environment are shown. Frequent co-occurring codes are also highlighted.

Table 191: Non-constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has not improved the factory's environmental footprint			3	1
Factories cannot have 0 impact on the environment			3	3

A small number of statements indicated that no response was given to the question regarding the natural environment in connection with Industry 4.0, or an interviewee indicated no opinion on the topic. This is represented in Table 192.

Table 192: No correlation between Industry 4.0 and environmental sustainability is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No Response / No opinion on Industry 4.0's impact on the environment			0	2

6.5.6 Theme 6: Industry 4.0 affecting the financial context environment

The financial context environment is a further element of the quadruple context environment. At the Chinese case facility a large number of statements have been identified as relating to the financial context environment. Management staff statements on a positive impact of Industry 4.0 on the case facility's financial performance are identified often and such discussions link the TicketManager to such financial benefits. Management and non-management statements show agreement that the application of Big Data benefits the quality of the products that are produced at the Chinese case facility. Tables 193 to 199 highlight the data gained through interviews at the Chinese facility in relation to staff linking Industry 4.0 with the financial context environment. The table below illustrates the data linking staff statements on their perception of Industry 4.0 and the organisation's financial position.

Table 193: Industry 4.0 has a link to 'The Company's' financial position

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive financial impact of Industry 4.0	TicketManager (3)	Negative financial impact of Industry 4.0, Positive impact of Industry 4.0 on product quality (2)	15	6
Negative financial impact of Industry 4.0		Positive financial impact of Industry 4.0 (2)	0	3
No financial Impact			0	0
No Response / No opinion on Industry 4.0's impact on financial sustainability			0	0

Table 194 presents the findings of statements that highlight Industry 4.0 as a driver of innovation or as a hindrance.

Table 194: Industry 4.0 has a link to innovation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 is a driver of innovation			3	0
Industry 4.0 is a hindrance for innovation			0	0
Industry 4.0 is neither a driver nor a hindrance to innovation			1	0

The product is at the core of a manufacturing facility's reason of being. Table 195 highlights the findings of statements that link Industry 4.0 to a change in product development.

Table 195: Industry 4.0 has a link to product development

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive effect on product development		Autonomous machinery (2)	1	3
Negative effect on product development			0	0
No change to product development			2	2

Continuing from Table 195, Table 196 highlights the perceived relation of the introduction of Industry 4.0 to the quality of the product that the Chinese facility produces.

Table 196: Industry 4.0 has a link to product quality

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on product quality	Big Data (4)	Big Data (3)	10	7
Negative impact of Industry 4.0 on product quality			0	0
No change to product quality			2	0

Industry 4.0 is regarded as changing the dynamics in supply chains. In Table 197, the perceptions of the introduction of Industry 4.0 and the links to changes in the supply chain are highlighted.

Table 197: Industry 4.0 has a link to the supply chain

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on the supply chain			3	1
Negative impact of Industry 4.0 on the supply chain			1	0
Industry 4.0 has no impact on the supply chain			0	0

One of factors which determines the financial performance of an organisation is organisational efficiency. The findings of perceived links between Industry 4.0 and organisational efficiency are illustrated in Table 198.

Table 198: Industry 4.0 influences organisational efficiency

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.	Positive financial impact of Industry 4.0 (2)	TicketManager (4)	10	14
Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations			0	1

The table below presents the findings on the perceived link between the introduction of Industry 4.0 and operational competitiveness.

Table 199: Industry 4.0 influences operational competitiveness

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Improved competitiveness of facility due to Industry 4.0	Positive financial impact of Industry 4.0 (3)		3	1

6.5.7 Theme 7: Industry 4.0 affecting the purpose context environment

The final dimension of the quadruple context environment is the purpose or governance environment. In Tables 200 to 203, the links between the context environment and the introduction of Industry 4.0 are presented. Below, the responses to the perceived responsibility of the organisation to upskill its workers in light of the implementation of Industry 4.0 are presented.

Table 200: Corporate responsibility to upskill workforce in context of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
'The Company' has a responsibility to upskill its workforce			1	7
'The Company' has no responsibility to upskill its workforce			0	0

Table 201 shows the perceived change or lack or change in the societal purpose of the organisation due to the implementation of Industry 4.0.

Table 201: Industry 4.0 impacts the societal purpose of the case organisation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has changed the purpose of 'The Company'			1	0
Industry 4.0 has not changed the purpose of 'The Company'			2	0
Positive change in the societal role of 'The Company'			0	1
Negative change in the societal role of 'The Company'			0	0
No reply / No opinion on the societal role of 'The Company'			0	0

All statements that relate to the perceived influence that the implementation of Industry 4.0 will have on the case facility's region are presented in Table 202 below.

Table 202: Industry 4.0 influences the case organisation's region

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Impact of Industry 4.0 on the region			0	0

Table 203 highlights the expected change to the manufacturing sites due to the implementation of Industry 4.0. A particularly strong co-occurrence with additive manufacturing techniques is noted.

Table 203: Change in manufacturing sites due to Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected changes to the form of factories	Experience of organisational change with a link to Industry 4.0 (2)	3D printing (2)	3	2
No expected changes to the form of factories			1	0

6.5.8 Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders

The introduction of Industry 4.0 will affect the stakeholders of the organisation. The data on the altering of stakeholder roles due to the introduction of Industry 4.0 is presented in the following tables, with a particular focus on those stakeholders whose roles are positively altered by the introduction of Industry 4.0. Chinese management staff statements identify the skilled staff of the case facility as being the key beneficiaries of the introduction of Industry 4.0. Similarly to their management colleagues, non-management staff also identify skilled team members as benefiting from Industry 4.0. A small number of statements made by members of both staff groups identify less skilled staff as benefiting from the application of Industry 4.0 technology. In Table 204, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 204: The workforce is positively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on skilled workforce		Negative impact of Industry 4.0 on less-skilled workforce (4)	5	6
Positive impact of Industry 4.0 on less-skilled workforce			2	2

In Table 205, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on age group.

Table 205: The workforce is positively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on old-aged employees			0	1
Positive impact of Industry 4.0 on young-aged employees			0	1

In Table 206, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based perceived adaptability.

Table 206: The workforce is positively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on persons who are willing to accept change			0	1

Statements with no clear stakeholder identification but highlighting a positive impact on stakeholder are presented in Table 207.

Table 207: Various Stakeholder are affected positively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on undefined workforce			1	5
Positive impact of Industry 4.0 on other stakeholders	Positive financial impact of Industry 4.0 (2)		8	1
No negative impact on stakeholders			0	0
No reply / No opinion on the impact of Industry 4.0 on stakeholders			1	5

6.5.9 Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affects some stakeholders

As previously stated, the introduction of Industry 4.0 will affect the stakeholders of the organisation. This can be positive for some stakeholders but could be negative for others. Having presented the perceived internal stakeholders that will benefit from the introduction of Industry 4.0, those that are perceived to be less well-off will now be presented. The data that presents the statements of perceptions of stakeholder roles that will be negatively affected by the introduction of Industry 4.0 is presented in the following tables. In general, it can be stated that the group that is chiefly disadvantaged by the introduction of Industry 4.0 is the group of less skilled staff. This perception is shared by management and non-management staff members. In Table 208, the staff groups that are negatively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 208: The workforce is negatively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on skilled workforce			1	0
Negative impact of Industry 4.0 on less-skilled workforce		Positive impact of Industry 4.0 on skilled workforce (4)	3	7

Table 209 presents, based on age, the staff groups that are negatively affected by the introduction of Industry 4.0.

Table 209: The workforce is negatively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on old-aged employees			0	0
Negative impact of Industry 4.0 on young-aged employees			0	0

In Table 210, the staff groups that are negatively impacted by the introduction of Industry 4.0 are presented based on perceived adaptability.

Table 210: The workforce is negatively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on persons who are not willing to accept change			0	1

Not all responses in the interviews make direct reference to stakeholder groups but instead highlight negative implications on stakeholders. These are presented in Table 211.

Table 211: Various Stakeholder are affected negatively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on undefined workforce	Positive financial impact of Industry 4.0 (2)	Autonomous machinery, Big Data, Exposure to changes of work tools (2)	4	7
Negative impact of Industry 4.0 on other stakeholders			1	0

6.5.10 Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform

Tables 212 to 214 present the codes and respective frequency of statements and co-occurrence of statements relating to the perceived pace of the implementation of Industry 4.0 technology at the respective facility of this study. Table 212 shows the data for the perception of a fast implementation. Whereas the largest group of statements made by management staff does not show a clear opinion in respect to the pace of implementation of Industry 4.0, non-management staff statements demonstrate a split opinion on the pace of implementation of Industry 4.0.

Table 212: Fast paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was fast			1	2

In Table 213, statements that are contrary to the assertions of Table 212 are shown.

Table 213: Slow paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was slow			1	3

Some statements may not conform to the requirements of Tables 212 or 213. Statements that indicate no knowledge of the pace of implementation or statements that indicate an interviewee declines to comment on this are presented in Table 214.

Table 214: The rate of implementation of Industry 4.0 is not identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No reply / No opinion on the rate of change			2	0

6.5.11 Theme 11: Employee experience of implementation of Industry 4.0

In the following section, employee experience of the implementation of Industry 4.0 is presented. This relates to the association of the implementation of Industry 4.0 at the respective facility and outside organisations, the link of organisational change and the introduction of Industry 4.0 and possible resistance to the implementation of Industry 4.0. Management staff and non-management staff statements demonstrate a strong awareness of supportive and non-supportive external influencers of Industry 4.0 at the Chinese case facility. Such experiences are strongly intertwined as shown by the strong co-occurrence of statements that highlight supportive and non-supportive external influencers. Table 215 presents statements which identify outside organisations.

Table 215: Entities associated with the implementation of Industry 4.0

	Frequent co-occurrence		Grounded	
CODE	**Management**	**Non-management**	**M**	**N-M**
Drivers of change towards Industry 4.0			5	4
Supportive external influencers on the implementation of Industry 4.0	Non-supportive external influencers on the implementation of Industry 4.0 (2)		8	3
Non-supportive external influencers on the implementation of Industry 4.0	Supportive external influencers on the implementation of Industry 4.0 (2)		2	3
No reply / No opinion on external influencers of the implementation of Industry 4.0			0	2

Statements on the perceived change within the case organisation and the Chinese case facility are presented in Table 216. A differentiation is made between statements that link such changes with the implementation of Industry 4.0, and those that do not. Of note is that the statements made by the staff at the Chinese case facility can be identified as strongly linking organisational change with the introduction of Industry 4.0.

Table 216: Change in the organisation is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Experience of organisational change with a link to Industry 4.0	Expected changes to the form of factories (2)		7	6
Experience of organisational change with no link to Industry 4.0	Experience of organisational change with a link to Industry 4.0 (2)	3D printing (2)	2	1

Table 217 is of note in this study. It presents the number of statements and the co-occurrence of statements by staff of the Chinese case facility that indicate that a resistance to the introduction of Industry 4.0 is perceived or not perceived. A dissonance between management staff and non-management staff can be identified in the statements on the resistance towards change. Whilst the majority of management staff statements indicate little or no resistance to the introduction of Industry 4.0, the majority of non-management staff state the contrary. Only a single statement of non-management staff at the Chinese case facility indicates an absence of a resistance to change being experienced.

Table 217: Resistance to the change towards Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Resistance to the introduction of Industry 4.0		Communication of Industry 4.0 related changes (2)	2	4
No resistance to the introduction of Industry 4.0			4	1
No reply / No opinion on possible resistance to change			0	0

6.5.12 Theme 12: Industry 4.0 is introduced through the use of change communication

This section presents the data that is linked to the implementation of Industry 4.0 and the communication perceived to facilitate this process. In Table 218, the prevalence of statements relating to the use of communication channels in the communication of the implementation of Industry 4.0 are presented. Management and non-management staff statements show a strong awareness of communication being employed during the implementation of Industry 4.0. A regional peculiarity is the absence of statements identified as highlighting shortcomings in the communication of the implementation of Industry 4.0.

Table 218: A variety of communication channels are utilized to communicate the changes associated with the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Channels utilised to communicate changes	Communication of Industry 4.0 related changes (12)	Communication of Industry 4.0 related changes (13)	12	13

Table 219 presents the statements and co-occurrence of statements relating to the communication of change.

Table 219: Messaging towards staff during the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Communication of Industry 4.0 related changes	Channels utilised to communicate changes (12)	Channels utilised to communicate changes (13)	14	16

Several statements are identified that highlight perceived communication shortcomings of the introduction of Industry 4.0. Such statements are grouped in Table 220 and presented with the respective co-occurrence of statements.

Table 220: Identified shortcomings of communicating the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Perceived change communication shortcomings			0	0

6.5.13 Theme 13: Changes in internal communication are experienced by staff

Communication is used to facilitate the implementation of Industry 4.0, but this research shows that the perception of the introduction of Industry 4.0 is also linked to the change in communication due to the introduction of the novel technology at the facility in China.

Table 221 highlights the perception in change of face-to-face conversation, the increased use of communication means and other changes in internal communications due to increased digitalisation of the workplace. Statements indicate the importance of face-to-face communication at the Chinese case facility. The introduction of Industry 4.0 has changed the communication of staff but statements by management and non-management staff often reiterate the important role of face-to-face communication in the age of Industry 4.0. Particularly non-management staff statements show an increased accessibility of other staff and transparency of data due to the use of digital communication.

Table 221: Human communication is shaped by the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Face-to-face communication	Change in communication as a result of digitalisation (4)	Use of digital communication means, Change in communication as a result of digitalisation (3)	7	8
Use of digital communication means	Face-to-face communication (3)	Increased collaboration of workers due to Industry 4.0 technologies (5)	6	15
Change in communication as a result of digitalisation	Face-to-face communication (4)	Use of digital communication means (4)	6	5

A further change to be addressed in the presentation of data is the changing availability of co-workers and superiors and the change in access to these persons due to Industry 4.0. This is presented in Table 222.

Table 222: Digital communication has affected the accessibility of co-workers in the work environment

CODE	Frequent co-occurrence	Grounded

	Management	Non-management	M	N-M
Increased accessibility of co-workers due to digital communication		Use of digital communication means (2)	1	3
Decreased accessibility of co-workers due to digital communication			0	0

The perceived change in the formality of communication at the Chinese facility is presented below in Table 223.

Table 223: Digital communication has affected the formality of communication at the workplace

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased formality in communication due to digitalisation			0	0
Decreased formality in communication due to digitalisation			0	0
No change in formality of communication due to digitalisation			0	1

Table 224 presents the number of statements and the co-occurrence of statements that relate to the change in internal communication due to digital communication at the case facility.

Table 224: Digital communication has changed the internal communication

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has a positive effect on communication			0	2
Industry 4.0 has a negative effect on communication			0	0

Data transparency is a critical element of Industry 4.0. Below, Table 225 presents the codes and co-occurrences of changes in the transparency of data within the organisation and its supply chain due to the introduction of Industry 4.0.

Table 225: Digital communication has influenced the transparency of data

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased transparency of data due to digital communication		Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations, Big Data (3)	1	7
Decreased transparency of data due to digital communication			0	0
Willingness to share data within the supply chain			4	0

6.5.14 Theme 14: Employees are perceiving a change towards the virtual workplace

The interviews were conducted in 2020 and 2021, during a time when travel and physical presence at the workplace was difficult for some. Many interviewees have worked from home, but not all. The statements of staff at the Chinese case facility indicate that staff at this facility have gathered less experience than those staff at the other case facilities. Staff statements do, however, indicate that the outlook on home office is optimistic and that the role of home office for some staff will be possible and practical. Below, in Table 226, the data on positive and negative experiences of interviewees at the Chinese facility in regard to the home office is presented.

Table 226: Experience with home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive experience with home office			1	1
Negative experience with home office			1	0

Industry 4.0 is expected to change the manner in which work is performed. In Table 227, the frequent co-occurrence of codes that highlight the possibility or the impossibility of home office work for factory staff is presented along with the relevant codes.

Table 227: Expectation towards the future implementation of home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive outlook on the possibility of home office for production staff			4	3
Negative outlook on the possibility of home office for production staff			2	1
Outlook on the future of home office			7	4

Table 228 highlights the statements that indicate whether an interviewee has been in the home office or not.

Table 228: Employee experience of home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee has been in home office			2	0
Interviewee has not been in home office			1	4

Last, Table 229 illustrates the interviewees desire to perform their work tasks from a home office setting or if the interviewees of the Chinese facility prefer an office in a traditional setting.

Table 229: Employee attitude towards home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee wants to work from home			0	0
Interviewee does not want to work from home			1	0

CHAPTER 7

7 DISCUSSION OF FINDINGS

7.1 INTRODUCTION

The introduction of Industry 4.0 technologies changes the work environment and impacts the roles of an organisation's stakeholders. In an environment that is transitioning towards stakeholder capitalism and where organisational endeavours move towards responsible business practices, communication plays a pivotal role. This is examined by addressing the research questions provided in the following sections.

The research questions are addressed by examining the data gathered from 50 interviews in four facilities. These facilities are located in Germany, Slovakia, the United States and China. A total of 25 interviews reveal the perceptions of Industry 4.0 by non-management staff, while the remaining 25 reveal perceptions of management staff. Building on the literature highlighted in this document, the interpretation of these perceptions provides a solid foundation to address the research questions in this chapter.

7.2 ADDRESSING THE RESEARCH QUESTIONS

7.2.1 Addressing Research Question 1

Research question 1: How is the implementation of Industry 4.0 technology being perceived from a managerial perspective?

Following the resource-based view, a resource is any asset, capability, process, information or knowledge controlled by an organisation that enables it to sustain its operations and build organisational effectiveness through the implementation of a strategy (Barney, 1991:99–101).

Arend and Levesque (2010) state that resources that fulfil the following requirements are of particular importance to organisations and their prolonged sustainability: Such a resource needs to be valuable, difficult or impossible to replicate, rare and the source of a prolonged competitive advantage. With regard to the implementation of Industry 4.0 technology, it is highly important to evaluate the perceptions of management staff concerning areas that highlight the constituent technologies as assets and/or reveal the limitations in their application. The implementation of Industry 4.0 entails a substantial shift in the manner in which work is performed, altering human interactions with physical machines and cyber-systems.

The complex and interconnected nature of Industry 4.0 technologies can best be explored with reference to systems theory. A system is a manner in which a complex and interconnected structure is explored in relation to its respective environments, according to systems theory (Bertalanffy, 1972:417). As stated by Bortolini *et al.* (2017:5700–5705), Industry 4.0 is an amalgamation of several technologies in the physical and non-physical realms. These technologies have been implemented in the four distinct facilities that are part of this research, and the perceptions of the management staff, who are important stakeholders of the parent organisation, are here explored.

One key element for success in engaging in communication with staff is awareness of the existing knowledge on the topic of Industry 4.0, its constituent technologies and its associations with the implementation process of Industry 4.0.

It was found that perceptions of Industry 4.0 amongst the managerial staff varied between geographical regions. When examining the identified Industry 4.0 technologies constituting the managerial staff members' initial definition of Industry 4.0, the most cited technology was big data. One regional difference in the German management staff's perception of the implementation of Industry 4.0 was the association of the technology with positive effects on the quality of the products manufactured at the site. The management staff of the facilities outside Germany focused the discussion of their initial understanding of Industry 4.0 on the technological aspects of the technology without highlighting their association with functional benefits or disadvantages to their operations.

Literature segments Industry 4.0 into several distinct constituent technologies based on their characteristics. These technologies create the system that in its entirety is described as Industry 4.0. Bortolini *et al.* (2017:5700–5705) and Parsons *et al.* (2018:7) describe Industry 4.0 as being formed by the following technologies: big data, cloud computing, cyber–physical systems, collaborative robots, augmented reality, machine learning, the internet of things, additive manufacturing and mobile connectivity.

This study found that such technologies formed a part of the management staff's perceptions regarding technologies viewed as part of the implementation of Industry 4.0. At the same time, the associated attributes and the focus on dominant technologies varied between the case regions. These attributes can be further differentiated by the segmentation of technologies between generic technology and proprietary technology. The generic technology described in the perceptions of Industry 4.0 technology by management staff is identified as follows in this study.

Big data technology was the generic Industry 4.0 technology most often cited by the management staff in this study. The most common statements that the management staff associated with big data was the experience or expectation that, through the use of big data, an improvement of the quality in a manufactured product could be achieved. There were also facets of views on big data that varied by region.

When discussing the role of big data as part of the introduction of Industry 4.0, a key element frequently highlighted was the large amount of data available to management. Emmanuel and Stanier (20161–5), who associate big data with large quantities of data beyond the means of traditional technologies, highlight this as a key element of the technology. Thus, agreement was revealed between the management staff's associations of big data, Industry 4.0 and the large quantity of data available to decision-makers.

As an example, interviewee US 5 Management stated: 'Automatic system's coming in for big data… Coming in, you know, all the information coming in from all the different sources. Getting instant data to help make decisions. Statements such as this one mirror the characteristics of big data identified in literature. Koseleva and Ropaite (2017:545–546) argue that large amounts of data need to bring value to the user to be considered big data. In addition to the value of data, Sun *et al.* (2018:56–58) argue that veracity is a key aspect of big data. The use of big data by decision-makers in the organisation made it clear that the veracity of the contents of big data is a crucial element of the technology. The statements of management staff at the US facility clearly indicated that big data formed a critical element in their perceptions of the implementation of Industry 4.0 technology.

Members of the management staff group in Germany showed that one of their associations with Industry 4.0 was big data, which they considered as a source of increased data transparency to management and non-management staff in their daily work. This positive sentiment was shared with other regions, with a single exception: One US management staff member stated that they felt overwhelmed at times by the large amount of data available to staff.

The improvement of product quality that can be achieved through the use of big data was highlighted by two German management staff members, one Slovak manager, one US manager and three managers in China. The improvement was associated with the increased capacity to track quality data and the improved the traceability of products. These help to identify variabilities in the product and, through the use of machine learning, alter production to improve the product quality.

Cloud computing is another constituent technology of Industry 4.0 (Bortolini *et al.*, 2017:5700–5705). However, it became obvious through the interviews that none of the management staff in any of the investigated explicitly associated cloud computing with the introduction of Industry 4.0 technology. The sole statements on cloud computing were made by the management staff in Germany.

Collaborative robots (cobots) are a highly recognisable Industry 4.0 technology and were recognised by a large proportion of the management staff interviewed in this study. Most identified collaborative robots as a part of their experience of the introduction of Industry 4.0 technology. The management staff's experience of the introduction of collaborative robots was mostly positive, particularly regarding the technology's effect on financial performance. The introduction of collaborative robots was seen as means of ensuring sustainable competitiveness of the production facility located in the US as it was regarded as a possible way to address high labour costs and increase operative efficiency at the facility. Concerning the financial investment in cobots, the US staff stressed that the return on investment criteria did not hinder their implementation, whereas the management at the Chinese facility considered the return on investment criterion as a prohibitive factor in the implementation of cobots at the facility. The managers in China also linked the introduction of robots to the moderation of increasing labour costs at the facility, while some expected the future introduction of collaborative robots. Interviewee CN 2 Management suggested that increased costs could be circumvented through a business case for collaborative robots as a means to increase product quality. This sentiment was shared by Interviewee SK 1 Management, who envisioned that improvement in quality costs could justify the cost of implementing collaborative robots at the Slovak facility. Academic literature supports the association of Industry 4.0 technology with improvements in product quality and costs (Egger & Masooq, 2020:10–12).

Management staff of the Slovak manufacturing facility had the least exposure to collaborative robots, which did not represent a substantial element of their experience of the introduction of Industry 4.0. The only similar experiences the staff at this facility highlighted were associated with non-collaborative robots or the supply of components for collaborative robots at other facilities. Generally, Industry 4.0 is a means of reducing labour costs, although this does not appear to be a driving force at the Slovak case facility (Wallace, 2021:299–309).

Further, one management interviewee from Slovakia stated that the introduction of collaborative robots is hindered by legislative limitations that severely limit the practical application of collaborative robots in the region. This experience was shared by the staff at the German facility, who stated that the introduction of collaborative robots is substantially limited by worker safety legislation that restricts the pace at which collaborative robots can perform their tasks if human workers are in the vicinity. At facilities that rely on high production outputs, this makes most collaborative robot applications unfeasible. The interviewees from Slovakia and Germany also pointed out that, in contrast to Europe, legislation in the US and China supports the introduction of collaborative robots.

Management staff at the US case facility demonstrated the strongest association between the implementation of Industry 4.0 technology and collaborative robots. Generally, collaborative robots are segmented by the degree of possible cooperation with humans (International Federation of Robotics, 2018). The statements indicated that the US case facility houses over 20 collaborative robots that can coexist and perform sequential collaboration with human workers. At the German case facility, the staff indicated that the few existing collaborative robots are able to coexist with human workers and perform sequential collaboration tasks to a very limited degree.

Augmented reality technology was also featured in the statements of the management staff describing the introduction of Industry 4.0 technology at the four facilities. Bortolini *et al.* (2017:5700–5705) note that augmented reality is one of the technologies constituting Industry 4.0.

It needs to be noted that the management staff of most of the case facilities largely associated the augmented reality technologies at their facilities with the proprietary technology HoloLens, developed by Microsoft. The management staff of the facility in China also closely associated augmented reality technology with the facilitation of meetings with other management staff in geographical regions where the possibility for travel was limited or disallowed at the time of the interviews.

The facilities in the US and in Slovakia were found to have used augmented reality extensively to facilitate communication between the facilities during the relocation of a production line from the US to Slovakia. This transitioning of a production line took place in the context of global travel restrictions that severely limited the possibility for specialists to travel to and from the case facilities. This technology thus facilitated a novel type of communication at the workplace based on the unique context of the relocation of the factory line. Egger and Masooq (2020) argue that a core application of augmented reality technology, such as HoloLens, is to empower workers to perform complex tasks and to aid other staff in the maintenance and assembly of machinery. This was demonstrated on a very large and complex scale by the staff at the US and Slovak facilities.

Machine learning is a cornerstone of the complex system of interconnected and interdependent technologies represented by Industry 4.0. Machine learning is dependent on several input technologies and produces experienceable outcomes for factory workers in a variety of manners. Academic literature suggests that the process of machine learning can be segmented by the type of learning that the machine performs. The spectrum of machine learning thus spans supervised learning on one end to fully unsupervised learning on the other (Yalçin, 2018). One additional type of machine learning is reinforced learning.

As suggested by literature, machine learning is a means to address human limitations on using streams of big data in a manufacturing setting to leverage the aforementioned characteristics of big data (Gan *et al.,* 2021:397–404). The management staff of the case facilities closely associated machine learning with the use of autonomous machinery and big data. All of these are Industry 4.0 technologies.

Following Yalçin (2020), the types of machine learning described at the facilities were supervised and reinforced learning based on the big data from the production process. Overall, this was regarded as positively influencing the quality of the products. Interviewees from the German, Slovak and US facilities stated that machine learning using big data had a positive impact on product quality. Management interviewees from the Chinese facility highlighted this association significantly less often.

TicketManager is a technology that combines several elements of Industry 4.0. It formed a key element of the management staff's perceptions of the implementation of Industry 4.0 technologies. TicketManager is used to automate machine status and facilitate communication between humans and machines. In the facilities that use the TicketManager technology, namely, the German and Chinese facilities, the technology acts as an autonomous diagnosis system using big data and as a control system for production systems. Additionally, it encourages machine learning and is an interface for human and machine communication. TicketManager was amongst the dominant technologies in the management staff's experience of the implementation of Industry 4.0, although it was not implemented in all the facilities.

Whilst the literature segments the constituent technologies of Industry 4.0, it was found that the experiences of the staff regarding the introduction of Industry 4.0 and its technologies led to a less-segmented view. The system of interdependent elements that form Industry 4.0 was emphasised by interviewees highlighting specific proprietary technologies that often incorporate numerous aspects of Industry 4.0.

The German management staff also associated the introduction of Industry 4.0 with resistance among staff at the case facility. Nonetheless, they believed that the introduction of the TicketManager improved the efficiency at the facility.

Parsons *et al.* (2018:7) argue that mobile connectivity is an important part of the infrastructure of Industry 4.0. However, it was found not to substantially shape the managers' perceptions of the implementation of Industry 4.0 technology. Similarly, the Internet of Things, as described by Bortolini *et al.* (2017:5700–5705), was not often mentioned in the discussions of the management staff's experience regarding the implementation of Industry 4.0 technologies.

One key advantage of additive manufacturing is that it substantially reduces the complexity of the manufacturing process, enabling just-in-time production and reduced warehousing needs (Gebhardt, 2011). In this study, the managers in all regions associated the introduction of Industry 4.0 technology with additive manufacturing. The nature of the current traditional product was seen as highly complex and not suitable for additive manufacturing. In this sense, the management staff did not view the advent of additive manufacturing as a threat to current production methods. The staff also assigned additive manufacturing an important role in the product prototyping process. In particular, the prototyping process was viewed as being sped up by the fast output of individual prototypes on site without the need for external suppliers. Further, on-site spare part production using additive manufacturing reduces stoppage time, costs and the need for excess inventory of spare parts.
The management staff frequently highlighted the use of manufacturing execution systems (MESs). These systems were perceived to be part of the implementation of Industry 4.0 in all the investigated facilities. The specific products associated with manufacturing execution systems were Siemens Camstar, Camline, My QI and QRQC. The associations with this technology were positive and are best summarised by the following statement made by Interviewee US 1 Management:

> "I mean, that's the case with an MES. We found that there were lots of paper reports and people that were writing stuff down and putting it into file cabinets, and they felt uncomfortable that maybe this was being taken away from them. But when you understand that everything was going into common databases and

> there were reports that were generated automatically, they didn't have to do this. They were freed up to do more meaningful and more productive things.”

It was thus found that management did not agree with the view that machinery is feasibly upgradeable on either a global or a regional scale. Instead, the management staff in the US, German and Chinese facilities highlighted a limited ability or utility associated with upgrading existing non-Industry 4.0 manufacturing tools.

The US management staff in particular stressed a shortage of labour at the facility and that the role of Industry 4.0 was uncertain. Whilst acknowledging that Industry 4.0 could contribute to the reduction of staffing needs, the increasing complexity of the technologies was viewed as requiring increasingly well-educated staff on site.

The implementation of Industry 4.0 technology is a capital-intensive endeavour, and it can thus be argued that it is of critical importance that sufficient resources are available to the facilities to implement these measures. A total of 32 statements indicated the presence of sufficient resources to implement Industry 4.0, whereas 23 highlighted limitations in the funding of the associated technologies. The current requirement of increasingly short returns on investment on capital expenditure was cited as the primary cause of there being insufficient resources to implement Industry 4.0 technology. However, the management staff in all regions had identified two methods to circumvent such restrictions: (1) by arguing that introducing Industry 4.0 will reduce the facility’s environmental impact and (2) by arguing that the implementation of Industry 4.0 will improve product quality. Whilst literature does indicate that increased resource efficacy is a realistic expectation, it needs to be noted that using environmental argumentation can lead to accusations of greenwashing, which can have negative effects on an organisation’s reputation and could impact its social license to operate (Roblek *et al.,* 2021).

Based on their experience of the implementation of Industry 4.0, the management staff expected an increase in the amount of Industry 4.0 technology at the case facilities in future.

7.2.2 Addressing Research Question 2

Research question 2: How is the implementation of Industry 4.0 technology being perceived from a non-managerial perspective?

The introduction of novel technology and the associated costs provide an opportunity for a business but also expose it to risk. The decision to implement a technology is made on the assumption that it will profit the organisation in the long-term. In this case, the resources of temporal and monetary assets are spent to acquire new assets. The implementation of Industry 4.0 has had a particularly strong impact on the manufacturing workforce of organisations, as these individuals are directly exposed to the use and application of Industry 4.0. According to Barney (1991:101), a resource is any asset, capability, process, information or knowledge controlled by an organisation that enables it to sustain its operations and build organisational effectiveness through the implementation of a strategy (Barney,1991:99–101). Further, a resource needs to be valuable, difficult or impossible to replicate, rare and the source of a prolonged competitive advantage (Barney & Hesterly, 2020:89–99). Industry 4.0 technology and its role as an asset are reliant on the acceptance and application of non-management staff (a key stakeholder group) as a lack of awareness or aversion to this technology may severely limit its usefulness at the workplace.

The complex and interconnected nature of Industry 4.0 technologies can best be explored by highlighting systems theory. According to this theory, a system is a manner in which a complex and interconnected structure is explored in relation to its respective environments (Bertalanffy, 1972:417). Bortolini *et al.* (2017:5700–5705) assert that Industry 4.0 is an amalgamation of several physical and cyber technologies. Particularly for non-management staff, change in the work environment and the manner in which work is conducted is expected (Immerman, 2021). As outlined, these technologies have been implemented in the four distinct facilities of the single parent organisation investigated in this study. Here, the perceptions of the non-management staff as an important stakeholder group are explored.

Using previous literature to segment the various constituent technologies of Industry 4.0, several key technologies forming the core of any Industry 4.0-enabled manufacturing facility can be identified. Overall, the system created by the following technologies forms Industry 4.0 are as follows (Bortolini *et al.*, 2017:5700–5705; Parsons *et al.*, 2018:7): big data, cloud computing, cyber–physical systems, collaborative robots, augmented reality, machine learning, the internet of things, additive manufacturing and mobile connectivity. The discussions of these systems with the interviewees highlighted that the introduction of Industry 4.0 technology was not perceived as the introduction of a single technology but rather as the implementation of numerous interdependent systems.

This study found that several of these technologies formed part of non-management staff's perceptions of the implementation of Industry 4.0. Similar to their management staff colleagues, the non-management staff experienced this change through the introduction of Industry 4.0 technologies at their respective facilities. The degree and types of technology experienced did exhibit regional similarities, although they also highlight differences in the usage of Industry 4.0. When prompted as to whether they had knowledge of Industry 4.0, the vast majority of the staff indicated some familiarity with it. Of the 25 non-management interviewees, 23 had knowledge of Industry 4.0, while only two stated that they were unfamiliar with the term, although the latter still demonstrated a knowledge of the associated technologies in their description of the change.

The non-management staff associated Industry 4.0 with the ever-increasing use of autonomous technologies at their respective case facilities. The fact that the initial statements on Industry 4.0 were closely associated with autonomous machinery highlights that, whilst no staff explicitly highlighted cyber–physical systems as an element of Industry 4.0 (as suggested by literature), they did indirectly link Industry 4.0 with cyber–physical systems. That is, autonomous systems are an amalgamation of Industry 4.0 technology of a physical and cyber nature (Hellinger & Seeger, 2011:15–19; Pereira & Romero, 2017:1210–1211). The non-management staff at the Chinese and German facilities in particular highlighted their experience of the implementation of Industry 4.0 as being based on autonomous machinery. The non-management staff at the Slovak case facility instead highlighted the increasing use and collection of large amounts of data in their initial assertions on the topic.

The non-management staff's discussions of Industry 4.0 technologies centred around several of the associated technologies. The most-cited technology throughout the discussions was autonomous machinery. This technology was cited 55 times during the interviews, mostly by the staff at the German and Chinese facilities. Overall, this was the most identified non-brand-specific technology. The sentiment towards the technology was positive, and the staff highlighted the supportive function of autonomous machinery for their work purposes. Further, the staff members asserted that this technology would likely find further application at their facilities. The staff least aware of autonomous machinery were those in the US.

At the German case facility, autonomous machinery was the most often mentioned generic technology that the non-management staff associated with the introduction of Industry 4.0. A total of 20 statements from case facility 1 and eight statements from case facility 2 indicated such a link. These statements accounted for half of all statements on the use of autonomous machinery. As suggested by Atzori *et al.* (2010:2787–2790) and Hellinger and Seeger (2011:15–19), the use of Industry 4.0 technologies creates novel logistics based on the internet of things and cyber–physical systems. Although cyber–physical systems and the internet of things were not explicitly named, the underlying technology was acknowledged as a final visible output by several staff members, who cited autonomous logistics systems as part of their experience of the introduction of Industry 4.0. In the case of the German facility, aspects of the experience of cyber–physical systems was addressed when discussing the introduction of autonomous logistics systems.

TicketManager is a technology implemented at several of the case facilities that combines several elements of Industry 4.0. It is the proprietary technology that most strongly shaped the non-management staff's perceptions of the implementation of Industry 4.0. Perceptions of TicketManager were particularly prevalent at the German and Chinese case facilities. TicketManager is a means to automate machine status reporting and facilitate the communication between human and shopfloor workers. Based on big data, the internet of things and artificial intelligence, TicketManager is used at the relevant case facilities to inform shopfloor staff of machine malfunctions and schedule preventative maintenance. To achieve this, it alerts the most qualified staff available at the facility to attend to the identified issues (Robert Bosch Manufacturing Solutions, 2018).

Following the arguments made by Bortolini (2017:5700–5705) and Parsons *et al*. (2018:7) on the elements considered to form part of Industry 4.0, it can be concluded that TicketManager's use of big data and machine learning and its ability to interact with the relevant human parties make it a good example of the application of Industry 4.0 technology at manufacturing facilities.

Overall, the TicketManager system was the most-discussed technology at the German facility, with it being referred to in a total of 41 statements. The technology was also an important topic in relation to the facility being upgraded to the Industry 4.0 standard, and the facility has been newly designed with this technology. However, the evaluations of the technology among the workforce were mixed. Whereas the staff at the facility that had been upgraded to include Industry 4.0 technology perceived TicketManager as having positively influenced the organisation's operations, numerous assertions were made indicating that aspects of the implementation of the technology negatively influenced efficiency and product quality. Still, these drawbacks were often highlighted to be of a short-term nature. The literature suggests that the introduction of Industry 4.0 technologies generally has positive effects, such as increased traceability and product quality (Karnik *et al.,* 2022:5–7; Egger & Masooq, 2020:10–12). These assertions are in line with the statements made by the staff at the German case facility, which was designed to include Industry 4.0 technology.

The non-management staff at the Chinese facility mentioned TicketManager often, similar to the German non-management staff. At the same time, many of the statements of the staff in China closely associated the TicketManager technology with Camstar. Manufacturing execution systems, such as Camstar or Camline, form an integral part of the digitalised manufacturing process (Illa & Padhir, 2018:55163–55164). The non-management staff at the Slovak facility, similar to their colleagues at the Chinese facility, closely associated the introduction of Industry 4.0 with the application of MESs. Statements relating to the use of Camstar and generic statements relating to the use of MESs were amongst the most frequent made by the non-management staff at the Slovak facility. However, these staff did not explicitly link their experience of Industry 4.0 technology with the use of big data, collaborative robots or machine learning.

The non-management staff at the US facility's perceptions of the introduction of Industry 4.0 were focused on a single dominant technology. In particular, the staff very strongly highlighted the introduction of collaborative robots in relation to the advent of Industry 4.0 at the facility. The 17 statements that mentioned collaborative robots highlight that the introduction of a physical element within cyber–physical systems can dominate the experience of the introduction of Industry 4.0. Collaborative robotics can be segmented into several different types based on the complexity of the collaborative task that is to be performed by the cobot. The spectrum of collaborative robots extends from those that can coexist with human workers without posing a safety risk to the workforce on the one side to those that are able to collaborate with human workers and respond to these workers autonomously, performing work tasks in tandem, on the other (International Federation of Robotics, 2018). Through the exploration of the non-management staff's statements, it was made clear that the US facility non-management staff had been highly exposed to collaborative robots. These cobots are mostly used for work at the end of the production line and perform mostly autonomous work with little human collaboration during the work process. This qualifies them as the kind able to coexist and perform basic sequenced tasks with human staff.

Interviewee US 5 Non-management stated that the use of collaborative robots would improve the facility's financial sustainability, although the introduction of collaborative robots was linked by many of non-management staff to the initiation of a shift towards lower staffing needs on a shopfloor level. The collaborative robots were also viewed as a means used by the facility to address understaffing issues. However, there was no clear consensus on whether the robots had a positive or negative impact on staffing at the facility. Considering the strong prominence of the collaborative robot technology at the US facility, it should be noted that the implementation of Industry 4.0 was also associated with a resistance to change at this facility. However, this resistance associated with Industry 4.0 was not strongly linked to the introduction of collaborative robot technology at the facility.

Whilst they were aware of augmented reality devices and their use at the facilities, the non-management staff indicated that the use of these devices was reserved for management and engineering staff. The sole exception to this were the Chinese non-management staff, who had some limited access to such devices. Similar to their management peers, the non-management staff closely associated augmented reality devices with Microsoft's HoloLens.

Bortolini *et al.* (2017:5700–5705) state that additive manufacturing is a core technology of Industry 4.0. It is also argued that, in the future, the use of additive manufacturing influences the manner in which the prototyping and the manufacturing of goods will be executed (Gaub, 2016:401; Horst *et al.*, 2018:3). The staff at all the facilities stated that they had experienced the introduction of additive manufacturing. That, statements pertaining to additive manufacturing made by non-management staff were identified in all facilities, and the vast majority of the non-management staff demonstrated knowledge of the technology at their respective facilities.

7.2.3 Addressing Research Question 3

Research question 3: How is Industry 4.0 altering the role of stakeholders of the organisation?

Following stakeholder theory, an organisation holds responsibility not only towards shareholders but also towards its stakeholders in a wider sense. An organisational focus on stakeholders is associated with the endeavour to ensure long-term existence and responsibility towards social, environmental and economic sustainability (Schwab, 2021:171–173). Stakeholders can take many forms. When segmenting stakeholders into groups, a distinction is often made between internal and external stakeholder groups. Internal stakeholder groups comprise all members who are internal members of an organisation. When organisations fail to be aware of stakeholder grievances or the changing role that particular internal stakeholders hold in an organisation, the risk arises that discontented internal stakeholders may revoke an organisation's license to operate through means such as strikes or sabotage (Cornelissen, 2020:70). This may be particularly relevant when stakeholders are faced with significant change in their occupation or role within an organisation.

It is illustrated in literature that education is the key to harnessing positive results for the workforce from the introduction of Industry 4.0. The interviewees largely echoed this sentiment as the majority had witnessed or expected negative impacts as a result of the introduction of Industry 4.0 on the least-educated members of the respective facility's workforce. A total of 41 statements from management staff also indicated that such a negative outcome resulting from the introduction of Industry 4.0 was expected. Of the 25 management staff who participated in this study, 18 indicated that they had such negative experiences or expectations regarding less-educated workers.

The experience and expectation of negative impacts on the less-educated staff at the facilities was shared between management and non-management staff. The latter indicated this point in 36 statements. Of the 25 non-management case staff interviewed in the study, a total of 17 stated they had an experience or expectation of a negative impact on less-educated workers. The negative impact on less-educated staff was least-perceived by the non-management staff located at the US case facility, among whom several did not indicate any experience or expectation of negative impacts on less-skilled staff. On the contrary, in discussing the impacts of Industry 4.0 on stakeholders, Interviewee US 3 Non-management highlighted a lack of educated staff at the case facility and the need for a wider recruitment of skilled staff who were not local to the region:

> "We need a little bit more like knowledge on computers and all that stuff I guess. Whereas, Hillsboro is kind of a quiet town, very small, we don't really have a lot of like knowledge with that stuff, so it's definitely brought more people into town. I've noticed there's just, everyone that we're bringing in is more knowledgeable on this stuff already."

This sentiment was echoed by one of the most senior staff at the US facility, who stated that the less-skilled staff were removed from the case facility only through attrition and not through active retrenchment, while a regional shortage of skilled staff was causing the facility to recruit from a larger region than usual.

It should be noted that not all aspects of the introduction of Industry 4.0 were perceived as negative. A total of 12 statements made by 10 management case staff and a total of 10 statements made by 9 non-management case staff indicated that Industry 4.0 had a positive impact on less-skilled staff. In the German facility in particular, the management staff noted an increase in organisational efficiency that benefited less-skilled staff as they were offered more intellectually challenging and less physical challenging tasks. TicketManager is one of the means to this end. However, this sentiment was not shared by the non-management staff at the German facility. This dissonance highlights a potential cause of conflict in terms of the stakeholder approach, as stakeholder support is regarded as vital in ensuring continued organisational sustainability (Freeman *et al.*, 2018). Possible causes of this dissonance will become evident in further discussions of this chapter, particularly in context of job security and production efficiency.

The staff expectations regarding the changes in the stakeholder roles at the facilities across all regions revealed a co-occurrence of statements indicating a negative impact of Industry 4.0 on less skilled staff and a positive impact on skilled staff. This is in line with literature, which argues that Industry 4.0 leads to an increased demand for specialist staff and the creation of previously unknown employee roles that are increasingly demanding and require higher levels of education (Bonekamp & Sure, 2015:33–40).

The stakeholder group of skilled staff performing increasingly specialised roles in the case facilities were thus perceived as the principal benefactors of the introduction of Industry 4.0. A total of 52 statements indicated Industry 4.0 had a positive impact on skilled staff, while only 8 statements indicated it had a negative impact. The perceived negative impact on skilled staff was closely associated with the notion that the automatisation and autonomisation of production processes requires less management supervision, meaning Industry 4.0 increases its scope into high-skill and high-cost occupations. On the positive spectrum of Industry 4.0 lie the skilled staff at the case facilities in engineering occupations. These specialist information technology (IT) staff are regarded as key workers of the future at these case facilities.

Whilst literature indicates that Industry 4.0 is a potential means to address global demographic trends towards increasingly elderly societies, there was little evidence from the facilities in this study to support such assertions (Sallati & Schützer, 2021:810–815). A single non-management staff member from China stated that elderly staff benefitted from Industry 4.0 based on the idea that these staff members could be reskilled to perform other tasks. All other statements indicated that the older staff, similar to the less-skilled staff, are amongst the primary groups disadvantaged by Industry 4.0. This interviewees very often associated this claim with the above-average IT literacy needed to proficiently operate Industry 4.0-enabled technology. Building on the statements regarding Industry 4.0 and older employees, some indicated that younger-aged staff were among the primary benefactors of Industry 4.0. Interviewees from all four facilities cited the higher acceptance of change by younger staff as the reason for this. The perceived nature of their upbringing was cited as a further reason for Industry 4.0 benefiting younger over older staff. That is, younger staff are regarded as digital natives, whereas older staff face the need to change due to a lack of prior exposure to digital technology.

7.2.4 Addressing Research Question 4

Research question 4: How can change management programmes facilitate the implementation of Industry 4.0 on managerial and non-managerial level?

Following the argumentation of punctuated equilibrium theory, revolutionary periods occur when the equilibrium in an operating environment is compromised, and organisations engage in radical change to adapt to the novel environment as an effort to find a new state of equilibrium to sustain their existence. Revolutionary periods can be caused either internally or through an exogenous stimulus, which refers to an external trigger that initiates a series of events that categorically changes the context in which an organisation operates. This motivates the organisations and leadership to engage in efforts to adapt to the new situations (Boushey, 2012:128; Gersick, 1991:23; Bonciu, 2017:9).

Currently, the organisation studied is altering its ownership structure, organisational structure and product portfolio as well as entering new product categories. This is all being done simultaneously during a period of great global instability brought about by the COVID-19 pandemic. In addition to this change, the organisation is upgrading its facilities with Industry 4.0 technology. Gersick (1991:23) describes such factors as core elements of a revolutionary period according to punctuated equilibrium theory.

To manage change, an organisation needs to be aware of its employees' perceptions of the change in order to manage it. This raises the question as to how these employees perceive the pace of the implementation of Industry 4.0 in comparison to that suggested in literature.

Most of the management staff interviewees indicated that the perceived rate of change was slow rather than fast. The managers of the Chinese facility did not regard the rate of change as either remarkably slow or fast, with only a single statement indicating either one. Unlike those of their management colleagues, the majority of statements of the Chinese non-management staff indicated a consensus that the implementation of Industry 4.0 is slow. The managers of the German facility also appeared not to have clear opinion on the pace of Industry 4.0 implementation; a total of five statements indicated a slow implementation, while four indicated a fast implementation. In contrast, the German non-management staff had a clear opinion in this regard, with the majority of statements indicating that Industry 4.0 was being implemented at a fast pace. However, this was the only employee group among all the facilities to voice this opinion in a majority of statements. The majority of the management and non-management staff in both Slovakia and the US voiced statements indicating a slow pace of Industry 4.0 implementation. Those at the Slovak facility considered the implementation of the Industry 4.0 technologies to be especially slow. At the US case facility, a considerable number of non-management staff did not know or did not have an opinion on the pace of Industry 4.0 implementation.

Using these numbers, one could conclude that most statements indicated the implementation is slow, but this would not reflect the entire picture conveyed by the interviewees. Firstly, it needs to be noted that the Slovak case facility has relatively few Industry 4.0 technologies available at the current time. Thus, the employees argued that the implementation was slow compared with other facilities due to the relatively low labour costs at the facility. Secondly, at the other facilities, particularly those with high levels of Industry 4.0 implementation, the pace of implementation was regarded by numerous employees at both the management and non-management levels as initially fast but continually slowing down over time with increasing levels of technological saturation.

Tang (2019:77) highlights that a key change management initiative to ensure a successful implementation is to consolidate positive changes and sustain a sufficient momentum of change. This is also one of Kotter’s (2014:29) innovation accelerators. Overall, the are sufficient indicators to suggest that the case organisation is not succeeding in ensuring that the initial pace of implementation is sustained in the investigated facilities. Statements such as the ones made by Interviewee US 4 Non-management, who stated, ‘Uh, I think at first it was really fast and we've kind of plateaued and we're slowing down now…’, reveal this perception. This highlights that there are some employees who regard the process as slowing over time, which is a sign of unsuccessful momentum management by management staff.

Tichy (1983:188) states that efficient resource allocation is the key to ensuring successful change implementation. The allocation of resources is vital for change management as the introduction of most changes involves capital expenses, which a profit-driven organisation seeks to minimise to maximise organisational efficiency. The management staff's statements in all regions except the US indicated that the organisation is offering sufficient resources to introduce Industry 4.0. However, these statements were not unanimous, and some management staff highlighted areas where the organisation is limiting funding for the introduction of Industry 4.0. Particularly, the short return on investment of two years was seen as a limiting factor to the introduction of Industry 4.0. Managers highlighted workarounds for these resource limitations, such as product quality improvements and improved environmental performance of the respective facilities through the use of Industry 4.0.

Minimising friction and conflict during the implementation process of new technologies is of paramount importance for change management programmes (Kotter, 2014:22). The interviewees demonstrated strong opinions when questioned as to whether they had experienced resistance to change in relation to the implementation of Industry 4.0. A total of 98 statements were related to the interviewees' opinions on the topic of resistance to change at the facilities. Most of these statements were related to employees experiencing or witnessing some degree of change towards the introduction of Industry 4.0. Of the 98 statements, a total of 83 indicated resistance to the introduction of Industry 4.0, compared with only 14 statements that indicated no resistance (additionally, 1 interviewee did not wish to respond). Statements highlighting resistance to the introduction of Industry 4.0 had a high co-occurrence with statements highlighting the communication used to introduce Industry 4.0, for both the management and non-management levels. Further, a high co-occurrence was observed between statements highlighting a negative impact of Industry 4.0 on less-skilled workers and those highlighting a resistance to the implementation of change. At the German case facility, both management and non-management staff associated the TicketManager technology with resistance to the introduction of Industry 4.0, highlighting an exceptionally negative perception of TicketManager.

The staff in Germany displayed very strong resistance to the introduction of Industry 4.0, with both management and non-management staff elaborating on their extensive experience in this respect. The management staff highlighted that their non-management staff strongly associated the introduction of the TicketManager technology with increased organisational efficiency that would result in job rationalisation. Interviewee DE 3 Management indicated they expected non-management staff to feel that Industry 4.0 was being used to replace human labour. In particular, this interviewee stated:

> “Also der Einrichter an der Maschine sollte dieses Tool nutzen. Er weiß “naja ich muss es nutzen”. Wenn ich nun einige meiner Kollegen abbaue ist natürlich die Akzeptanz nicht da. Das ist gerade, finde ich, das ist die Gefahr bei diesen Tools, wo man sagt, es ist eine Unterstützung ja. Also wenn man genug Leute hat, braucht man den TicketManager gar nicht, ja? Sag ich mal. Sondern der TicketManager hilft einem mit einem geringeren Personalstamm die gleiche Arbeit zu tun ja.”
>
> *Translation: The machine setter should use this tool. He knows “well I have to use it”. If the machine setter knows that this contributes to the laying-off of some of his colleagues, the acceptance will of course not be great. That's exactly what I think the danger with these tools lies: When people say it's a support. Because if you have enough people, you don't need the TicketManager at all, right? The TicketManager is an enabler to do the same work with a smaller workforce.*

This sentiment matched those of many non-management staff. One US non-management staff member stated:

> “Right, yeah, I mean... so I guess on that topic it's... a lot of people were really worried about it at first, the whole “Oh, robots are gonna take our jobs”.

Whilst the interviews revealed that not all non-management staff categorically rejected Industry 4.0 technologies and that some even embraced the technology, this area should be of high interest to the organisation. At the same time, there is merit to the introduction of Industry 4.0, and this is known among some non-management staff. Interviewee US 3 Non-management stated, ‘I mean I get it, but it seems like they've just almost just made our lives easier, and we can move people around to other areas that we need'. This sentiment is not well communicated by the organisation, highlighting numerous shortcomings in the change management approach of the organisation. The interviewees' references to the resistance to the introduction of Industry 4.0 had a co-occurrence with statements highlighting perceived shortcomings in the communication of changes towards Industry 4.0, further underlining the need for concise internal communication.

Kotter (2015:17) suggests that a volunteer army that believes in a change should propagate the change along with a vision and strategic goals communicate these efficiently to ensure employee buy-in. Some interviewees demonstrated a lacking sense of urgency when discussing the changes of the organisation, both those related and unrelated to Industry 4.0. As previously stated, many staff members highlighted the slowing pace of implementation of Industry 4.0. In general, it was observed that the organisation is going through a great degree of change based on changes in its ownership and product portfolio and the introduction of Industry 4.0, which are coinciding. All of these factors affect a large portion of the organisation's workforce and create a sense of uncertainty. To address issues such as this one, Kotter (2014:19–26) suggests the use of a dual system approach where change is firstly applied to a smaller group or portion of an organisation to minimise uncertainty and harness the flexibility of a small group whilst also harnessing the efficiency of a large organisation.

The management staff at the German facility identified the Industry 4.0 team based at the facility as a key driver of the introduction of Industry 4.0. However, it needs to be highlighted that the organisation's need for financial success and prolonged financial sustainability was cited the strongest driver towards the introduction of Industry 4.0. Further, few non-management staff highlighted the Industry 4.0 team as the driver of Industry 4.0. The staff at the US and Chinese facilities in particular highlighted senior management and government entities as the drivers of the introduction of Industry 4.0. This is in line with the suggestion in literature that senior management should be one of the primary champions of change (Phillips, 1983:190).

Kramer and Pfitzer (2016:2) state that, instead of operating in silos, organisations should engage in the creation of ecosystems of shared value in an effort to maximise efficiency and harness specialised organisational strengths whilst mitigating weaknesses, with the goal of maximising the organisations’ long-term sustainability. The senior management staff in particular highlighted that cooperation was taking place between outside organisations and the investigated organisation. The German staff associated several outside companies with the introduction of Industry 4.0 technology at the facility. Those identified included Bosch (for the introduction of the TicketManager), Siemens (for the Camstar system) and the German Telekom (for the 5G mobile campus network). The non-management staff at the case facilities outside Germany did not mention such a close association between the introduction of Industry 4.0 and other organisations. The following statement of Interviewee US 3 Non-management provides an example of this:

> “I honestly have no idea. I know a lot of our managers and supervisors will work with people like that. I just kinda, I run the line, make sure it's running. We do have people, not a lot lately again because of COVID, but we used to have a lot of other companies, a lot of our, um, the people we've supplied to. They'd come by and looked to... and they'd ask questions, but we haven't seen any outside people in a long time.”

7.2.5 Addressing Research Question 5

Research question 5: How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?

At the basis of any communication is the exchange of meaning between multiple parties. Following the communication transmission model, communication requires a sender of a message, a receiver of a message, a message and channels to convey the message (Tubbs & Moss, 2008:1–19).

The introduction of Industry 4.0 has not only altered the communication within the facilities investigated but also influenced the communication among the facilities. Internal communication encompasses all communication within the limits of a single organisation and is used to convey meaning and build relationships (Mazzei, 2010:221). These functions are particularly necessary in times of uncertainty. In taking the open systems view on organisations, evidence was found of an environmental influence on the organisation, on the case facilities and on the internal communication (Gregory, 2000:266–277). In particular, the increasing amount of Industry 4.0-enabled machinery and the events associated with the consequences of the COVID-19 pandemic, which led to limitations on physical proximity between co-workers and the associated drive towards telework, can be regarded as events suitable to induce a period of a revolutionary nature (Gersick, 1991:13; Vetter, 2017; Schwab & Malleret, 2020:175).

The introduction of Industry 4.0 changes the dynamics of internal communication, which transitions further into the digital realm. The perceptions of employees at the facilities reveal that the role of face-to face communication is changing through the introduction of the virtual office and the increased use of digital communication and work tools. Internal communication programmes are a means to increase employee engagement. However, the changes in communication and repercussions that may need to be addressed due to internal communication programmes should be highlighted beforehand to ensure complete understanding.

Face-to-face communication was featured in a total of 43 statements across all case facilities. From these statements, two distinct trends can be observed. In many cases, a preference for face-to-face communication was highlighted along with the observation that this type of interaction had decreased over time in the facilities. The non-management staff at the facility in Germany were particularly fond of personal face-to-face communication and highlighted a shift towards non-personal communication means. Interviewee DE 6 Non-Management argued that the use of any digital communication tool causes a loss of meaning in the messages communicated. This sentiment was echoed by Interviewee DE 8 Non-management, who stressed that in-person communication is vital and that the use of digital communication means that enable the parties to visually interact with each other are not an adequate substitute for in-person face-to-face communication.

Whilst the shift towards digital communication was often cited as leading to faster and less-hierarchical communication, the non-management staff at the facilities also stressed that they often found the use of digital means to be less efficient and slower than in-person face-to-face interactions.

Whilst the non-management staff at the German and US facilities highlighted a preference for face-to-face communication, the advantages of digital communication were also clearly acknowledged. At the same time, the non-management staff in China held face-to-face communication in particularly high regard. This applied to communication both with superiors and amongst colleagues. Interviewee CN 4 Non-management at the case facility in China stated that digital communication had increased and did have some advantages but that they still preferred face-to-face communication in any case. The preference for face-to-face communication in organisations and a shift towards digital means, as highlighted in literature, is in agreement with the perceptions of the staff at all the facilities (Tenhiälä & Salvador, 2018).

From the perspective of the management staff, the transition in communication towards digital means was a welcome development to some degree in relation to the fact that these staff are currently responsible for more personnel than they are used to. In this respect, the use of digital communication enables the management staff to communicate with other staff from a greater distance, particularly in context of the COVID-19 social distancing restrictions. One exception to this were the management staff at the Chinese facility, who shared an affinity for in-person face-to-face communication both amongst themselves and with the factory staff. Interviewee CN 5 Management highlighted that communication via digital means is a sign of distrust and that the motivations of the sender are automatically questioned. This interviewee also asserted that the use of tracible digital communication can be interpreted in a manner that implies that the other party desires proof of the exchange. Other management interviewees in China asserted that the use of digital communication is unsuitable for communication with the workforce as direct public interaction in person and face to face on the shop-floor is the most effective manner to reward high performance and can also be used as means to motivate staff and prevent them from underperforming at their tasks. One Slovak manager asserted that their communication towards colleagues and staff was solely digital and that this did not foster only desirable outcomes.

The use of digital communication means has, for the vast majority of workers, increased the accessibility of colleagues, even though some argued that the quality of communication using digital communication is inferior to in-person conversations. One German non-management staff highlighted that digital communication and the automatic exchange of data among departments can be used as a means to break down barriers and address silos in organisations. However, the building of interpersonal relationships is more difficult using digital means.

The formality of communication within the organisation is also undergoing a transition, and most of the staff at the facilities considered the communication style at the workplace as becoming decreasingly formal. This development has also been highlighted as a global trend in in business. However, literature highlights that not all types of informal communication and flat hierarchies are desirable (Tenhiälä & Salvador, 2018). Of the 20 statements related to the formality of internal communication, only a minority indicated that little or no change was occurring. A single interviewee at the German case facility indicated that during the first stages of online meetings, one might have experienced increased formality but that this formality was temporary and decreased over time. Despite the decreased formality of digital communication, the interviewees noted that the use of online meetings has a distinct advantage of leading to a perception of improved timeliness among participants.

Home offices have also come to play a substantial role in organisations, with many employees performing their work at home due to COVID-19 restrictions (Lopez-Leona *et al.*, 2020:371). The facilities studied here are no exception to this trend. The facility in China engaged in the least home office work, whereas those in the remaining regions had largely adapted to a hybrid work environment. The German and US manufacturing staff are amongst those most satisfied with home office work and engage in it frequently.

Amongst non-management staff at the case facilities, a desire to work from a home office setting could be identified. In particular, the staff from the German and Slovak facilities mentioned this desire. Discussion of the expectation of this becoming a reality for production staff exposed a divergence between management and non-management staff's perceptions of future developments regarding the possibility of production staff working from home. Whilst an overwhelming majority of production staff expected such a development, it is clear that the majority of management statements indicated that it is unlikely to become feasible in the foreseeable future. At the German and Slovak facilities, such divergences in the perception of future development could be addressed through the use of internal communication. The staff in China and the US were in agreement that such developments are possible, whereas the management staff in Slovakia and Germany were less positive regarding the likelihood of home office work for manufacturing staff.

The experiences of staff in regard to working from home were found to be largely positive. Most management staff and some manufacturing staff highlighted that their experience was a positive one. The manufacturing staff who had the opportunity to work from home stressed that this was made possible solely due to the digital nature of manufacturing and the availability of IT. This development confirms the possibility of a transition towards factory work from home offices. Immerman (2021) highlights the transition towards remote manufacturing work and the use of digital means to achieve this. To foster this, internal communication programmes should play the role of informing staff of possibilities regarding the development of digital skills as IT literacy is one of the key enablers of home office work (Vnoučková, 2020:19-21).

The organisation used as a case in this paper is in a state of transition, and the changes to communication should be addressed by internal communication programmes. In particular, these should address the transition towards less formal communication and increased reliance on digital communication. In the facilities, the change in formality is of particular importance to clarify. The organisation is also in the process of being acquired by a smaller high-tech organisation. Technology organisations and the modern culture of such businesses are often associated with an informal dress code, employee self-organisation and flat hierarchies, contrasting with traditional business organisations (Tenhiälä & Salvador, 2018).

The expected fusion will bring together contrasting organisational cultures, with the case organisation being anchored in traditional industries and the high-tech organisation having modern elements. The fusion of these two organisations has already changed the organisation's internal structure. One of these changes is the introduction of Industry 4.0 technologies at the investigated facilities, with the change at the German facility being by far the most substantive. The organisation also underwent a split from its traditional business sectors into different businesses prior to being acquired by the high-tech organisation. This was described by Interviewee DE 5 Management as resulting in the case facility having fencing within the factory buildings that separates not only the traditional business organisation and the case organisation but also former colleagues who have known each other for years. One can argue that the use of barriers within a facility to divide a manufacturing site is not ideal messaging towards staff, particularly given the historical context of Berlin and its history of being a divided city. Whilst other case facilities have not been as affected by the separation of the business, this is undoubtably a source of uncertainty for staff.

The staff at the German case facility were exposed to the most dramatic changes in the facility. This was partly responsible for high levels of resistance towards the introduction of Industry 4.0 technology at the facility. In addition, German culture is noted to be the least accepting of risk compared to those of the other case regions (Hofstede *et al.* 2010:141–143). Aversion to risk is directly linked to the aversion of uncertainty. The transition in ownership and separation of the organisation are certainly sources of uncertainty typically avoided in German culture.

Two main functions of internal communication are the management of relationships within an organisation and the building of internal commitment (Mazzei, 2010:221). Both functions of internal communication are relevant to reducing the uncertainty amongst the staff of the studied facilities. One goal of an internal communication programme should be to inform staff. Hofstede *et al.* (2010:255–257) highlight factors that make this particularly relevant for facilities operating within cultures that do not value uncertainty and are forward-facing.

In introducing Industry 4.0, the case organisation has employed internal communication to introduce the technology to its employees. First, all employees who held a position during the implementation of Industry 4.0 at the case facilities expressed that they were exposed to various types of communication concerning the introduction of Industry 4.0. This illustrates that through internal communication, staff were effectively informed of a change in the organisation through an internal communication process. The employees highlighted the channels used, the original senders of such messages and the original messages, which is line with literature on the elements of communication (Tubbs & Moss, 2008:9). A total of 91 statements made by the management staff along with 88 statements made by the non-management staff highlighted the use of communication to introduce Industry 4.0 at case facilities. In addition, a total of 74 management and 74 non-management staff statements identified the channels used to communicate the introduction of Industry 4.0.

The management staff identified several channels employed to communicate the introduction of Industry 4.0 to non-management employees. Tubbs and Moss (2008:12–15) outline several channels of mass communication that can be used to engage with an audience. The management staff recalled the use of public townhall meetings, public displays, posters, in-person meetings, departmental meetings, the company's intranet and workshops to communicate the transition to Industry 4.0 to non-management staff. Interviewee DE 10 Management stressed the standardised manner in which the hierarchical communication of changes was addressed, representing a clear case of top-down communication. Interviewee DE 2 Management stated that the clear communication of Industry 4.0 initiatives within the German facility was a primary concern as such communication is of vital importance to the successful implementation of the initiatives. Interviewee DE 1 Management appeared to agree with this statement, highlighting that as many channels as possible should be used to communicate this to non-management staff. Whilst internal communication has occurred during the implementation of Industry 4.0, the effectiveness has varied amongst different channels. The non-management staff most often referred to meetings and communications with colleagues and superiors on the implementation of Industry 4.0, whilst the use of other channels, particularly digital channels, were less prominent in the discussions of the introduction of Industry 4.0. This further underlines the importance of formal in-person face-to-face communication within an organisation.

The use of two-way communication allowing staff to provide feedback and in turn providing these staff the feeling of being heard is highlighted by literature as a suitable manner of communicating change in an organisation (Falkheimer & Heide, 2018:37–42). Pandi-Perumal *et al*. (2015:3) further suggest that the engagement of stakeholders is vital and that stakeholders can be engaged most efficiently when sufficient knowledge about them is held. This principle was applied by the managers implementing Industry 4.0 at the German and US facilities, who both explicitly highlighted the need for internal stakeholder identification and engagement in asymmetrical communication with the identified employee groups.

Interviewee DE 2 Management argued that as part of communicating the introduction of Industry 4.0, management identified the key users of the novel technology and engaged with these in a manner that allowed for feedback integrated in the devices the staff would be using. The alterations suggested by staff were implemented at a low cost, whilst these actions engaged key stakeholder groups and ensured a reduction of the resistance to the implementation of the novel technology.

According to Interviewee DE 3 Management, initial communication of Industry 4.0, particularly at the German facility, failed to highlight the possibility of a reduction of the labour force at the facility. Once this had become clear to staff, the trust and cooperation of non-management staff were limited. This highlights that trust needs to be fostered and that a license to operate may be revoked by definitive stakeholders (Gehman *et al.*, 2017:301; Cornelissen, 2020:70). Failures in internal communication of such proportions compromise other communications and undermine the trust of powerful stakeholders, as demonstrated by the German non-management staff, greatly increasing the risk of a failed implementation of technology.

The co-occurrence of statements discussing the communication of the introduction of Industry 4.0 technologies and the resistance to change was particularly high for the German case, while that at the other facilities was relatively low. This stresses cultural differences and alterations to internal communication that are needed to facilitate a successful implementation of Industry 4.0 in a single organisation operating on a global scale (Hofstede *et al.*, 2010:53–300).

The organisation's management staff, particularly at the Chinese facility, at times employ one-way communication. This means of communication of senior management towards staff results in little or no opportunity to provide feedback. Whilst this approach of communicating change may have been successful at this particular facility, it is not suitable for the other facilities. The staff at the German case facility in particular demonstrated that unregistered implicit resistance can develop into explicit resistance. As highlighted by Interviewee DE 1 Non-management, who stated that, despite some efforts towards two-way communication by management, non-management staff had the perception of being offered no choice but to accept the novel technology. This interviewee stated ‚Man hätte die Leute, wenn man sowas macht, vorher mehr aufklären müssen…und die ins Boot holen, sozusagen und nicht einfach was vor die Füße werfen: Friss oder Stirb‘. Addressing such cultural differences within this single organisation resulting from four distinct cultural and communication contexts should be achieved through regionally customised internal communication.

7.2.6 Addressing Research Question 6

Research question 6: To what extent do managerial staff link the introduction of Industry 4.0 with elements of sustainability?

To be considered a responsible member of society that acknowledges the importance of the quadruple context environment, the case organisation is required to abide by societal expectations to maintain the sustainability of its existence and be a truly responsible business (Cornelissen, 2020:5). Following stakeholder theory, a business cannot be solely dedicated to creating value for its shareholders and operate sustainably at the same time. It rather holds a responsibility for maximising total welfare for all stakeholders and thus avert long-term risk in its operation (Magill *et al*., 2015:1687).

Following the argumentation of Schwab (2021:171), stakeholder theory and stakeholder capitalism indemnify businesses to ensure respect for the interests of the absent stakeholders, who include future generations (Engelbrecht & Ungerer, 2011:11–14). Thus, following stakeholder theory, it is of paramount for business actions to be evaluated based on the criteria of sustainability. Referencing business actions against the quadruple context environment is vital to ensuring the long-term sustainability of society, business and the environment. The quadruple context environment is made up of the social environment, the natural environment, the financial environment and the governance environment (Schwab, 2021:171–173). Management staff and their perceptions are an important indicator of the impact of Industry 4.0 on the long-term sustainability in the quadruple context environment. Crucially, management is made up of a group of persons who have a direct influence on the actions of organisations, and thus on sustainability.

In this study, the discussions of the changing role of employees at the case facilities as perceived by the managers indicated that the management staff link social sustainability with the change brought about by Industry 4.0. Whilst the management staff reported substantially fewer radical changes to their work environments than the non-management staff, it needs to be noted that the management staff in all the facilities highlighted the increasing ability to cooperate with colleagues across the globe through means such as augmented reality devices. The management staff at the facility in Slovakia highlighted the Microsoft HoloLens in particular as bringing about a major change in their work environment.

The timing of this study coincided with unique limitations to human movement globally due to the COVID-19 pandemic. During this time, home offices played a particularly important role as home office work is in line with many governments' recommendations for limiting physical contact. This is a further social change enabled by Industry 4.0 technology and highlighted by the management staff. Lampropoulos *et al.* (2019:6) point out that Industry 4.0 technologies enable connectivity beyond borders but that the unique situation of the COVID-19 pandemic changed society over the short course of a few weeks and, with it, the manner in which organisations function. For the management staff at the case facilities, the positive experiences with home office work outweighed the negative ones. At the German case facility in particular, the managers had strong opinions on the benefits of home office work. In contrast to their German colleagues, the Chinese management staff were the least outspoken on home office use during this unique time.

As stated by Shaikh *et al.* (2022), there is a perception that business contributes to global pollution and places a heavy burden on the natural environment. Management staff at the case facilities, in their leadership functions, considered there to be a strong link between the introduction of Industry 4.0 and the facilities' environmental sustainability.

A single statement by a US management staff member indicated uncertainty regarding the impact of Industry 4.0 on the facility's environmental sustainability. Managers from the German and Slovak facilities exhibited the strongest belief that Industry 4.0 technology positively affects their respective case facilities' environmental sustainability. These managers closely associated Industry 4.0 with increased operational efficiency, which, amongst other factors, results in less-natural resource-intensive manufacturing practices. A total of eight statements from Germany and Slovakia indicated that the managers closely associate the use of Industry 4.0 with a reduced use of energy at the facility. This was once again linked to efficiency gains in the production process resulting from the increased capabilities of Industry 4.0 technologies. Such associations made by management are in line with literature suggesting that Industry 4.0 will reduce the consumption of energy-intensive industries in the long term (UNIDO, 2017). One senior Industry 4.0 manager of the German facility made it clear that the application of Industry 4.0 goes further than solely saving energy or increasing efficiency. This interviewee also associated the use of Industry 4.0 with the Six Sigma management method and expanded upon this stating that Industry 4.0 is the key to producing goods using the Six (and Mix) Sigma method. The interviewee envisioned Industry 4.0 as a tool that, through computation by artificial intelligence, enables the use of out-of-specification components in the assembly process to avoid scrapping less-than-perfect product components without compromising the final product. This can substantially reduce wastages in the production process.

Whilst many statements were made by managers indicating they associated Industry 4.0 with a positive impact on environmental sustainability, several statements indicated that some management staff members had reservations towards Industry 4.0 in relation to environmental sustainability. A total of 8 statements indicated a negative association to Industry 4.0 in this respect, in contrast to 31 statements indicating a positive association.

Contrasting with the large majority of statements indicating that Industry 4.0 can reduce the environmental impact of the facilities, the majority of managers at the case facilities still believed that Industry 4.0 will not lead to the case facilities reaching environmental neutrality. A total of 14 statements by managers indicated that they do not believe that environmental neutrality can be achieved through the use of Industry 4.0.

Of the seven management staff statements indicating belief that environmental neutrality can be achieved through Industry 4.0 technologies, the majority were made by managers at the German facility. Further, the statements indicating environmental neutrality could be achieved were often referring to a distant future. It needs to be noted that in the German context environmental neutrality is a development that has been in the public focus and is therefore seen as a key driver for a change in business conduct. Literature stresses the need of organisations to ensure that expectations on green initiatives are met; otherwise, they risk greenwashing their efforts and tainting their reputations (Roblek *et al.,* 2021).

Schwab (2021:14–19) argues that in a time of rising stakeholder capitalism, a business needs to act in accordance with the requirements of the quadruple bottom line. Even though the focus is shifting away from the shareholder-centric worldview towards a stakeholder view, representing a shift away from an organisational focus solely on financial aspects, this does not entail a renunciation of financial success (Magill *et al.*, 2015).

It is evident that the management staff at all case facilities function as leaders and are inseparable with the private organisation's quest for financial success and sustainability. This is reflected in the management staff's high level focus on Industry 4.0's financial impact on the facilities' operations.

It is clear that the management staff at all the case facilities associated the introduction of Industry 4.0 with positive aspects of the facilities and of the organisation as a whole. In addition, statements associating Industry 4.0 and financial sustainability were amongst the most frequently occurring statements made by the management staff. Bonciu (2017:1–13) states that businesses constantly strive to remain competitive and improve existing competitiveness. It is evident that the management staff at the facilities are united in linking Industry 4.0 technologies with their respective facilities' sustained competitiveness. Whilst there was some discussion of factors impacting the competitiveness of the facilities with external competitors, the discussion of increased competitiveness focused on increasing the competitiveness among the case facilities. The fact that all of the facilities are part of the same parent organisation also highlights that financial competitiveness is not solely linked to external competition but also that within the organisation, particularly at the Slovak and US facilities.

There is substantial evidence that the vast majority of managers at all the facilities linked Industry 4.0 with a positive change in the organisation's financial position. This was one of the most frequent points brought up in the interviews with the management staff at all the facilities. The US and Chinese managers closely related this to specific Industry 4.0 technologies. In particular, the management staff at the US facility associated financial benefits for the US case facility with collaborative robots, while the management staff in China linked financial benefits with TicketManager (Knudsen & Kaivo-Oja, 2020). Only a few management staff members argued that there was a possibility of Industry 4.0 having negative impacts on the case facilities' financial sustainability. Certain statements made by the German and US facility managers reflected this, but these managers simultaneously highlighted the financial benefits of Industry 4.0. The main reservations towards the financial benefits of Industry 4.0 were found in the perceived high initial capital expense the technology requires.

Phillips (1983:183) argues that an organisation's ability to innovate and adapt to evolving settings is a key element to remaining relevant and financially sustainable. Industry 4.0 was a driver of such innovation in the eyes of most management staff, with the exception of a single US manager, who highlighted that the flood of information available due to big data may become overwhelming for staff. Increased operational flexibility is a further advantage of Industry 4.0 technologies, with higher potential product quality at lower costs. Additive manufacturing is a key driver of streamlined product development at lower costs (Gebhardt, 2011).

The link that management staff drew between the purpose of the case organisation and Industry 4.0 was less clear than the link drawn between Industry 4.0 and financial sustainability. Few statements indicated that management clearly linked the advent of Industry 4.0 with the prolonged sustainment of the case organisation's purpose or a change in the purpose of the organisation. A total of five statements indicated that the interviewees linked Industry 4.0 with a change in purpose of the organisation. Several of these statements indicated that this was related to organisational re-alignment, which is also is driven by the implementation of Industry 4.0 technology.

The change in organisational purpose is also closely related to the case organisation's need to adapt to new operating environments due to the pandemic. The COVID-19 pandemic has severely restricted the transfer of goods and limited the movement of human workers in a time where the core markets of the case business are rapidly changing, and new products are being sought after to sustain the organisation in future. This situation and the associations highlighted by the management staff at the organisation reveal the characteristics of an organisation in a revolutionary period as outlined by the punctuated equilibrium theory. The actions of the organisation can be deemed to alter the business's core reason for being as it is not only altering its product offerings and production locations also changing the industry it is a part of. In addition to the change of industry, a change in ownership and split of company assets with a further new owner company highlights the deep change the organisation is undergoing to find a sustainable purpose and achieve long-term sustainability (Gersick, 1991:10–36). Interviewee SK 2 Management from the Slovak case facility stated that the societal purpose of the case facility has changed in light of the COVID-19 pandemic as the factory is no longer the centre of employment in the region. Additionally, the prevalence of home office work has decentralised the role of the case facility for most office staff. The management staff of the US facility associated Industry 4.0 with a change in the societal role of the case organisation in the region. These managers argue that the organisation is changing from a large employer of less-skilled workers towards a force that draws more skilled labour into the area as a result of its increased use of collaborative robots. The use of additive manufacturing was also linked to future changes at the facilities from a management staff perspective. This expectation is in agreement with literature, which predicts that additive manufacturing will alter supply chains and manufacturing practices (Jandyal *et al.*, 2022:36).

To address this and in light of organisations' need to address global sustainability goals, it can be argued that employee education is part of a business's responsibility towards society (United Nations Development Programme, 2022). The perception of such a re-alignment of organisational purpose was shared amongst the case management staff. The management staff's statements on the organisation's responsibility revealed unanimous agreement that this is part of the purpose of the organisation. The statements made by the managers of the German facility especially reflected this, although statements of this kind from the US management staff were notably absent.

7.2.7 Addressing Research Question 7

Research question 7: To what extent do non-managerial staff link the introduction of Industry 4.0 with elements of sustainability?

One of the roles of a business in society is as a centre of employment, and thus of power. With the introduction of Industry 4.0, it is reasonable to argue that the use of such technology needs not only to benefit the short-term financial sustainability of the case organisation but also to ensure long-term environmental sustainability, sustainable organisational purpose and societal sustainability.

Stakeholder theory and stakeholder capitalism indemnify businesses to respect and protect the interests of future generations. These future generations are also referred to as absent stakeholders (Engelbrecht & Ungerer, 2011:11–14). Achieving long term-sustainability is one way in which business can meet such requirements. Thus, to be truly responsible, a business must act in a manner that maximises benefits in the context of the quadruple context environment by fulfilling the expectations to maintain the sustainability of its financial existence, the sustainability of the natural environment, the sustainability of society and the sustainability of the contextual environment (Cornelissen, 2020:5; Magill *et al*., 2015:1687; Schwab, 2021:171).

As non-managerial staff form a substantial portion of the employee group of the organisation studied, the social impact of the introduction of Industry 4.0 is evaluated based on the understanding that non-managerial staff should also benefit from such technologies. As part of the change towards Industry 4.0, it was established that the work of stakeholders is changing. In particular, the roles of less-skilled workers at the investigated facilities were expected to come under pressure, whereas specialised labourers, such as engineers and IT specialists, will be high demand, as stated in literature and demonstrated by the responses of the non-management staff at the facilities. As a result of such changes, it is reasonable to expect changes in the work environment shaped by Industry 4.0 technology. A very large proportion of non-management staff are experiencing a change in work tools that they associate with the advent of Industry 4.0 at the facility. A total of 75 non-management staff at the case facilities also noted that they experienced a change in work tools due to Industry 4.0. The distribution of these statements was spread evenly across all case facilities, with the most statements occurring at the German case facility and the least at the case facilities in Slovakia and the US. The increased scope of responsibilities for workers was featured in a total of 23 statements, whereas a minority of statements indicated a decrease in workers' responsibility as a result of Industry 4.0. The statements of the staff of the US case facility indicated that the perceived change in work tools was constituted by the introduction of collaborative robots and the increased accessibility of MESs to workers. In the US case facility, the chief proprietary technologies named by the staff were Camstar and QRQC. The non-management staff of the Slovak and Chinese facilities indicated that the primary change in work tools they experienced was related to the reduction of physical paper files and increased digital data transfer.

So far, these experiences did not indicate that any actions of the case company might be regarded either as unfavourable or as having a positive societal role. It needs to be highlighted that the non-management staff at the German facility associated the change in work tools with the TicketManager. The majority of statements of the non-management staff at all the facilities indicated that the changes caused by the introduction of Industry 4.0 were increasing workers’ ability to collaborate in their work environments whilst also increasing their ability to work without the need of outside assistance for various routine tasks. Thus, the introduction of Industry 4.0 appears to have improved the work environment for the employed staff by offering the employees more opportunities to cooperate through means such as augmented reality (Egger & Masooq, 2020). In addition, the readily available big data and tools to access relevant information empowers junior level employees to work more independently as there are fewer barriers to relevant information.

Following the arguments made by Cornelissen (2020:70) and Alhaddi (2015:6–10), the changes in work tools and worker responsibilities need to be to the advantage of the stakeholders (in this case, the workers) to ensure that the case facilities and organisation retain their social license to operate. Responsible business conduct in the societal context environment changes the relation between organisations and society – in this case the case, a company’s workforce – towards increasing collaboration and social value creation (Beschorner, 2013:109–112).

As a positive impact of Industry 4.0 on the workforce, the non-management staff also associated Industry 4.0 with increased worker safety at some of the facilities. Two US non-management staff stated that the use of collaborative robots has made work safer as it reduces the physical strain on human workers. Some workers in Germany and China indicated a similar reduction of risk to human workers through the use of Industry 4.0 technology. A single statement from a German non-manufacturing staff indicated a reduction in worker safety based on the idea that the increase in home office work may reduce the employer’s liability for accidents. This discussion will form part of a later section on home and mobile offices in relation to Industry 4.0.

Interviewee DE 3 Non-management was one of the most outspoken interviewees regarding the negative impacts of the introduction of Industry 4.0 on less-skilled staff, providing a representative example of the general sentiment among the German non-management staff. In particular, the interviewee stated:

> “Okay, na. Viele …sehen das ja kritisch äh, weil man davon ausgehen kann oder denkt äh, dass durch dieses mehr Automatisieren äh Arbeitsplätze wegfallen, weil halt alles halt automatisch stattfindet äh, das ist, was man so hört, aber so allgemein. Ich persönlich denke es, also mich betriffts hier so nicht, also ich kann nicht sagen, dass dadurch, seit dem es zum Beispiel den TicketManager gibt, dass jetzt weniger Arbeitsplätze geworden sind, würde ich nicht behaupten. Weil es ja auch mehr son son Pilotprojekt war hier. Aber, das ist wahrscheinlich die größte Sorge… and ‚Genau, also negativ werden auf jeden Fall, die die die Einrichter an den Maschinen betroffen sein, weil man halt weniger braucht durch Industrie 4.0, weil halt viel automatisiert ist.”
>
> *Translation: Okay, well. Many take a critical view of this, because one can assume or think, increased automation will result in jobs being lost, because everything takes place automatically. That is what one generally hears. Personally, I don't think so, it doesn't affect me here, I can't say that the introduction of TicketManager, for example, decreased the number of personnel here. Because this was rather a pilot project at the facility. But job losses probably are the biggest concern... and machine setters will definitely be negatively affected, because you need fewer of them with Industry 4.0, because a lot is automated.*

The interviewee highlighted several emotional aspects of experiencing change. Although he did not see Industry 4.0 as a threat to less-educated staff who operate machinery that is not yet automated, the interviewee, who operates machinery, also did not regard Industry 4.0 as a threat to his role in the case facility as he deemed TicketManager to be part of a pilot study and as having no future impact on his job. Following Kübler-Ross (1969), the denial of an incumbent change is the first stage towards emotional acceptance of an inevitable occurrence. The high prevalence of statements that indicate a negative impact of Industry 4.0 on less-skilled staff is in line with assertion that substantial numbers of less-skilled occupations are at risk (Bonciu, 2017:13). The aforementioned shortage of skilled labour further correlates with Menon’s (2019) assertion that up to 44% of US and European staff will need to be up- or re-skilled in future. At the German case facility in particular, a strong correlation between the negative impact on less-skilled workers and the resistance towards change was evident.

Framing a new technology as green but failing to meet the expectations attached to the introduction of such a technology may result in allegations of greenwashing (Roblek *et al.,* 2021). As far as the introduction of Industry 4.0 is concerned, whilst some authors argue that no clear positive or negative bias towards Industry 4.0 and environmental sustainability can be established, a clearly dominant opinion was found amongst the statements made by the non-management staff at the case facilities (Chiarini, 2021:3195). The non-management staff's statements agree with the literature suggesting that energy-intensive industries will reduce their energy consumption in the long run and clearly link Industry 4.0 with environmental sustainability (UNIDO, 2022).

At a ratio of 4 to 1, the non-management staff's statements indicated the experience or belief that their respective case facility's environmental footprint would be improved by Industry 4.0. The statements of the non-management staff outnumbered those made by their managers in this respect. Similar to their managers, the non-management staff linked ecological sustainability with the positive financial performance of the case facilities. Whilst the non-management staff in all regions indicated an experience or expectation of improved environmental sustainability, the US facility had the fewest such statements, highlighting that the non-management staff in the US viewed the link between environmental sustainability and Industry 4.0 as relatively weak, contrasting with the results of the other facilities.

Worldwide sustainability initiatives are aiming for environmental neutrality among manufacturing facilities. From the perspective of non-management staff at the case facilities, whilst Industry 4.0 is a means to reduce the negative environmental impact of the facilities, it is not a means to reach environmental neutrality. Interestingly, the US is the only region where the majority of responses indicated that the staff believe that Industry 4.0 can lead to environmental neutrality. This highlights that, whilst the US facility had the fewest non-management staff who believed in the positive environmental impact of Industry 4.0, those who did also more often believed in the possibility that Industry 4.0 could lead to carbon neutrality.

Schwab (2021:171) states that stakeholder capitalism is becoming increasingly important in the current global context. Thus, it is increasingly important for businesses to act in line with the values and goals of the quadruple bottom line. Magill *et al*. (2015:1687) highlight that a shift away from a shareholder-centric worldview towards the stakeholder view is also a shift towards long-term financial sustainability. Additionally, this shift does not dilute a profit-driven organisation's drive towards financial profitability.

In contrast to the management staff in this study, the non-management staff are often not exposed to the organisation's financial statements. At the same time, these staff and their labour still form the basis of the private organisation's operating goal for financial sustainability. Similar to the management staff, the non-management staff did, however, associate Industry 4.0 with financial sustainability. As Schwab (2021:171) argues, there is a trend towards stakeholder capitalism, meaning corporate responsibility goes beyond corporate financial sustainability. It is also argued that the triple bottom line inadequately integrates all the factors that influence global and organisational sustainability. On a corporate level, an organisation's purpose and corporate governance are further elements influencing its sustainability.

From this perspective, it needs to be explored whether the non-management staff associate Industry 4.0 with either the change or sustainment of the case organisation's purpose. The non-management staff at the US facility stated that the introduction of Industry 4.0 had changed the role of the organisation in the region. For example, Interviewee US 3 Non-management stated that the environmental burden the facility places on the region has decreased through the use of Industry 4.0. Other non-management staff in the US stated that the introduction of Industry 4.0 the US facility will change the organisation's labour requirements and thus the demographics of the region as a result of attracting more skilled labour to the facility.

The non-management staff at all the case facilities regarded it as a responsibility of the organisation to offer its staff the opportunity to adapt to future requirements posed by Industry 4.0, such as through skills development offerings. A total of 22 statements indicated such a sentiment, whereas a single US non-management staff member and a single German non-management staff member stated that upskilling is the sole responsibility of the staff. It can also be argued that the upskilling of staff is part of the United Nations Sustainable Development Goals (United Nations Development Programme, 2022).

Generally, non-management staff experiences and expectations regarding the purpose of the case organisation were in line with those of the management staff. One major exception to this was observed in the non-management staff's expectation regarding future changes to the forms of the respective case facilities. Whereas the vast majority of management staff at the facilities expected changes to the form of their facilities, this expectation was not shared with non-management staff. Communication is needed to address such dissonances in expectations and the degree of information available to all levels of staff. Academic literature indicates that additive manufacturing does in fact have the potential to alter the form of manufacturing facilities (Horst *et al.*, 2018:3).

7.3 ADDRESSING THE PRIMARY RESEARCH QUESTION

Primary Research Question: How is the implementation of Industry 4.0 being perceived on a management and a non-management level in a multi-national organisation operating in four countries?

The perception of management and non-management staff is explored in a very specific time and setting. Using punctuated equilibrium theory, three distinct phases of a life cycle, namely deep structure, periods of stability, and revolutionary periods, can be identified (Gersick, 1991:13).

It is argued in the literature that the advent of Industry 4.0 is the impetus for deep-rooted change that could be regarded as an initiator of a revolutionary period in society and within organisations. Additionally, according to punctuated equilibrium theory, this was followed by the outbreak of a global pandemic that necessitated deep-rooted social change and greatly reshaped businesses' reliance on digital communication and Industry 4.0 technology.

In such a tumultuous time, the implementation of Industry 4.0 is undoubtably being perceived by all the interviewees in this study. This is the case in all the regions and on a managerial and non-managerial level within the case organisation. While the perception of the implementation varies between regions and organisational role, there are numerous similarities among statements about interviewees' experience of the implementation of Industry 4.0.

According to punctuated equilibrium theory, the revolutionary period is one of fast and deep-rooted change in an organisation caused by an event that substantially disrupts the social and economic equilibrium (Gersick, 1991:23). The deep-rooted changes include alterations to the deep structure of an organisation, which includes the organisation's structure, its product portfolio, regional manufacturing choices and allocation of resources (Tushman & Romanelli, 1985:175).

Staff statements centred on the perceived pace of the implementation of Industry 4.0 at the case facility are divided. Of the 43 identified statements regarding the pace of implementation, 18 assert that the implementation is considered fast, whereas 25 highlight the relative slow pace of implementation. Looking at the development of the preceding three industrial revolutions, it is clear that the pace of implementation of such revolutions is increasing and the time between revolutions is decreasing (Ślusarczyk, 2018:236).

From the perspective of staff who are experiencing the implementation of Industry 4.0, however, this is not always perceived by all as a high-paced implementation. Furthermore, in examining the responses, it is evident that, at times, the pace of the implementation of initial Industry 4.0 technology is perceived as fast, but that later implementations are done at a slowing pace. This will be addressed further when exploring the perception of change management and communication programmes later in this discussion. Nonetheless, most staff at the case facilities do expect an increase in Industry 4.0 technologies, with the exception being US management staff, who are undecided. As stated earlier, the technological change is one of the changes that an organisation implements in a revolutionary phase, and another is the change of organisational structure (Tushman & Romanelli, 1985:175).

The case organisation underwent a radical change over the preceding 5 years. The organisation was owned by a large German conglomerate for decades but was listed as a separate entity on the German stock exchange. This was followed by the separation of its consumer products and the sale of this business sector to an investor group from Asia. Finally, the case organisation that is implementing the Industry 4.0 technology at its remaining facilities is in the process of being acquired by a much smaller Austrian technology firm. Undoubtedly, this five-year transition would be a valid representation of organisational change, as highlighted by punctuated equilibrium theory (Tushman & Romanelli, 1985:175; Gersick, 1991:13). Such changes are perceived by staff as changes being implemented in the organisation, both technological and organisational changes. To what extent the implementation of Industry 4.0 is linked with these changes is not always clear to staff. A total of 82 statements highlight organisational change. Of these statements, 48 draw links to Industry 4.0 and 34 do not do so.

It is clear that Industry 4.0 is not a singular technology but a system of interdependent technologies that are introduced in distinct global settings (Bortolini *et al.*, 2017:5702-5703). The interconnected nature of the Industry 4.0 technologies and the context in which they are introduced effects the technological choices made by the case facilities and influences the perception of the implementation of such technologies. This realisation is closely related to systems theory, which states that a system is the description of several elements that are related to each other and the respective environment (Bertalanffy, 1972:417).

Of the 50 interviewees, all expressed knowledge and experience of the introduction of Industry 4.0 in their respective case facility. However, it was identified that two non-management staff interviewees have limited familiarity with the term Industry 4.0. Management and non-management staff state that Industry 4.0 technology is being implemented at the respective case facility. Most statements of management and non-management staff on technology are centred on the TicketManager technology. This technology is a proprietary technology of Bosch that integrates several aspects of Industry 4.0. It is a means for preventative maintenance and remote supervision of machinery using Big Data, machine learning and artificial intelligence via the use of the digital infrastructure. Big Data, cloud computing and machine learning, along with mobile connectivity, are all technologies that form part of Industry 4.0 (Bortolini *et al.*, 2017:5703; Parsons et al., 2018:7; Robert Bosch Manufacturing Solutions, 2018; Karnik *et al.*, 2022:3-8).

The dominant role of TicketManager highlights that Industry 4.0 and its technologies are not perceived in silos, but staff state that the technology is perceived by users as a system of interlinked technologies in their application rather than as singular technologies. This is further underscored by the high frequency of statements that refer to MES systems and Camstar (an MES system). These systems, while not formal constituents of Industry 4.0, are strongly associated with Industry 4.0. This, again, highlights that Industry 4.0 is a complex system. MES systems are among the sources of Big Data and, critically, a means to control modern manufacturing and track production data and statistics (Illa & Padhir, 2018:55163-55164; Karnik et al., 2022:7).

This does not mean, however, that staff do not highlight individual technologies. Big Data is of particular note for management staff owing to their increasing reliance on data analytics. Furthermore, non-management staff closely associate the introduction of Industry 4.0 with the introduction of increasingly autonomous machinery at the case facilities. In terms of regional focus, it is noted that staff at the US facility associate Industry 4.0 with collaborative robots at the facility. In Germany, many staff perceptions are shaped by the TicketManager technology, and Chinese staff demonstrate a focus on the TicketManager and MES systems. In Slovakia, although staff are not as exposed to Industry 4.0 at those at the other case facilities, they also demonstrate the perception of Industry 4.0 being implemented at the case facility. Non-management staff highlight Camstar in their discussion of Industry 4.0, and Slovak management staff refer to autonomous machinery and Big Data.

The implementation of the various Industry 4.0 technologies in an organisation is the introduction of novel technology and thus associated with substantial capital expenditure. When exploring the perceived motivations for implementing Industry 4.0 in a profit-driven organisation is evaluated based on the quadruple bottom line, the choices made in the implementation and the perceived outcomes can best be illustrated through the resource-based view. Barney (1991:99-100) highlights that this theory is appropriate in exploring the allocation of resources and the desire for sustainable competitive advantage.

A benefit of implementing Industry 4.0 in a manufacturing organisation is improved product quality and the cost of quality. It is highlighted in the literature that the use of digital twins and Big Data analytics as key elements of Industry 4.0 may have a positive effect on production quality (Karnik *et al.*, 2022:7). According to the resource-based view, the improvement of product quality may be a manner in which the implementation of Industry 4.0 can be considered as displaying features of an asset to the manufacturing organisation (Barney & Hesterly, 2020:89-99).

Management staff in the US, Slovakia and China are unanimous in stating that they have experienced or expect Industry 4.0 to positively impact product quality. It is of note that a manager in Germany states that while Industry 4.0 may lead to an improvement in product quality, it can be questioned whether this is needed in an age of increasingly short product life cycles. The interviewee further states that high quality can be assured without the use of Industry 4.0. This perception of Industry 4.0, however, does not represent the consensus among management staff at the case facilities. German management staff also indicate that their perception that Industry 4.0 improves the product quality. The consensus among non-management staff shows that these staff also perceive that the introduction of Industry 4.0 benefits the quality of the product manufactured at the respective case facilities. While statements of non-management staff in the US, China and Slovakia are unanimous in the assertion of positive expectations or observations of the effect of Industry 4.0 on the quality of products, in Germany, non-management staff's assertions are less definite. Several statements indicate that the implementation of Industry 4.0 technologies at the facility resulted in a short-term worsening of the quality of the product. Nonetheless, the majority of indications in Germany highlight a positive, be it longer-term, impact on product quality from a non-management perspective.

Furthermore, another role of Industry 4.0 in altering the product development process is highlighted in the literature. Of particular note in the literature is the role of additive manufacturing and simulations. The use of Industry 4.0 is particularly associated with manufacturers' ability to mass customise products and react in a much timelier manner compared to traditional manufacturing and product development methods (Gaub, 2016:401; Karnik *et al.*, 2022:2-8).

Staff perceive that product life cycles are getting increasingly shorter. The use of additive manufacturing, the increased availability of data on manufacturing and the increased abilities of product quality tracking have enabled staff to improve the product development process and increase the pace of product development.

It can be argued that in a profit-driven organisation, one of the main drivers of implementing novel technologies is to strive to increase efficiency and lower costs. Lamberti *et al.* (2014) state that the use of Industry 4.0 technology can reduce the cost of machinery ownership and maintenance. Furthermore, Horst *et al.* (2018:3) highlight that the use of print-on-demand and additive manufacturing may represent a manner in which production costs may be lowered. Of the 146 statements that indicate a perceived change in the efficiency of the case organisation linked to the introduction of Industry 4.0, 126 indicate that Industry 4.0 has improved or will improve efficiency. Additive manufacturing is linked in the literature to the future ability of print-at-home scenarios, where the final customer receives a print file to produce the good himself, rather than receiving a finished product from a manufacturer, and further cloud production would be a possibility for increasing production efficiency (Horst *et al.*, 2018:3; Duvoisin & De Almeida Vieira, 2018:3). While 17 statements of management staff indicate the possibility of this happening and a substantial change in the form of manufacturing facilities being possible in the future, this is often limited by the products' complexity and multiple materials used. The majority of non-management staff statements, 11 out of 17, indicate that these staff do not belief that the form of factories will change substantially.

Industry 4.0 is closely linked to innovation (Yang & Gu, 2021:1312). This sentiment in the literature is echoed by management staff in all the case facilities, who stated on 21 occasions that the introduction of Industry 4.0 is a driver of innovation. According to the literature, the shift towards a holistic focus on society, the environment and financial interests is a driver of investment in novel technologies (Furstenau *et al.*, 2020:140079-140096).

It is becoming increasingly evident that Industry 4.0 technology is a complex system of interdependent technologies that is being introduced in a highly complex and dynamic quadruple context environment that needs to be accompanied by management and communications professionals.

Tichy (1983:188) argues that the implementation of change has three primary aspects. The technical environment, the allocation of resources and cultural values are aspects that are to be addressed by change management programmes to ensure the successful implementation of Industry 4.0. The technological implementation of Industry 4.0 is largely regarded as positive, as highlighted by the discussion of the quadruple context environment and the perceptions of the implementation of Industry 4.0. When discussing the allocation of resources to implement Industry 4.0, limited resources are evident in the regions. This, however, is not considered by staff as limiting the introduction of Industry 4.0 technology with regional specificities regarding the technologies introduced. Nonetheless, staff highlight that the shortening of return on investment times is negatively impacting future implementation of technologies. However, local staff, most notably in China, highlight environmental and quality arguments to circumvent resource allocation limitations.

Accounting for change in regions with differing cultural attributes and values is the role of change management that is highlighted in this study as crucial. When examining statements on the implementation of Industry 4.0, a common topic is identified. The resistance to change is a perception that is shared among staff at all the case facilities. This perception does show regional variations and is associated with different technologies, however. Of the 98 statements on resistance to the introduction of Industry 4.0, 83 indicate that interviewees are aware of resistance to the implementation of Industry 4.0 or have experienced resistance to its implementation. This perception of resistance is particularly prevalent at the German case facility. Statements on TicketManager and the expected negative impact of Industry 4.0 on less skilled staff occur together with statements on the resistance to the implementation of Industry 4.0.

Change management can facilitate the transition towards the novel work environment of Industry 4.0. In several instances, staff indicate that the introduction of Industry 4.0 is regarded as widespread in the case facility. Kotter (2014:20) highlights that a dual change approach may be a more suitable approach to change in large organisations, as this harnesses the efficiencies of large bureaucracies in the forming of small teams to implement change and test this technology before introducing it to the wider organisation. According to Kotter (2015:15), small successes should be celebrated and propagated to continue the momentum of change and manage a positive frame for the implementation. One interviewee highlights that the opposite has occurred at the German case facility, where the roll-back of certain TicketManager implementations is regarded as a success by the employees opposed to the technology. The implementation of Industry 4.0, however, is not solely reliant on the use of change management programmes. Internal communication programmes are of similar importance in the implementation of Industry 4.0 and the associated perceptions.

The implementation of novel technology, and the perception of such technology, is not solely based on perceived changes and technological factors. In answering the primary research question, the role of change management and internal communication is highlighted. Both internal communication programmes and change management programmes are reliant on the exchange of messages. Thus, the communication transmission model forms the basis of the exploration of the communication that occurs during the implementation process and the changes in communication caused by the introduction of Industry 4.0 technology in the case organisation. The model states that any communication is contingent on several elements, which are the sender of a message, the receiver of a message, the message conveyed, the channels used to transport the message, and noise (Tubbs & Moss, 2008:1-19).

Mazzei (2010:221) states that internal communication is the exchange of communication between parties within the limits of a single organisation. It is noted that the internal communication exchange plays an important role within organisations, as it serves as a relationship management role and functions as a means to build internal commitment to an organisation. Internal communication is also crucial in ensuring that the staff of an organisation are engaged in the relevant organisation's endeavours (Mbhele & de Beer, 2021:154).

In answering the primary research question, stakeholder theory is an important anchor, as it accounts not only for the role and importance of the stakeholder in an organisation that undergoes change but also for the role of the operating environment as a source of potential risk or strengths (Magill *et al*., 2015:1687). The absentee stakeholder is placed at the centre of management and non-management staff's perception of the implementation of Industry 4.0 by highlighting the perceived links between Industry 4.0 and sustainability. This is done by exploring Industry 4.0 in light of the quadruple context environment (Engelbrecht & Ungerer, 2011:11-14; Schwab, 2019:2).

First, however, perceptions of the role of the stakeholder need to be discussed, particularly that of the internal stakeholder. Staff are experiencing a change in work tools and associating this with Industry 4.0, as the implementation of Industry 4.0 has changed and will substantially change the work environment at manufacturing facilities. At all the facilities, the staff have experienced changes in their work tools since the implementation of Industry 4.0. Of particular note as novel work tools are TicketManager (particularly for non-management staff at the German case facility), the increasing use and availability of Big Data, the use of manufacturing execution systems, increased use of collaborative robots, and use of digital communication means. Furthermore, internal communication programmes are used to inform staff of the possibilities of such novel technologies. The year 2020 saw substantial travel limitations and restrictions of physical presence at the workplace. Internal communication, as a facilitator of exchange between parties, is used to ensure not only that the organisation is adapting to the changing communication means but also that despite increasing reliance on digital communication, the staff of an organisation are engaged in the relevant organisation's endeavours. The HoloLens technology may be highlighted as Industry 4.0 technology used as a means not only for addressing travel restrictions due to the COVID-19 pandemic but also for increasing staff cooperation. The US and Slovak facilities highlight that despite travel restrictions, staff have been able to transfer a manufacturing line from the US to Slovakia and reassemble it using the HoloLens technology to communicate across continents.

Furthermore, in organisations that span the globe, regional differences in culture and contexts are to be addressed by internal communication. In the case organisation, the resistance to the implementation of Industry 4.0, as highlighted previously, is particularly widespread in the perception of German staff. Hofstede *et al.* (2010:53-300) highlight six dimensions of culture, and these can be included in the planning and execution of internal communication to support the introduction of Industry 4.0. In the German case facility, the apprehension regarding change and the value of certainty may not have been addressed sufficiently. This is evidenced by the statements about resistance to Industry 4.0 co-occurring with statements about the manner of communicating the introduction of Industry 4.0 and the channels used. Some statements indicate that the communication may not always have reflected the staff's desire for a symmetrical communication engagement. Facilities in other regions that have a more authoritative approach to the introduction of Industry 4.0, such as China, have shown greater success and less resistance than at the German facility.

All the interviewees in all the case facilities refer to elements of the quadruple context environment in their description of the perception of the implementation of Industry 4.0. The implementation of Industry 4.0 is associated with changing skills needed to perform work tasks. It is stated in the literature that the implementation of Industry 4.0 technology will require the reskilling of a substantial part of the workforce. Due to the fast-paced nature of technological developments, the learning process will need to be a life-long process (Maisiri *et al.*, 2019:94).

The changing role of the workforce in the case organisation is the basis of the first point to be raised when discussing the perception of the implementation of Industry 4.0.

In the social context of the quadruple context environment, the social effect of the operations of an organisation is evaluated as well as the changes that this organisation is implementing. The interviewees across the case facilities share the perception that the group that is the most disadvantaged by the introduction of Industry 4.0 is the less skilled staff, and highly skilled staff are perceived to be the main beneficiaries of the introduction of Industry 4.0. Of the 53 statements made by management staff on the change in role of less skilled staff, 41 indicate that the position of such staff is not positive and predict that they will be disadvantaged by the introduction of Industry 4.0. Non-management staff share this evaluation, with 36 of a total of 46 statements indicating a negative impact of Industry 4.0 on less skilled staff. The statements made in relation to benefiting less skilled employees often note that the displacement of their occupations through technologies enables these staff to focus on new tasks. These statements, however, are often vague.

This lack of possibilities for less skilled staff is linked to the governance context environment, as one of the governance practices of responsible businesses includes the addressing of the sustainable development goals. Cited goals that business would need to address are goals four and eight, which are ‘quality education’ and ‘decent work and economic growth’. The increased demand for skilled labour in Industry 4.0 highlights the need for businesses to ensure that these needs are met by developing the skills of their employees and providing safe work conditions (Maisiri *et al.*, 2019:93). The World Economic Forum (2020) asserts that the majority of sustainable development goals can be achieved using modern technology. Nonetheless, as Beier *et al.* (2021) highlight, addressing these issues will not alleviate all the negative impacts of Industry 4.0 in society. Across all the case facilities, management staff share the opinion that part of the role of the case organisation is to ensure that skills development takes place. Non-management staff echo this, with the exception of a single US worker and a single German worker, who state that skills development is the sole responsibility of the worker. Unlike the literature that highlights Industry 4.0 as a means to address an aging workforce and inclusivity, the majority of statements concerning age highlight that the introduction of Industry 4.0 is regarded as a process that benefits the younger generations.

Moreover, good governance requires businesses to address environmental issues, and the introduction of Industry 4.0 is closely linked to the addressing of issues in the natural context environment. According to Chiarini (2021:3195), in the literature, there is no consensus on the role of Industry 4.0 in addressing issues in the ecological context environment. Industry 4.0 is seen by staff as a means for addressing issues in the natural environment. While many staff do not expect manufacturing facilities to have no impact on the natural environment, management staff in all the regions believe this to be possible in the long term. Despite the majority of statements indicating that facilities having no impact on the natural environment is unlikely, staff do believe that the environmental footprint of the case facilities has been and can be reduced using Industry 4.0 technology.

The case facility is a profit-driven private organisation. Therefore, financial sustainability is of great importance to the organisation and particularly management, whose role it is to ensure the organisation's continued existence. The financial sustainability of the organisation is the basis upon which all other dimensions of sustainability are based (Cornelissen, 2020:259). The perception of the introduction of Industry 4.0 is strongly linked to financial sustainability by management of the case facilities. In efficiency-driven economies, a key driver of financial sustainability is organisational efficiency. Staff in all the case facilities assert that Industry 4.0 contributes to increased organisational efficiency. Furthermore, staff at all the case facilities indicate in 131 statements that the introduction of Industry 4.0 is having a positive effect on the financial performance of the case organisation. This is in contrast to 15 statements that regard Industry 4.0 as a deterrent to the positive financial development of the case organisation.

7.4 ADDRESSING THE PROBLEM STATEMENT

Addressing the problem that is formulated in the problem statement of this research has motivated the conducting of this research. Based on the formulated problem statement, a primary Research Question has been developed along with seven secondary Research Questions. Furthermore, the problem statement and the Research Questions are the impetus for the development of the semi-structured interview schedule and the items created for data analysis.

The problem statement of this study is as follows:

Industry 4.0 technology will alter the contemporary work environment considerably. A paramount change in organisations' work-environment (such as the introduction of Industry 4.0 technologies) requires the management of change processes to ensure a smooth transition to a new structure. A key element in addressing change in this context, is the use of internal communication programmes that inform and facilitate the implementation of the new technology. From this perspective, it can be argued, that the implementation of Industry 4.0 would need to be complemented by considerable communication efforts to be in line with responsible business conduct. In an environment that is transitioning towards a stakeholder capitalist society, businesses will be required to carefully address the role of stakeholders in the transition towards Industry 4.0 since its implementation will affect them. Further, organisations are not operating in a social, financial, environmental vacuum and thus need to adhere to stakeholder expectations, to ensure organisational sustainability. In the context of the stakeholder capitalist view, the purpose of an organisation and its operations is an additional factor upon which organisations' actions are to be evaluated. Whilst there is sufficient literature available on change management, internal communication, stakeholders and sustainability, the phenomenon of Industry 4.0 and its introduction into organisations is novel. Against this background, the investigation into the phenomenon required a multi-disciplinary approach.

To address the first paragraph of the problem statement, four secondary Research Questions have been formulated.

> Secondary Research Question 1: How is the implementation of Industry 4.0 being perceived from a managerial perspective?
>
> Secondary Research Question 2: How is the implementation of Industry 4.0 being perceived from a non-managerial perspective?

Secondary Research Question 4: How can change management programmes facilitate the implementation of Industry 4.0 on managerial and non-managerial level?

Secondary Research Question 5: How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?

The research endeavour is firmly based on punctuated equilibrium theory, stakeholder theory, systems theory and the resource-based view. After exploring available literature on internal communication and change management paired with technical knowledge of Industry 4.0 technologies, interview items have been developed and the answers coded to gain an insight into the role of change management and internal communication programmes in the implementation of the novel technology. This research finds clear indications that management processes play an important role in the successful implementation of Industry 4.0 technology in manufacturing organisations and that internal communication is a vital element in the successful implementation of novel technology in all the regional settings. Furthermore, it finds not only that the successful introduction of Industry 4.0 is shaped by internal communication programmes but also that internal communication is affected by Industry 4.0 and the changing technological context in which internal communication is being conducted. While regional differences are clearly highlighted in several cultural dimensions, all the case regions demonstrate that proactive and consequent change management can positively influence the implementation of Industry 4.0.

A key role in internal communication and change management is the addressing of perceived uncertainties that the introduction of Industry 4.0 entails. Notions of job displacements resulting from the introduction of Industry 4.0 are a common issue in all the case regions and a cause for internal resistance to change and the implementation of Industry 4.0. It is considered that such actions greatly reduce the success of the implementation of Industry 4.0 and increase the time frame needed to implement change.

The points raised in the second paragraph of the research problem led to the formulation of three further Research Questions that are presented below.

Secondary Research Question 3: How is Industry 4.0 altering the role of stakeholders of the organisation?

Secondary Research Question 6: To what extent do managerial staff link the introduction of Industry 4.0 with elements of sustainability?

Secondary Research Question 7: To what extent do non-managerial staff link the introduction of Industry 4.0 with elements of sustainability?

When addressing Secondary Research Question 3, the research finds that the implementation of Industry 4.0 will substantially alter the role of the stakeholders of a manufacturing organisation. Staff at all the facilities and at all levels of the corporate hierarchy associate the implementation of Industry 4.0 technology with alterations to staff skill requirements. The less and least skilled staff are identified as the stakeholders affected the most by the implementation of Industry 4.0 in a manufacturing setting. The effect of the introduction of Industry 4.0 is overwhelmingly associated with the stakeholders that are perceived to be negatively affected by the increased skills needed to perform work tasks in the novel Industry 4.0 work environment. Older employees and less skilled staff are regarded as the stakeholder groups that will be most negatively affected by the introduction of Industry 4.0.

In addressing Research Questions 6 and 7, the research finds that Industry 4.0 is strongly linked with the quadruple context environment by staff. It finds that the focus of management staff is on the financial aspects of the quadruple context environment in which a business operates. Conversely, non-management staff are focused on social aspects of concern when discussing the quadruple context environment. Of note is that the consensus of staff is that the introduction of Industry 4.0 has a positive effect on the quadruple bottom line.

The last paragraph of the research problem emphasises the limited availability of literature on Industry 4.0, as this is a novel phenomenon. Through the application of existing literature on change management, internal communication, stakeholders and sustainability, this research explored this novel phenomenon from a business management and communication management perspective. This is done to expand academic knowledge of the implementation of Industry 4.0. This study particularly addresses the phenomenon in four distinct regional contexts. These contexts are Germany (a developed Central European context), Slovakia (an Eastern European context), China (a rapidly expanding East Asian context), and the US (a North American context). This expansion of academic knowledge will also serve as the impetus for future research on Industry 4.0 to further expand on the phenomenon.

7.5 CONCLUSION

7.5.1 <u>Management implications</u>

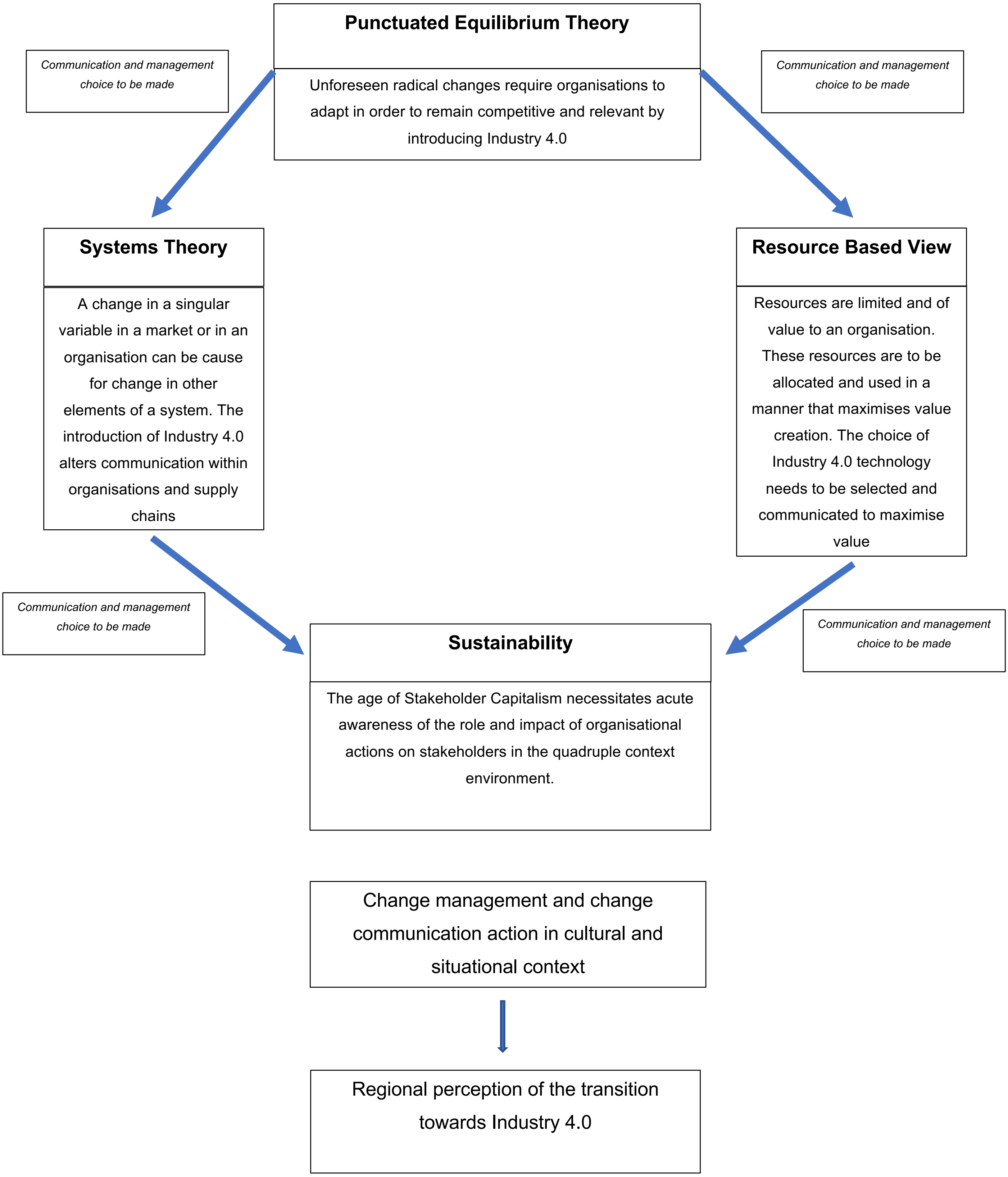
Whilst management staff can draw from precedence of communication management and change management actions of historic industrial revolutions, each of these revolutions have occurred in distinct social, technological and geographic contexts. This research examines the introduction of Industry 4.0 in four regional contexts in a multi-national manufacturing organisation. Practical insights into management approaches and senior staffs' understandings of the role of communication in the implementation of the social, organisational and technological changes in establishing a successful implementation of Industry 4.0 are elaborated. These insights are augmented by findings on the attitudes of non-management staff in the respective regions. Such findings form the basis for conclusions on regional attitudes at the facilities and the success or failure of communication in the implementation of Industry 4.0 at the case facilities. Lastly, the case organisation has faced a variety of factors that pose obstacles to the implementation of Industry 4.0. Particularly the impact of Covid-19 on the usefulness of Industry 4.0 in addressing travel restrictions highlights previously possibly undervalued aspects of the technology in facilitating human and machine communication. Regional and cultural differences at the case facilities highlight that differences in attitudes and communication do exist in a globalised world and need to be considered during the introduction of Industry 4.0.

7.5.2 Academic implications

Industry 4.0 is a novel phenomenon that is being addressed by communication practitioners and managers in a global context. As such, academic research needs to accompany the process of introducing the technological changes in businesses and society. This research is focused on communication during the introduction of Industry 4.0 at case facilities in four distinct regional contexts to address a lack of academic literature and therefore knowledge on the perception of employees of the introduction of Industry 4.0 based on an understanding that radical change in organisations is caused by internal or external factors breaking an organisational equilibrium. Punctuated Equilibrium Theory highlights such an understanding as a metatheory.

Building the exploration of the implementation of Industry 4.0 on a theoretical foundation of the Resource Based View and Systems Theory to explain organisational choices and the inclusion of Stakeholder Theory in explaining the role of relevant parties to the introduction of Industry 4.0 represents a novel approach to addressing this phenomenon. In Figure 18 the conceptual framework developed is illustrated. In exploring the actions and consequences of the introduction of Industry 4.0 it quickly becomes apparent that communication and management are at the core of every decision and action that can be found. Whilst the 21st century is a highly globalised age; the role of cultural differences and contextual differences are nonetheless of particular importance in understanding the phenomenon at hand.

Figure 18: Theories used to address the research questions



When exploring the perception of the implementation of Industry 4.0, it is evident that regional similarities and differences are identifiable. Whilst there may be an overarching organisational culture that influences the perception and the implementation of Industry 4.0 to a minor degree, the role of the cultures and contexts in which the case facilities are operating strongly influence the choice of technologies introduced and the choice in communication means to address these paramount changes.

Staff of the case facilities in China and Germany both associate the advent of Industry 4.0 with the TicketManager. The communication that formed part of the implementation effort of Industry 4.0 is regarded by both groups of non-management staff as top-down communication and decision making. The resistance to the introduction of changes associated with Industry 4.0 is strongly shaping the perception of the introduction of Industry 4.0 in Germany, this perception is much less dominant at the Chinse case facility.

The US case facility is facing unique situational pressures due to a lack of local labour and the associated high labour costs at the case facility. To address this, staff at this facility have experienced the introduction of cobots. It follows that staff perception of the implementation of Industry 4.0 is shaped by the introduction of cobots to the shopfloor. Further, staff perceptions of the introduction of Industry 4.0 are closely linked to the gathering and use of Big Data. This is a shared experience with the Slovak case facility. Such staff's perception is strongly shaped by aspects of operational efficiency and financial performance. Below a framework illustrates the regional perceptions of Industry 4.0 from a managerial and non-managerial perspective. Highlighting the cultural, contextual and communicative links between the associations in the regions and specific attributes associated with industry 4.0.

Figure 19: Strategic Framework

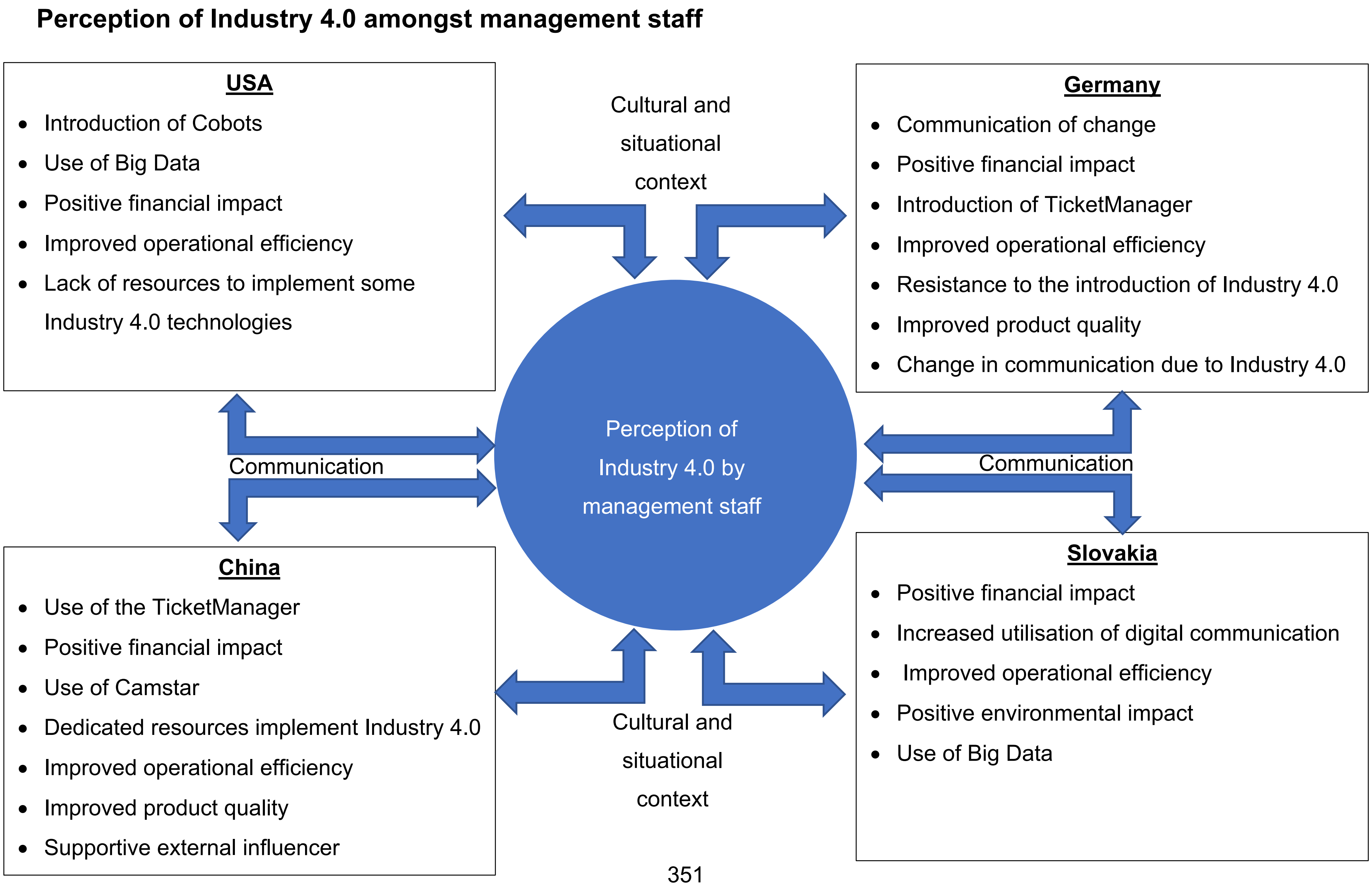
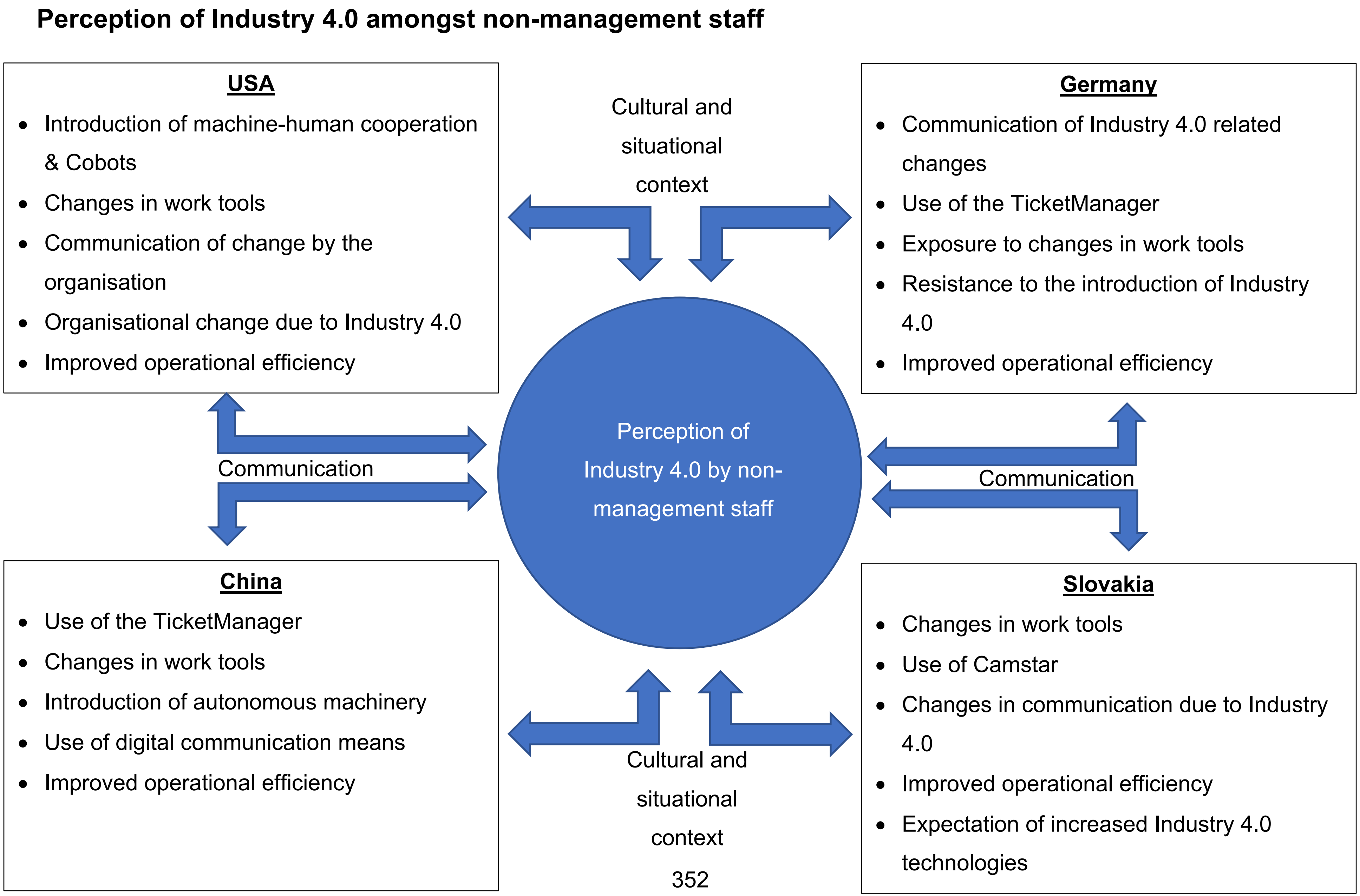


Figure 20: Strategic Framework



7.5.3 Suggestions for further research

As indicated by the problem statement, Industry 4.0 is a novel phenomenon. Currently, this technology is being implemented in manufacturing facilities around the globe. The exploration of the perception of Industry 4.0 among management and non-management staff in Germany, Slovakia, the US and China provides insights into the experience and understanding of Industry 4.0 in a time of extraordinary uncertainty. Industry 4.0 technologies will continue to evolve, and the context of their implementation will further develop. As with the exploration of any novel phenomenon, the exploration is to be continued by future researchers and, hopefully, compared to and contrasted with the findings of this study. Based on an understanding of the punctuated equilibrium theory, further research may be required to establish what, if any, Industry 4.0 technologies are established in the novel state of equilibrium.

In addition, during the current revolutionary state of many societies and organisations, it may be suggested that further research into the implementation and the perception of Industry 4.0 in other regions is conducted. The case organisation of this study does not have manufacturing facilities in Africa and South America, and therefore no insight into African and South American perceptions of the implementation of Industry 4.0 could be provided. Particularly in contexts such as Africa and South America, such research may be of great value to academics and practitioners.

7.5.4 South African context

This research was conducted by a PhD candidate at a South African University and whilst this research does not include facilities of the case organisation that is upgraded to Industry 4.0 standards in South Africa, it offers insight into the introduction of Industry 4.0 and the perception of Industry 4.0 from a managerial and non-managerial perspective. South Africa is a nation of diverse backgrounds and as an emerging economy faces unique challenges and opportunities. It follows that the lessons learned from this research endeavour are applicable not only from the cases located in the emerging economy of China, the low-cost economy of Slovakia and the well-established economies of Germany and the USA. Further, this research encountered a wide array of cultures, work-cultures and communication cultures that range from strongly collectivistic to highly individualistic, such differences can also be found in South Africa. It follows that this research may serve as a guide of tested practices to the introduction of Industry 4.0 in diverse contexts. The South African introduction of Industry 4.0 is in its infancy and may affect a large proportion of the population, businesses in South Africa are, however, in the advantageous position that they can draw from experience gained in other nations and research (such as this thesis) to ensure a successful transition towards Industry 4.0 with minimal conflict and uncertainty.

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Appendix A: Registration of title

Our ref.: 29322473
Contact person: Ms L Krappie
Tel: +27 12 420 5387
E-fax: +27 12 420 3063
E-mail: lerato.krappie@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

Faculty of Economic & Management Sciences
Student Administration

27 August 2019

Dear Mr DSV Pröbstl

SUBJECT: THESIS

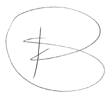
I have a pleasure in informing you that the following title registration has been approved:

The 4th industrial revolution: exploring employee perceptions and the implementation of change

Attached is the checklist (**EBW 08/06**) and Notice to Submit (**EBW 11/07**)

Your enrolment as a student must be renewed annually until you have complied with all the requirements for the degree, preferably during the official period of enrolment but before **28 February**. You will only be entitled to the guidance of your supervisor if annual proof of registration can be submitted.

Kind regards,



for: **Prof E Loots**
DEAN
FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES

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EBW13/505

POSTGRADUATE COMMITTEE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

26 July 2022

Prof E de Beer
Department of Business Management

Dear Prof de Beer

TITLE REGISTRATION (REVISED)

This serves to advise that the **revised** title submitted for the research of the candidate indicated below was approved by the Postgraduate Committee:

Student:	**DSV Pröbstl**
Student number:	29322473
Degree:	PhD (Communication Management)
Supervisor/Promoter:	Prof E de Beer
Co-supervisor/Co-promoter:	-
Approved title:	Employee perceptions of transitioning towards Industry 4.0 in distinct global contexts
Date approved:	25 July 2022

IMPORTANT:
Please note that, if ethics clearance has not yet been granted for the above research, the candidate should apply for ethics clearance before any research may be undertaken.

Sincerely

pp PROF K BARAC
CHAIR: POSTGRADUATE COMMITTEE

cc: Prof AJ Antonites
Student Administration

Fakulteit Ekonomiese en Bestuurswetenskappe
Lefapha la Disaense tša Ekonomi le Taolo

Appendix B: Ethical clearance

RESEARCH ETHICS COMMITTEE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

Approval Certificate

16 August 2020

Mr DSV Pröbstl
Department: Business Management

Dear Mr DSV Pröbstl

The application for ethical clearance for the research project described below served before this committee on:

Protocol No:	EMS135/20
Principal researcher:	Mr DSV Pröbstl
Research title:	The 4th industrial revolution: Exploring employee perceptions and the implementation of change
Student/Staff No:	29322473
Degree:	Doctoral
Supervisor/Promoter:	Dr E de Beer
Department:	Business Management

The decision by the committee is reflected below:

Decision:	Approved
Conditions (if applicable):	
Period of approval:	2020-08-17 - 2021-09-30

The approval is subject to the researcher abiding by the principles and parameters set out in the application and research proposal in the actual execution of the research. The approval does not imply that the researcher is relieved of any accountability in terms of the Codes of Research Ethics of the University of Pretoria if action is taken beyond the approved proposal. If during the course of the research it becomes apparent that the nature and/or extent of the research deviates significantly from the original proposal, a new application for ethics clearance must be submitted for review.

We wish you success with the project.

Sincerely

pp PROF JA NEL
CHAIR: COMMITTEE FOR RESEARCH ETHICS

Fakulteit Ekonomiese en Bestuurswetenskappe
Lefapha la Disaense tša Ekonomi le Taolo

Appendix C: German interview schedule for management staff

- Was verstehen Sie unter Industrie 4.0?
- Inwieweit sind Komponenten der Industrie 4.0 in Ihrem Umfeld eingeführt worden?
- Welche Veränderungen erwarten Sie als Folge der Einführung von Industrie 4.0?
- Wie werden sich die Produktionskosten Ihrer Meinung nach verändern?
- Was erwarten Sie in Bezug auf die Qualität?
- Welche Auswirkungen erwarten Sie in Bezug auf die Geschwindigkeit der Produktentwicklung?
- In welchem maße wird sich zukünftig die Anzahl an Robotern in Fabriken weiter erhöhen?
- Inwieweit wird sich der Übergang zur Industrie 4.0 auf die Nutzung der vorhandenen Ressourcen Ihres Unternehmens auswirken?
- Wie hängt die Einführung von Industrie 4.0 mit finanzieller Nachhaltigkeit zusammen?
- Denken Sie, dass Industrie 4.0 die gesellschaftliche Rolle Ihres Unternehmens verändern wird?
- Ihr Unternehmen hat in den letzten Jahren einen Wandel erlebt; wie beurteilen Sie die Rolle von Industrie 4.0 bei der Neuausrichtung der Zielsetzung Ihres Unternehmens?

- In wie fern sind ihrer Meinung nach Fabriken ohne negativen Einfluss auf die Umwelt möglich?

- Welche Personengruppen, auch außerhalb [redacted], werden Ihrer Meinung nach am stärksten von Industrie 4.0 betroffen sein?

- Welche Beschäftigtengruppen sind von Industrie 4.0 am stärksten betroffen?

- Kann man, ihrer Meinung nach, Fabrikarbeit irgendwann von Zuhause (Homeoffice) voziehen?

- Wie wird sich Industrie 4.0 Ihrer Meinung nach auf die Beziehungen innerhalb von Lieferketten auswirken?

- Inwieweit haben externe Institutionen die Einführung von Industrie 4.0 in
- Ihrer Region beeinflusst?

- War der Übergang zu Industrie 4.0 in Ihrem Unternehmen eher ein allmählicher oder zügiger Prozess?

- Was sind Ihrer Meinung nach die aktuellen und zukünftigen Faktoren, die den Wandel zur Industrie 4.0 vorantreiben?

- Welche innerbetrieblichen Probleme erwarten Sie durch Industrie 4.0?

- Sehen Sie die 4. industrielle Revolution als Wegbereiter oder Hindernis für neue Innovationen innerhalb des Unternehmens?

- Wird man Fabriken in ihrer jetzigen Form in ihrer Branche in Zukunft noch brauchen oder wird der Endverbraucher auch Produzent (z.b. 3D Drucken)?

- Wie kommuniziert das Unternehmen den Übergang zur Industrie 4.0?

- Bitte erläutern Sie, über welche Kanäle der Wandel zur Industrie 4.0 innerhalb der Führungsetage und gegenüber dem nicht leitenden Personal kommuniziert wird?

- Inwieweit, glauben Sie, wird die 4. industrielle Revolution die Kommunikationswege im Unternehmen verändern?

- Denken Sie, dass die 4. industrielle Revolution die Formalität der
- Interaktionen in Ihrem Unternehmen beeinflussen wird?

Appendix D: German interview schedule for non-management staff

- Haben Sie schon von Industrie 4.0 gehört?
- Was verstehen Sie unter Industrie 4.0?
- Hat sich der Anteil autonomer Maschinen verändert?
- Setzen Sie mehr digitale und physische Mittel ein, um Ihre Produktionsaufgaben zu erfüllen?
- Welche Veränderungen erwarten Sie als Folge der Einführung von Industrie 4.0?
- Welche Veränderungen haben Sie in Bezug auf die Produktqualität beobachtet?
- Haben Sie eine Veränderung im Tempo der Produktentwicklung beobachtet?
- In welchem maße wird sich die Anzahl der autonomen Roboter in ihrem Verantwortungsbereich verändern?
- Hat die Einführung von Industrie 4.0 die Produktionsabfälle verringert?
- In wie fern Glauben Sie, dass die Betriebsabläufe durch Industrie 4.0 effizienter werden?
- In wie fern Glauben Sie, dass die Produktionskosten durch Industrie 4.0 sinken werden?
- Welche Rolle spielen Ihrer Meinung nach private Organisationen bei der Bewältigung möglicher gesellschaftlicher Auswirkungen der 4. industriellen Revolution?

- Das Unternehmen hat in den vergangenen Jahren Veränderungen erlebt; können Sie diese beschreiben und mit Industrie 4.0 in Verbindung bringen?

- In wie fern sind ihrer Meinung nach Fabriken ohne negativen Einfluss auf die Umwelt in Zukunft möglich?

- Welche Personengruppen werden vom Wandel zur Industrie 4.0 am meisten betroffen sein?

- Welche Beschäftigtengruppen sind von der Industrie 4.0 am stärksten betroffen?

- Ist Industrie 4.0 für Sie ein Hilfsmittel, um Ihre Verantwortlichkeiten über das eigene Unternehmen hinaus auszuweiten?

- Inwieweit haben externe Institutionen die Einführung von Industrie 4.0 in Ihrer Region beeinflusst?

- Welche externen Gruppen waren an der Einführung von Industrie 4.0 beteiligt?

- War der Übergang zu Industrie 4.0 in Ihrem Unternehmen eher ein allmählicher oder zügiger Prozess?

- Wer bzw. was treibt aus Ihrer Sicht die Implementierung von Industrie 4.0 voran?

- Gibt es dramatische Veränderungen in Ihrer Tätigkeit und Ihrem Umfeld als Folge des Wandels zur Industrie 4.0 und können Sie diese beschreiben?

- Welche innerbetrieblichen Probleme erwarten Sie durch die Einführung von Industrie 4.0?

- Inwiefern erlauben Ihnen die Industrie-4.0-Tools, die Sie verwenden, Ihre Arbeitsprozesse ohne Beratung von außen zu verbessern?

- Wird man Fabriken in ihrer jetzigen Form in ihrer Branche in Zukunft noch brauchen oder wird der Endverbraucher auch Produzent (z.b. 3D Drucken)?

- Wie wurde Ihnen die Industrie 4.0 und damit einhergehende Neuerungen
- vorgestellt?

- Wie haben Ihre Führungskräften diese Neuerungen kommuniziert?

- Glauben Sie, dass sich die Art und Weise der Kommunikation mit Ihren Kollegen/innen und Führungskräften infolge von Industrie 4.0 verändern wird?

- Wird Industrie 4.0 die Kommunikation mit Ihren Führungskräften und Kollegen/innen erleichtern oder erschweren?

Appendix E: Research summery in English

The aim of this research endeavour is to explore the perceptions of Industry 4.0 from a management and a non-management perspective. These perceptions are explored in the context of a business' sustainability efforts and continuous social changes to highlight whether these factors influence the introduction of fully digitalised production methods. The issues and opportunities that arise from Industry 4.0 impact a plethora of disciplines and may change society as a whole, rather than solely impacting industrial manufacturing. The research question is as follows: How is the implementation of Industry 4.0 being perceived on a management and a non-management level in a multi-national organisation?

Some argue that sustainability efforts could counter the skills shortages and inequalities. Industry 4.0 may reduce the environmental footprint of manufacturers, which is one of the explicit goals of CSR. Thus, Industry 4.0 may improve efficiency and therefore increase businesses' financial performance. Ultimately, this may promote the pillars of sustainability: People, Planet, Profit. The specific secondary research questions are as follows:

- How is the implementation of Industry 4.0 being perceived from a managerial perspective?
- How is the implementation of Industry 4.0 being perceived from a non-managerial perspective?
- Do managerial and non-managerial staff link Industry 4.0 to sustainability?
- How is Industry 4.0 altering the role of stakeholders of the organisation?
- How can change management programmes facilitate the implementation of Industry 4.0 on managerial and non-managerial level?
- How can internal communication programmes facilitate the introduction of Industry 4.0 in the organisation?

This research will be conducted in the United States, Germany, Slovakia, China and Italy. Management and non-management employees will be interviewed to gather data on these groups' opinions and experiences relating to the above-mentioned research questions. The interviews will be recorded, anonymised and will not be shared with third parties that do not form part of this research. The recording of interviews is done to facilitate anonymous transcription. The name and date of the interviews will not be recorded. Only the interviewee's professional position, role within the organisation, years of employment and educational background will be registered. It is the explicit goal of this research to depict a wide representation of employees who have experienced the introduction of Industry 4.0. These interviews will be placed into a data-pool of 50 global interviews. The interviews will be coded with the aid of Atlas TI and analysed by region and employee group. The discussion of results will not make any specific reference to individual interviewees that would jeopardise anonymity nor will [redacted] be mentioned. An agreement with [redacted] has been signed, highlighting the terms of cooperation and terms for this research.

Appendix F: Research summary in German

Die 4. industrielle Revolution

Erforschung der Wahrnehmung und der Implementierung von Industrie 4.0

Der Zweck meines Forschungsvorschlages ist es, die Wahrnehmung von Industrie 4.0 auf das Management- und die Nicht-Management-Ebene zu untersuchen. In dem Forschungsvorhaben wird die Wahrnehmung von Industrie 4.0 im Kontext der Nachhaltigkeitsanstrengungen eines Unternehmens und dem fortlaufenden gesellschaftlichen Wandel untersucht und gefragt, ob dies den Übergang zu einer vollständig digitalisierten Fertigung ermöglicht. Die Forschungsfrage lautet wie folgt: Wie wird die Implementierung von Industrie 4.0 auf Management- und Nicht-Management-Ebene in einem internationalen Unternehmen wahrgenommen?

Einige argumentieren, dass Nachhaltigkeitsbemühungen von Unternehmen dem Fachkräftemangel und den sozialen Ungleichheiten entgegenwirken könnten. Industrie 4.0 kann den ökologischen Fußabdruck der Hersteller verringern, das Wirtschaften zukunftsfähig und langfristig nachhaltig gestalten, die Effizienz steigern und die finanzielle Leistung von Unternehmen verbessern. Dies kann die drei Säulen der Nachhaltigkeit (Ökonomie, Ökologie und Soziales) fördern. Die spezifischen Forschungsfragen sind wie folgt:

Wie beurteilt das Management und die Nicht-Management-Ebene die Implementierung von Industrie 4.0?
Verbindet das Management und die Nicht-Management-Ebene Industrie 4.0 mit Nachhaltigkeit?
Wie verändert Industrie 4.0 die Rolle der einzelnen Interessensgruppen (Stakeholder) des Unternehmens?
Wie können Veränderungsmanagement-Initiativen die Implementierung von Industrie 4.0 erleichtern?
Wie können interne Kommunikationsmaßnahmen die Einführung von Industrie 4.0 im Unternehmen begleiten und erleichtern?

Die Forschungsarbeit wird Interviews in Deutschland, der Slowakei, China, den USA und Italien beinhalten. Es werden Mitglieder des Managements und der Nicht-Management-Ebene interviewt um Meinungen und Erfahrungen zu den oben genannten Forschungsfragen zu dokumentieren. Diese Interviews werden anonymisiert und nicht an Dritte, an der Forschungsarbeit Unbeteiligte, weitergegeben. Die Interviews werden aufgezeichnet, um diese zu transkribieren und ins Englische zu übersetzen. Anschließend werden diese Transkripte anonym in einen Datenpool der insgesamt 50 weltweiten Interviews gegeben. Ziel ist es einen möglichst breiten Querschnitt des Managements und der Nicht-Management-Ebene des Unternehmens zu befragen. Es werden weder Namen des Interviewteilnehmers, noch der Zeitpunkt des Interviews aufgezeichnet. Persönliche Daten, welche aufgezeichnet werden sind: Anstellungsverhältnis zu [redacted], Jahre der Betriebsangehörigkeit, Aufgabe im Unternehmen und Bildungsgrad. Die Transkripte der Interviews werden anschließend qualitativ mit Hilfe von Atlas TI codiert und dann nach Rolle in dem Unternehmen und nach Region analysiert. In der Diskussion der Ergebnisse werden keinerlei Referenzen zu Namen der Interviewteilnehmer oder [redacted] gemacht. Ein Abkommen mit [redacted] zu den Bedingungen der Forschungsarbeit wurde bereits geschlossen.

Appendix G: Research summery in Slovak

Štvrtá priemyselná revolúcia

Zisťovanie vnímania zamestnancov a implementácie zmien

Cieľom prekladanej výskumnej práce je preskúmať vnímanie priemyslu 4.0 z manažérskej aj z nemanažérskej perspektívy. Toto vnímanie sa skúma v kontexte úsilia o udržateľnosť podnikania a nepretržitých spoločenských zmien v snahe určiť, či tieto faktory ovplyvňujú zavedenie plne digitalizovaných výrobných metód. Problémy a príležitosti, ktoré vyplývajú z konceptu priemyslu 4.0, ovplyvňujú množstvo disciplín a môžu zmeniť spoločnosť ako celok, a nielen priemyselnú výrobu. Výskumná otázka je nasledujúca: Ako je vnímaná implementácia koncepcie priemyslu 4.0 na manažérskej a nemanažérskej úrovni v nadnárodnej organizácii?

Niektorí tvrdia, že snahy o udržateľnosť by mohli zabrániť nedostatku kvalifikovaného personálu a sociálnym nerovnostiam. Priemysel 4.0 môže znížiť environmentálnu stopu výrobcov, čo je jedným z explicitných cieľov spoločenskej zodpovednosti podnikov. Priemysel 4.0 teda môže zvýšiť efektivitu, a tak zvýšiť finančnú výkonnosť podnikov. V konečnom dôsledku to môže podporovať piliere udržateľnosti: ľudia, planéta, zisk. Jednotlivé sekundárne výskumné otázky sú tieto:

- Ako je implementácia konceptu priemyslu 4.0 vnímaná z manažérskeho hľadiska?
- Ako je implementácia konceptu priemyslu 4.0 vnímaná z nemanažérskeho hľadiska?
- Spájajú si zamestnanci na manažérskych a nemanažérskych pozíciách priemysel 4.0 s udržateľnosťou?
- Ako mení priemysel 4.0 úlohu aktérov v organizácii?
- Ako môžu programy riadenia zmien uľahčiť implementáciu priemyslu 4.0 na manažérskej a nemanažérskej úrovni?
- Ako môžu programy internej komunikácie uľahčiť zavedenie priemyslu 4.0 v organizácii?

Tento výskum sa uskutoční v Spojených štátoch amerických, Nemecku, na Slovensku, v Číne a Taliansku. Budú oslovení zamestnanci na manažérskych a nemanažérskych pozíciách s cieľom zhromaždiť údaje o názoroch a skúsenostiach týchto skupín týkajúcich sa vyššie uvedených výskumných otázok. Rozhovory budú zaznamenané, anonymizované a nebudú zdieľané s tretími stranami, ktoré nie sú súčasťou tohto výskumu. Záznam rozhovorov sa vykonáva s cieľom uľahčiť anonymný prepis. Názov a dátum rozhovorov sa nebude zaznamenávať. Zaznamená sa iba odborná pozícia, úloha v rámci organizácie, doba zamestnania a získané vzdelanie respondenta. Deklarovaným cieľom tohto výskumu je znázorniť široké zastúpenie zamestnancov, ktorí majú skúsenosť so zavádzaním priemyslu 4.0. Tieto rozhovory sa umiestnia do súboru údajov s 50 globálnymi rozhovormi. Rozhovory budú kódované pomocou nástroja Atlas TI a analyzované podľa regiónu a skupiny zamestnancov. Rozbor výsledkov nebude uvádzať konkrétne zmienky o jednotlivých respondentoch, čo by ohrozilo anonymitu, ani nebude spomenutá spoločnosť [redacted]. Bola podpísaná dohoda so spoločnosťou [redacted], ktorá stanovuje podmienky spolupráce a podmienky tohto výskumu.

Appendix H: Research summery in mandarin Chinese

第四次工业革命

工业革命4.0的认知和实施研究

我提出此研究建议，旨在从管理层面和非管理层面上对工业革命4.0的认识进行分析。该项目将研究在企业追求可持续性发展和社会持续变革的情况下，工业革命4.0的认知情况，并且探讨这一转变能否帮助实现社会向完全数字化生产的过渡。研究问题如下：在国际性公司中，如何从管理和非管理层面分别认识工业4.0的实施？

一些人认为，企业对于可持续发展的追求可以缓解专业人员短缺和社会不平等的问题。工业4.0可以帮助减少制造商的生态足迹，实现企业业务可持续发展并且面向未来，提升效率，并改善公司的财务绩效。这有益于稳固可持续性发展的三大支柱（经济，生态和社会问题）。具体的研究问题如下：

- 如何从管理层和非管理层分别评估工业4.0的实施？
- 管理层面和非管理层面能否将工业4.0与可持续性相结合？
- 工业4.0如何改变个人利益集团（利益相关者）在公司中的作用？
- 管理改革计划如何促进工业4.0的实施？
- 企业内部沟通措施如何协助企业引进工业4.0？

该研究包含来自德国，斯洛伐克，中国，美国和意大利的采访资料。该项目分别采访了企业管理层和非管理层的职员，记录了他们对于上述研究问题的看法和经验。这些采访是匿名的，不会转达给未参与研究的第三方。采访内容已被录音，方便转换成文字和翻译成英文。转换的文本随后被录入指定数据库中，该数据库包含了来自世界各地的总共50场采访。目的在于尽可能广泛地调查企业管理和非管理层面现状。采访既不记录受访者的姓名，也不记录采访时间。记录的个人数据仅包括：与欧司朗公司的雇佣关系，在职时长，职位和教育程度。采访内容被转成文字后，借助于Atlas.ti软件进行定性编码，然后根据受访者职位和地区进行分析。在讨论研究结果时，将不会透露任何关于受访者姓名或欧司朗的提示。研究者已与欧司朗公司就此研究工作达成协议。

Appendix I: Non-disclosure and co-operation agreement

[redacted]

Mr. Dominique Pröbstl

Your reference/ your letter dated
PhD research Mr. Pröbstl

Department
[redacted]

09.03.2020

Cooperation agreement Mr. Pröbstl

We hereby confirm that [redacted] is aware of research to be conducted by Mr. Dominique Pröbstl (8906156288086), student at the University of Pretoria, on the topic of communication in the context of Industry 4.0.

With regard to the involvement of [redacted] the abovementioned research exclusively consists of interviews with [redacted] employees conducted by Mr. Pröbstl. Such interviews will be conducted in the period of July 2020 until September 2020 in person on [redacted] premises.

[redacted] will make suggestions for possible interview partners. Interviews with such nominated employees shall be conducted on a voluntary basis (i.e. given the employee's consent). All answers made by employees will be completely anonymized, i.e. reference will neither possible to [redacted] and any of its entities, nor to the answering employee.

The questionnaire and/or topics governed in the interview shall be provided to [redacted] Head of Industry 4.0 Program Management) in advance to ensure that no company or business secrets will be concerned.

[redacted] grants permission to the interviews under the condition, that no reference to any [redacted] entity worldwide or any [redacted] employee will be made in a publication (e.g. the thesis) of the interview results by Mr. Pröbstl.

We further confirm that authorisation was given to the above person to conduct said research for academic purposes.

[redacted] is looking forward to cooperate with Mr. Dominique Pröbstl in the aforementioned research endeavour.

With best regards

[redacted]

Agreed: in Pretoria
Date: 11.03.2020
Dominique Pröbstl: [signature]

Name [redacted] Phone [redacted] E-mail [redacted]

1/1

1201a 12/2017

[redacted]

Appendix J: Interviewee consent form in German

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

Anschreiben und Einverständniserklärung

Department of Business Management

Die 4. industrielle Revolution

Untersuchungen zur Sichtweise der Beschäftigten und zur Implementierung des Wandels

Studie durchgeführt von:

Herrn D. S. V. Pröbstl (29322473)
Mobiltelefon: 0797947696

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer,

Sie sind eingeladen, an einer akademischen Forschungsstudie teilzunehmen, die von Dominique Pröbstl, Doktorand in der Abteilung für Business Management an der Universität von Pretoria, durchgeführt wird.

Das Ziel dieser Studie ist es, die Wahrnehmung der Beschäftigten in Bezug auf den Wandel zur Industrie 4.0 zu untersuchen.

Bitte beachten Sie Folgendes:

- Es handelt sich um eine anonyme Befragung und Ihr Name wird nicht auf dem Fragebogen erscheinen. Die von Ihnen gegebenen Antworten werden streng vertraulich behandelt. Sie können anhand der von Ihnen gegebenen Antworten nicht persönlich identifiziert werden.
- Ihre Teilnahme an dieser Studie ist für uns äußerst wichtig. Sie können Ihre Teilnahme jedoch jederzeit ohne negative Auswirkungen beenden.
- Bitte beantworten Sie die Fragen des nachfolgenden Fragebogens so vollständig und ehrlich wie möglich. Das sollte nicht mehr als 75 Minuten Ihrer Zeit in Anspruch nehmen.
- Die Ergebnisse dieser Studie werden nur für akademische Zwecke verwendet und werden ggf. in einer wissenschaftlichen Fachzeitschrift veröffentlicht. Eine Zusammenfassung unserer Ergebnisse stellen wir Ihnen auf Anfrage gerne zur Verfügung.
- Bitte kontaktieren Sie die Studienleiterin Dr. E. de Beer per E-Mail (estelle.debeer@up.ac) oder per Telefon (082 688 0362), wenn Sie Fragen oder Anmerkungen zu dieser Studie haben.

Bei Studien dieser Art kann die Studienleitung ggf. mit den Befragten Kontakt aufnehmen, um die Authentizität der erhobenen Daten zu überprüfen. Alle persönlichen Kontaktdaten, die Sie uns zur Verfügung stellen, dienen ausschließlich diesem Zweck und gefährden keinesfalls die Anonymität oder die Vertraulichkeit Ihrer Teilnahme.

Bitte unterschreiben Sie das Formular, um Folgendes zu bestätigen:

- Sie haben die oben aufgeführten Informationen gelesen und verstanden.
- Sie erklären sich damit einverstanden, auf freiwilliger Basis an der Studie teilzunehmen.

____________________________ ____________________

Unterschrift der Teilnehmerin bzw. des Teilnehmers **Datum**

Appendix K: Interviewee consent form in English

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

Letter of Introduction and Informed Consent

Dept. of Business Management

The 4th industrial revolution

Exploring employee perceptions and the implementation of change

Research conducted by:
Mr. D.S.V. Pröbstl (29322473)
Cell: 0797947696

Dear Participant

You are invited to participate in an academic research study conducted by Dominique Pröbstl, Doctoral student from the Department of Business Management at the University of Pretoria.

The purpose of the study is to explore the perception of employees towards the change towards industry 4.0.

Please note the following:

- This is an anonymous study survey as your name will not appear on the questionnaire. The answers you give will be treated as strictly confidential as you cannot be identified in person based on the answers you give.
- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.
- Please answer the questions in the following interview as completely and honestly as possible. This should not take more than 75 minutes of your time.
- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.
- Please contact my study leader, Dr. E. de Beer, via e-mail: estelle.debeer@up.ac or via phone: 082 688 0362, if you have any questions or comments regarding the study.

In research of this nature the study leader may wish to contact respondents to verify the authenticity of data gathered by the researcher. It is understood that any personal contact details that you may provide will be used only for this purpose only, and will not compromise your anonymity or the confidentiality of your participation.

Please sign the form to indicate that:

- You have read and understand the information provided above.
- You give your consent to participate in the study on a voluntary basis.

___________________________ ___________________

Participant's signature **Date**

Appendix L: Interviewee consent form in Slovak

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

Úvodný list a informovaný súhlas

Katedra podnikového manažmentu

Štvrtá priemyselná revolúcia

Zisťovanie vnímania zamestnancov a implementácie zmien

Výskum realizuje:

Pán D. S. V. Pröbstl (29322473)
Mobil: 0797947696

Vážený účastník!

Pozývame vás zúčastniť sa na akademickej výskumnej štúdii, ktorú vedie Dominique Pröbstl, doktorand z Katedry podnikového manažmentu na Univerzite v Pretórii.

Účelom štúdie je preskúmať vnímanie zamestnancov v súvislosti so zmenou smerom k priemyslu 4.0.

Upozorňujeme na nasledujúce:

- Toto je anonymná štúdia, pričom vaše meno nebude uvedené v dotazníku. S odpoveďami, ktoré poskytnete, sa bude zaobchádzať ako s prísne dôvernými, aby vás nebolo možné osobne identifikovať na základe vami poskytnutých odpovedí.
- Vaša účasť na tejto štúdii je pre nás veľmi dôležitá. Môžete sa však rozhodnúť nezúčastniť sa a tiež môžete kedykoľvek ukončiť účasť bez akýchkoľvek negatívnych následkov.
- Na otázky v nasledujúcom rozhovore odpovedzte čo najúplnejšie a najčestnejšie. Nemalo by vám to trvať dlhšie ako 75 minút.
- Výsledky štúdie budú použité len na akademické účely a môžu byť zverejnené v akademickom časopise. Na požiadanie vám poskytneme súhrn našich zistení.
- Kontaktujte moju vedúcu výskumu Dr. E. de Beer, a to e-mailom: estelle.debeer@up.ac alebo telefonicky : 082 688 0362, ak máte akékoľvek otázky alebo pripomienky týkajúce sa štúdie.

Pri výskume tohto charakteru môže vedúci výskumu kontaktovať respondentov s cieľom overiť si pravosť údajov získaných výskumníkom. Rozumie sa pritom, že akékoľvek osobné kontaktné údaje, ktoré uvediete, budú použité iba na tento účel a nijakým spôsobom neovplyvnia anonymitu ani dôvernosť vašej účasti.

Prosím, podpíšte formulár, čím potvrdíte, že:

- ste si prečítali vyššie uvedené informácie a rozumiete im,
- súhlas s účasťou na štúdii udeľujete dobrovoľne.

___________________________ ___________________

Podpis účastníka **Dátum**

Appendix M: Interviewee consent form in Chinese

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences

介绍信函及知情同意书

工商管理系

第四次工业革命
探讨员工认知与变革实施

研究者：
D.S.V.Pröbstl 先生（29322473）
手机号：0797947696

尊敬的参与者：

我们邀请您参与由比勒陀利亚大学工商管理系研究生 Dominique Pröbstl 进行的学术研究。

这项研究旨在探讨员工对工业 4.0 变革的认知。

请注意以下事项：

- 这是一项匿名研究，因为您的名字不会出现在调查问卷上。 您所提供的答案将被严格保密，因为从答案中无法识别您本人的身份。
- 您对这项研究的参与对我们来说非常重要。不过，您可以选择不参与，也可以随时停止参与，不会产生任何负面后果。
- 请尽可能完整、诚实地回答以下采访中的问题。时间应该不会超过 75 分钟。
- 这项研究结果仅作学术用途，并可能在学术期刊上发表。我们将应要求向您提供调查结果的摘要。
- 如果您对这项研究有任何问题或意见，请通过电子邮件联系我的导师 Dr. E. de Beer：estelle.debeer@up.ac 或致电： 082 688 0362。

基于研究的性质，学科导师可能希望联系被调查者，以核实研究者所收集数据的真实性。 显然，您提供的任何个人联系信息仅用于此目的，不会危及您的匿名性或参与研究的保密性。

请在表格上签名，以表明：

- 您已阅读并理解以上信息。
- 您同意在自愿的基础上参与这项研究。

参与者签名 ______________________ **日期** ______________________

Appendix N: Analysis codes and definitions

Industry 4.0 Project

Report created by Dominique Proebstl

- 3D printing

Comment:

This code is to be applied to all statements that directly discuss elements of the 3D printing constituent of Industry 4.0 technology.

- 5G

Comment:

This code is to be applied to all statements that directly cite ‘5G’.

- Augmented reality

Comment:

This code is to be applied to all statements that directly discuss elements of augmented reality as a constituent of Industry 4.0 technology.

- Autonomous machinery

Comment:

This code is to be applied to all statements that directly discuss elements of autonomous machinery as a constituent of Industry 4.0 technology.

- Big Data

Comment:

This code is to be applied to all statements that directly discuss elements of Big Data as a constituent of Industry 4.0 technology.

- Camline

Comment:

This code is to be applied to all statements that directly cite ‘Camline’.

- Camstar

Comment:

This code is to be applied to all statements that directly cite ‘Camstar’.

- Cloud computing

Comment:

This code is to be applied to all statements that refer to cloud computing technology.

- Cobots

Comment:

This code is to be applied to all statements that directly cite ‘cobots’.

- Cyber-physical systems

Comment:

This code is to be applied to all statements discussing cyber-physical systems

- Employee does not know of Industry 4.0

Comment:

This code is to be applied to all statements directly stating that the interviewee has no knowledge of Industry 4.0.

- Employee knows of Industry 4.0

Comment:

This code is to be applied to all statements directly stating that the interviewee has knowledge of Industry 4.0.

- HoloLens

Comment:

This code is to be applied to all statements that directly cite ‘HoloLens’.

- Initial understanding of Industry 4.0

Comment:

This code is to be applied to any statement(s) indicating the interviewee’s explicit understanding of Industry 4.0.

- Internet of Things

Comment:

This code is to be applied to all statements discussing the Internet of Things.

- Machine learning / artificial intelligence

Comment:

This code is to be applied to all statements that directly discuss elements of machine learning as a constituent of Industry 4.0 technology.

- Machine–human cooperation

Comment:

This code is to be applied to all statements that directly discuss elements of machine–human cooperation as a constituent of Industry 4.0 technology.

- MES systems

Comment:

This code is to be applied to all statements that cite MES technology.

- My QI

Comment:

This code is to be applied to all statements that cite ‘My QI’ technology.

- QRQC

Comment:

This code is to be applied to all statements that directly site ‘QRQC’.

- TicketManager

Comment:

This code is to be applied to all statements that directly cite ‘TicketManager’.

- Dedicated resources for Industry 4.0

Comment:

This code is to be applied to all statements directly stating that the organisation has dedicated resources for Industry 4.0.

- High labour costs

Comment:

This code is to be applied to all statements indicating high labour costs.

- IT literacy of stakeholder

Comment:

This code is to be used on all statements that indicate the role of IT literacy in relation to the implementation of Industry 4.0.

- Lack of labour availability

Comment:

This code is to be applied to all statements stating that there is a lack of labour in the region.

- Lack of resources to implement Industry 4.0

Comment:

This code is to be applied to all statements directly stating that the organisation has not dedicated sufficient resources to Industry 4.0.

- Low labour costs

Comment:

This code is to be applied to all statements discussing low labour costs.

- Old machinery is not upgradable to Industry 4.0

Comment:

This code is to be applied to all statements directly stating that machinery has not been or cannot be upgraded to incorporate Industry 4.0.

- Old machinery is upgradable to Industry 4.0

Comment:

This code is to be applied to all statements directly stating that machinery has been or can be upgraded to incorporate Industry 4.0.

● Expected decrease of Industry 4.0 technologies at facility
Comment:
This code is to be applied to all statements explicitly referring to an expected decrease of Industry 4.0 technologies at the organisation's facility.

● Expected increase of Industry 4.0 technologies at facility
Comment:
This code is to be applied to all statements explicitly referring to an expected increase of Industry 4.0 technologies at the organisation's facility.

● No change expected of Industry 4.0 technologies at facility
Comment:
This code is to be applied to all statements explicitly stating that there is no change in Industry 4.0 technologies at the facility.

● No reply / no opinion on changes of Industry 4.0 technology at facility
Comment:
This code is to be applied to all statements indicating that the interviewee does not want to discuss the change of Industry 4.0 technology at the facility.

● Decreased collaboration of workers due to Industry 4.0 technologies
Comment:
This code is to be applied to all statements explicitly referring to a decrease in collaboration of workers to achieve aims as a result of the implementation of Industry 4.0.

● Decreased independent work due to Industry 4.0 technologies
Comment:
This code is to be applied to all statements explicitly referring to a decrease in independent work of staff towards achieving aims as a result of the implementation of Industry 4.0.

● Exposure to changes of work tools

Comment:

This code is to be applied to all statements explicitly referring to changes in the tools utilised to achieve work tasks.

● Increased collaboration of workers due to Industry 4.0 technologies

Comment:

This code is to be applied to all statements explicitly referring to an increase in collaboration of workers to achieve aims as a result of the implementation of Industry 4.0.

● Increased independent work due to Industry 4.0 technologies

Comment:

This code is to be applied to all statements explicitly referring to an increase in independent work of staff towards achieving aims as a result of the implementation of Industry 4.0.

● Negative impact on work safety

Comment:

This code is to be applied to all statements indicating all negative impacts on work safety .

● No change in the degree of independent work

Comment:

This code is to be applied to all statements explicitly stating no change to independent work of staff towards achieving aims as a result of the implementation of Industry 4.0.

● Positive impact on work safety

Comment:

This code is to be applied to all statements indicating all positive impacts on work safety.

● Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies

Comment:

This code is to be applied to all statements stating that workers have not experienced an increased scope of responsibilities due to Industry 4.0 technologies.

● Workers experience an increased scope of responsibilities due to Industry 4.0 technologies

Comment:

This code is to be applied to all statements stating that workers have experienced an increased scope of responsibilities due to Industry 4.0 technologies.

● Factories can have a zero impact on the environment

Comment:

This code is to be applied to all statements directly stating that factories can have a zero effect on the environment.

● Factories cannot have a zero impact on the environment

Comment:

This code is to be applied to all statements directly stating that factories cannot have a zero effect on the environment.

● Industry 4.0 has improved the factory's environmental footprint

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will reduce the environmental impact of factories.

● Industry 4.0 has not improved the factory's environmental footprint

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has not or will not reduce the environmental impact of factories.

● No response / no opinion on Industry 4.0's impact on the environment

Comment:

This code is to be applied to all statements directly stating no opinion or no knowledge of the impact of Industry 4.0 on factories' impact on the environment.

- Improved competitiveness of facility due to Industry 4.0

Comment:

This code is to be applied to all statements that express improved competitiveness of the facility due to the introduction of Industry 4.0 technologies.

- Industry 4.0 has no impact on the supply chain

Comment:

This code is to be applied to all statements explicitly stating that Industry 4.0 has no impact on the organisation's supply chain.

- Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations

Comment:

This code is to be applied to all statements indicating that Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations.

- Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations

Comment:

This code is to be applied to all statements indicating that Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.

- Industry 4.0 is a driver of innovation

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 is or will be a driver of innovation.

- Industry 4.0 is a hinderance for innovation

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 is or will be a hindrance to innovation.

● Industry 4.0 is neither a driver nor a hindrance to innovation

Comment:

This code is to be applied to all statements in relation to Industry 4.0's role in innovation indicating that it is neither a driver nor a hindrance to innovation.

● Negative effect on product development

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will have a negative impact on product development.

● Negative financial impact of Industry 4.0

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 will negatively impact the financial position of the organisation.

● Negative impact of Industry 4.0 on product quality

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will have a negative impact on product quality.

● Negative impact of Industry 4.0 on the supply chain

Comment:

This code is to be applied to all statements explicitly stating that Industry 4.0 has a negative impact on the organisation's supply chain.

● No change to product development

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has no effect on the product development process.

● No change to product quality

Comment:

This code is to be applied to all statements stating that Industry 4.0 does not or will not have an effect on product quality.

- No financial impact

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 will not impact the financial position of the organisation.

- No response / no opinion on Industry 4.0's impact on financial sustainability

Comment:

This code is to be applied to all statements directly stating that the interviewee has no opinion on or no knowledge of the impact that Industry 4.0 has on the financial position of the organisation.

- Positive effect on product development

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will have a positive impact on product development.

- Positive financial impact of Industry 4.0

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 will positively impact the financial position of the organisation.

- Positive impact of Industry 4.0 on product quality

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will have a positive impact on product quality.

- Positive impact of Industry 4.0 on the supply chain

Comment:

This code is to be applied to all statements explicitly stating that Industry 4.0 has a positive impact on the organisation’s supply chain.

- ‘The Company’ has a responsibility to upskill its workforce

Comment:

This code is to be applied to all statements stating that ‘The Company’ has a responsibility to upskill its employees to cope with the transition towards Industry 4.0.

- ‘The Company’ has no responsibility to upskill its workforce

Comment:

This code is to be applied to all statements stating that ‘The Company’ has no responsibility to upskill its employees to cope with the transition towards Industry 4.0.

- Expected changes to the form of factories

Comment:

This code is to be applied to all statements that directly explain the expected changes to the form of factory manufacturing methods.

- Impact of Industry 4.0 on the region

Comment:

This code is to be applied to all statements explicitly explaining the impact on the region where the organisation is implementing Industry 4.0 technologies.

- Industry 4.0 has changed the purpose of ‘The Company’

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has or will change the purpose or societal role of ‘‘The Company”.

- Industry 4.0 has not changed the purpose of ‘The Company’

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 has not orwill not change the purpose of ‘The Company’.

- Negative change to the societal role of ‘The Company’

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 will negatively impact the purpose of the organisation.

- No expected changes to the form of factories

Comment:

This code is to be applied to all statements directly stating that there are no expected changes to the form of factory manufacturing methods.

- No reply / no opinion on the societal role of ‘The Company’

Comment:

This code is to be applied to all statements directly stating that the interviewee has no knowledge or opinion on the impact of Industry 4.0 on the purpose of the organisation.

- Positive change in the societal role of ‘The Company’

Comment:

This code is to be applied to all statements directly stating that Industry 4.0 will positively impact the purpose of the organisation.

- No negative impact on stakeholders

Comment:

This code is to be applied to all statements indicating that no negative impact is expected on stakeholders.

- No reply / no opinion on the impact of Industry 4.0 on stakeholders

Comment:

This code is to be applied to all statements of no opinion or no comment on the impact of Industry 4.0 on stakeholders.

- Positive impact of Industry 4.0 on less-skilled workforce

Comment:

This code is to be applied to all statements explicitly referring to a positive impact on less-skilled workers as a result of the implementation of Industry 4.0.

- Positive impact of Industry 4.0 on older employees

Comment:
This code is to be applied to all statements indicating a positive impact on older employees as a result of Industry 4.0 technologies.

- Positive impact of Industry 4.0 on other stakeholders

Comment:
This code is to be applied to all statements explicitly referring to a positive impact on non-worker stakeholders as a result of the implementation of Industry 4.0.

- Positive impact of Industry 4.0 on persons who are willing to accept change

Comment:
This code is to be applied to all statements referring to a positive impact on persons unwilling to accept change as a result of the implementation of Industry 4.0.

- Positive impact of Industry 4.0 on skilled workforce

Comment:
This code is to be applied to all statements explicitly referring to a positive impact on skilled workers as a result of the implementation of Industry 4.0.

- Positive impact of Industry 4.0 on undefined workforce

Comment:
This code is to be applied to all statements explicitly referring to a positive impact on an undefined workforce as a result of the implementation of Industry 4.0.

- Positive impact of Industry 4.0 on younger employees

Comment:
This code is to be applied to all statements indicating a positive impact on younger employees as a result of Industry 4.0 technologies.

- Negative impact of Industry 4.0 on less-skilled workforce

Comment:
This code is to be applied to all statements explicitly referring to a negative impact on less-skilled workers as a result of the implementation of Industry 4.0.

● Negative impact of Industry 4.0 on older employees

Comment:

This code is to be applied to all statements indicating a negative impact on older employees as a result of Industry 4.0 technologies.

● Negative impact of Industry 4.0 on other stakeholders

Comment:

This code is to be applied to all statements explicitly referring to a negative impact on non-worker stakeholders as a result of the implementation of Industry 4.0.

● Negative impact of Industry 4.0 on persons who are not willing to accept change

Comment:

This code is to be applied to all statements stating a negative impact on persons unwilling to accept change as a result of the implementation of Industry 4.0.

● Negative impact of Industry 4.0 on skilled workforce

Comment:

This code is to be applied to all statements referring to a negative impact on skilled workers as a result of the implementation of Industry 4.0.

● Negative impact of Industry 4.0 on undefined workforce

Comment:

This code is to be applied to all statements referring to a negative impact on an undefined workforce as a result of the implementation of Industry 4.0.

● Negative impact of Industry 4.0 on younger employees

Comment:

This code is to be applied to all statements indicating a negative impact on younger employees as a result of Industry 4.0 technologies.

● Implementation of Industry 4.0 was fast

Comment:

This code is to be applied to all statements explicitly stating that the implementation of Industry 4.0 was quick.

● Implementation of Industry 4.0 was slow

Comment:

This code is to be applied to all statements explicitly stating that the implementation of Industry 4.0 was slow.

● No reply / no opinion on the rate of change

Comment:

This code is to be applied to all statements that do not explicitly express that the introduction of Industry 4.0 was either fast or slow.

● Drivers of change towards Industry 4.0

Comment:

This code is to be applied to all statements explicitly highlighting the drivers of change towards Industry 4.0.

● Experience of organisational change with a link to Industry 4.0

Comment:

This code is to be applied to all statements explicitly referring to an organisational change with a link to Industry 4.0.

● Experience of organisational change with no link to Industry 4.0

Comment:

This code is to be applied to all statements explicitly referring to an organisational change with no link to Industry 4.0.

● No reply / no opinion on external influencers of the implementation of Industry 4.0

Comment:

This code is to be applied to all statements stating that the interviewee has no knowledge or has declined to explain the role of external influencers on the implementation of Industry 4.0.

● No reply / no opinion on possible resistance to change

Comment:

This code is to be applied to all statements indicating that the interviewee declined to comment on resistance to the introduction of Industry 4.0 or has no opinion.

● No resistance to the introduction of Industry 4.0
Comment:
This code is to be applied to all statements explicitly stating that there has been no resistance to the introduction of Industry 4.0.

● Non-supportive external influencers on the implementation of Industry 4.0
Comment:
This code is to be applied to all statements explicitly referring to non-supportive external influencers on the implementation of Industry 4.0.

● Resistance to the introduction of Industry 4.0
Comment:
This code is to be applied to all statements explicitly stating that there has been resistance to the introduction of Industry 4.0.

● Supportive external influencers on the implementation of Industry 4.0
Comment:
This code is to be applied to all statements explicitly referring to supportive external influencers on the implementation of Industry 4.0.

● Channels utilised to communicate changes
Comment:
This code is to be applied to all statements discussing the channels used to communicate the changes to Industry 4.0.

● Communication of Industry 4.0 related changes
Comment:
This code is to be applied to all statements discussing the communication of the transition to Industry 4.0.

● Perceived change communication shortcomings

Comment:

This code is to be applied to all statements discussing shortcomings of the organisation's communication of the transition to Industry 4.0.

● Change in communication as a result of digitalisation

Comment:

This code is to be applied to all statements discussing changes to communication due to the transition to Industry 4.0.

● Decreased accessibility of co-workers due to digital communication

Comment:

This code is to be applied to all statements discussing decreased accessibility of co-workers as a result of the transition to Industry 4.0.

● Decreased formality in communication due to digitalisation

Comment:

This code is to be applied to all statements discussing decreased formality to communication due to the transition to Industry 4.0.

● Decreased transparency of data due to digital communication

Comment:

This code is to be applied to all statements discussing decreased transparency of data as a result of the transition to Industry 4.0.

● Face-to-face communication

Comment:

This code is to be applied to all statements indicating the use of face-to-face communication.

● Increased accessibility of co-workers due to digital communication

Comment:

This code is to be applied to all statements discussing increased accessibility of co-workers as a result of the transition to Industry 4.0.

● Increased formality in communication due to digitalisation

Comment:

This code is to be applied to all statements discussing increased formality of communication due to the transition to Industry 4.0.

● Increased transparency of data due to digital communication

Comment:

This code is to be applied to all statements discussing increased transparency of data as a result of the transition to Industry 4.0.

● Industry 4.0 has a negative effect on communication

Comment:

This code is to be applied to all statements discussing all perceived negative effects of Industry 4.0 on communication.

● Industry 4.0 has a positive effect on communication

Comment:

This code is to be applied to all statements discussing all perceived positive effects of Industry 4.0 on communication.

● No change in formality of communication due to digitalisation

Comment:

This code is to be applied to all statements discussing no change in the formality of communication due to the transition to Industry 4.0.

● Use of digital communication means

Comment:

This code is to be applied to all statements indicating the use of digital communication means to communicate within the organisation.

● Willingness to share data within the supply chain

Comment: This code is to be applied to all statements indicating all experiences or expectations related to willingness to share data within the supply chain.

○ Interviewee does not want to work from home

Comment:

This code is to be applied to all statements indicating that the interviewee does not want to work from home.

○ Interviewee has been in home office

Comment:

This code is to be applied to all statements explicitly stating that the interviewee has been working from a home office.

○ Interviewee has not been in home office

Comment:

This code is to be applied to all statements explicitly stating that the interviewee has not been working from a home office.

○ Interviewee wants to work from home

Comment:

This code is to be applied to all statements indicating that the interviewee wants to work from home.

○ Negative experience with home office

Comment:

This code is to be applied to all statements indicating any negative experiences or expectations of a home office.

○ Negative outlook on the possibility of home office for production staff

Comment:

This code is to be applied to all statements indicating all negative experiences or expectations of the possibility of a home office for production workers.

○ Outlook on the future of home office

Comment:

This code is to be applied to all statements that describe the interviewee's outlook on a home office in general without specifying factory workers.

○ Positive experience with home office
Comment:
This code is to be applied to all statements indicating all positive experiences or expectations of a home office.

○ Positive outlook on the possibility of a home office for production staff
Comment:
This code is to be applied to all statements indicating all positive experiences or expectations of the possibility of a home office for production workers.

Appendix O: Compiled Regional Findings

ALL FIELDSTUDIES COMBINED

Theme 1: Employees associating Industry 4.0 with specific technologies

The number of statements associated to the individual codes that highlight the employees' association of Industry 4.0 with specific technologies are set out in the following three tables. In addition, the most frequent co-occurrence of statements throughout the interviews in all regions are highlighted below. First, the data highlighting the perceived initial understanding of constituent technologies of Industry 4.0 from a management and non-management perspective is presented in Table 230. 'M' indicates management perceptions, and 'N-M' indicates non-management perceptions. This applies to all tables in this chapter.

Table 230: Industry 4.0 can be defined through Industry 4.0 constituent technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Initial understanding of Industry 4.0	Big Data (9)	Autonomous machinery (8)	31	22
Employee knows of Industry 4.0		Initial understanding of Industry 4.0 (3)	0	23
Employee does not know of Industry 4.0			0	2

Table 231 illustrates the proprietary technologies identified by management and non-management staff in the regions of study.

Table 231: Proprietary technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**

Camline	Positive impact of Industry 4.0 on product quality (2)	My QI (2)	3	3
Camstar	TicketManager (10)	TicketManager (9)	32	42
HoloLens	Increased collaboration of workers due to Industry 4.0 technologies (11)	Increased collaboration of workers due to Industry 4.0 technologies (8)	25	14
My QI		Camline, TicketManager (2)	2	4
QRQC			2	1
TicketManager	Machine–human cooperation (15)	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations. (14)	63	66

Technology can be referred to with reference to specific brand names or through the use of generic terms of technology. Table 232 illustrates the identified generic technologies and statements with high co-occurrence to these technologies.

Table 232: Generic technologies identified by staff as Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
3D printing	Expected changes to the form of factories, Positive effect on product development (6)	No expected changes to the form of factories (8)	33	30
5G	Supportive external influencers on the implementation of Industry 4.0 (2)		8	1
Augmented reality	HoloLens, Use of digital communication means (4)	HoloLens (5)	13	10
Autonomous machinery	Machine learning / artificial intelligence, Positive financial impact of Industry 4.0 (7)	TicketManager (9)	33	55
Big Data	Positive impact of Industry 4.0 on product quality (11)	Exposure to changes of work tools (8)	49	37
Machine learning / artificial intelligence	Autonomous machinery, Positive impact of Industry 4.0 on product quality (7)	Autonomous machinery (5)	20	8

Machine–human cooperation	TicketManager (15)	TicketManager (8)	42	32
MES systems		Big Data, Positive impact of Industry 4.0 on product quality (2)	**8**	11
Cloud computing			3	1
Cobots	Positive financial impact of Industry 4.0 (13)	Camstar (6)	48	26
Internet of Things			0	0
Cyber-physical systems			0	0

Theme 2: Factors affecting the implementation of Industry 4.0

Theme 2 consists of codes which highlight all statements made in the regions, that feature specific factors that are perceived to affect the implementation of Industry 4.0 at the facilities. Table 233 illustrates the perceived compatibility of existing machinery at the facility with Industry 4.0 technology and the codes with the highest co-occurrence with such statements.

Table 233: Machine compatibility with Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Old machinery is upgradable to Industry 4.0	Machine–human cooperation (2)		5	6
Old machinery is not upgradable to Industry 4.0	Machine–human cooperation (2)		5	4

Table 234 highlights the link between the availability or lack of labour and the labour cost for the implementation of Industry 4.0. The co-occurrence of such statements with other statements is also highlighted.

Table 234: Labour resources affecting the implementation of Industry 4.0 technology

CODE	Frequent co-occurrence	Grounded

	Management	Non-management	M	N-M
Lack of labour availability	Cobots, Positive financial impact of Industry 4.0 (2)	'The Company' has a responsibility to upskill its workforce (2)	5	6
High labour costs	Positive financial impact of Industry 4.0 (3)	Negative impact of Industry 4.0 on undefined workforce (2)	5	4
Low labour costs			3	0
IT literacy of stakeholder	Resistance to the introduction of Industry 4.0 (2)		2	4

The implementation of Industry 4.0 represents a high capital expense to business. The perception of resource availability and association to this is highlighted below in table 235.

Table 235: Availability of corporate resources to the implementation process of Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Dedicated resources for Industry 4.0	Positive financial impact of Industry 4.0 (12)	Drivers of change towards Industry 4.0 (2)	32	7
Lack of resources to implement Industry 4.0	Big Data, Cobots, Implementation of Industry 4.0 was slow, No change expected of Industry 4.0 technologies at facility (2)		23	10

Theme 3: Future implementation of Industry 4.0

In Tables 236 and 237, the data that highlights the staff's expectations regarding future developments of Industry 4.0 technologies at the facilities is presented. In addition, the co-occurrence of other codes with these statements is illustrated.

Table 236: Expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected increase of Industry 4.0 technologies at facility	'The Company' has a responsibility to upskill its workforce, Autonomous machinery, Negative impact of Industry 4.0 on undefined workforce (2)	Autonomous machinery, Camstar (4)	11	28
Expected decrease of Industry 4.0 technologies at facility			1	0

Table 237: No expected future changes of Industry 4.0 technologies

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No change expected of Industry 4.0 technologies at facility	Cobots, Lack of resources to implement Industry 4.0 (2)		4	6
No reply / No opinion on changes of Industry 4.0 technology at facility			0	3

Theme 4: Industry 4.0 affecting the social context environment

Following Schwab (2021), the quadruple context environment consists of the social, the natural, the economic and the governance or purpose context environment. In Tables 238 to 242, the data relating to the social context environment is presented. Table 238 highlights the interviewees' perceptions of the changing responsibilities of staff at the facilities due to the introduction of Industry 4.0.

Table 238: Industry 4.0 alters the scope of workers' responsibilities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Workers experience an increased scope of responsibilities due to Industry 4.0 technologies		Increased collaboration of workers due to Industry 4.0 technologies (4)	2	23
Workers do not experience an increased scope of responsibilities due to Industry 4.0 technologies			1	10

The perceptions of management and non-management staff of all facilities in regard to changing work tools due to Industry 4.0 are presented in Table 239. The frequency of code co-occurrences is also illustrated.

Table 239: Industry 4.0 is associated with a change in workers' tools

	Frequent co-occurrence		Grounded	
CODE	**Management**	**Non-management**	**M**	**N-M**
Exposure to changes of work tools	Autonomous machinery, Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations., Machine–human cooperation, No Resistance to the introduction of Industry 4.0, Resistance to the introduction of Industry 4.0, Use of digital communication means (2)	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations., TicketManager (11)	9	75

Table 240 sets out the changes in the perceived ability of workers to perform work tasks independently.

Table 240: Industry 4.0 is associated with a change in the independence of their work activities

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**

Increased independent work due to Industry 4.0 technologies		Exposure to changes of work tools (2)	1	11
Decreased independent work due to Industry 4.0 technologies			0	1
No change in the degree of independent work			0	2

The perceived changes in workers' ability for work collaborations in all regions are highlighted in Table 141.

Table 241: Industry 4.0 is associated with a change the degree of worker cooperation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased collaboration of workers due to Industry 4.0 technologies	HoloLens (11)	HoloLens (8)	16	16
Decreased collaboration of workers due to Industry 4.0 technologies			0	2

Worker safety and the perceived change that Industry 4.0 has on this is illustrated in Table 242. The frequent code co-occurrences are also presented.

Table 242: Industry 4.0 impacts workers' safety

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact on work safety	Cobots, Negative impact of Industry 4.0 on less-skilled workforce (2)	Cobots, Positive impact of Industry 4.0 on undefined workforce (3)	7	7
Negative impact on work safety	Cobots (2)		2	1

Theme 5: Industry 4.0 affecting the environmental context environment

The environmental or natural context environment is a further element of the quadruple context environment.

In Table 243, below, the number of statements that are coded as indicating a positive correlation between Industry 4.0 and the natural context environment are highlighted. Frequent co-occurring codes are also displayed.

Table 243: Constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has improved the factory's environmental footprint	Positive financial impact of Industry 4.0 (12)	Positive financial impact of Industry 4.0 (7), Factories cannot have 0 impact on the environment (6)	31	40
Factories can have 0 impact on the environment	Industry 4.0 has improved the factory's environmental footprint (2)		7	3

In Table 244, the number of statements coded as indicating a negative correlation between Industry 4.0 and the natural context environment are shown. Frequent co-occurring codes are also highlighted.

Table 244: Non-constructive correlation between Industry 4.0 and environmental sustainability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has not improved the factory's environmental footprint		Factories cannot have 0 impact on the environment (2)	8	10

Factories cannot have 0 impact on the environment	Industry 4.0 has improved the factory's environmental footprint (5)	Industry 4.0 has improved the factory's environmental footprint (6)	14	14

A small number of statements indicated that no response was given to the question regarding the natural environment in connection with Industry 4.0, or an interviewee indicated no opinion on the topic. This is represented in Table 245.

Table 245: No correlation between Industry 4.0 and environmental sustainability is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
No Response / No opinion on Industry 4.0's impact on the environment			1	7

Theme 6: Industry 4.0 affecting the financial context environment

The financial context environment is a further element of the quadruple context environment. Tables 246 to 252 highlight the data gained through interviews in all regions in relation to staff linking Industry 4.0 with the financial context environment. The table below illustrates the data linking staff statements on their perception of Industry 4.0 and the organisation's financial position.

Table 246: Industry 4.0 has a link to 'The Company's' financial position

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive financial impact of Industry 4.0	Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations. (24)	Negative impact of Industry 4.0 on undefined workforce (8), Industry 4.0 has improved the factory's environmental footprint (7)	96	35
Negative financial impact of Industry 4.0	Positive financial impact of Industry 4.0 (4)	Positive financial impact of Industry 4.0 (2)	8	7

No financial Impact			1	0
No Response / No opinion on Industry 4.0's impact on financial sustainability			2	1

Table 247 presents the findings of statements that highlight Industry 4.0 as a driver of innovation or as a hindrance.

Table 247: Industry 4.0 has a link to innovation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 is a driver of innovation	Positive financial impact of Industry 4.0 (2)		21	0
Industry 4.0 is a hindrance for innovation			1	0
Industry 4.0 is neither a driver nor a hindrance to innovation			2	0

The product is at the core of a manufacturing facility's reason of being. Table 248 highlights the findings of statements that link Industry 4.0 to a change in product development.

Table 248: Industry 4.0 has a link to product development

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive effect on product development	3D printing (6)	3D printing (4)	25	10
Negative effect on product development			2	1
No change to product development			5	11

Continuing from Table 248, Table 249 highlights the perceived relation of the introduction of Industry 4.0 to the quality of the product that the respective facilities produce.

Table 249: Industry 4.0 has a link to product quality

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on product quality	Positive financial impact of Industry 4.0 (17)	Autonomous machinery, Big Data (4)	54	22
Negative impact of Industry 4.0 on product quality		Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations, TicketManager (4)	1	8
No change to product quality		Resistance to the introduction of Industry 4.0 (2)	4	8

Industry 4.0 is regarded as changing the dynamics in supply chains. In Table 250, the perceptions of the introduction of Industry 4.0 and the links to changes in the supply chain are highlighted.

Table 250: Industry 4.0 has a link to the supply chain

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on the supply chain	Willingness to share data within the supplychain (6)		26	3
Negative impact of Industry 4.0 on the supply chain			5	0
Industry 4.0 has no impact on the supply chain	Willingness to share data within the supplychain (3)		1	0

One of many factors which determines the financial performance of an organisation is organisational efficiency. The findings of perceived links between Industry 4.0 and organisational efficiency are illustrated in Table 251.

Table 251: Industry 4.0 influences organisational efficiency

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations.	Positive financial impact of Industry 4.0 (24)	TicketManager (14)	68	58
Industry 4.0 has or will have a negative effect on the efficiency of the organisation's operations	Resistance to the introduction of Industry 4.0 (3)	Negative impact of Industry 4.0 on product quality, TicketManager (4)	7	13

The table below presents the findings on the perceived link between the introduction of Industry 4.0 and operational competitiveness.

Table 252: Industry 4.0 influences operational competitiveness

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Improved competitiveness of facility due to Industry 4.0	Positive financial impact of Industry 4.0 (9)		19	3

Theme 7: Industry 4.0 affecting the purpose context environment

The final dimension of the quadruple context environment is the purpose or governance environment. In Tables 253 to 256, the links between the context environment and the introduction of Industry 4.0 are presented. Below, the responses to the perceived responsibility of the organisation to upskill its workers in light of the implementation of Industry 4.0 are presented.

Table 253: Corporate responsibility to upskill workforce in context of Industry 4.0

CODE	Frequent co-occurrence	Grounded

	Management	Non-management	M	N-M
'The Company' has a responsibility to upskill its workforce	Resistance to the introduction of Industry 4.0 (3)	Communication of Industry 4.0 related changes, Lack of labour availability, Positive impact of Industry 4.0 on less-skilled workforce, Resistance to the introduction of Industry 4.0 (2)	8	22
'The Company' has no responsibility to upskill its workforce			0	2

Table 254 shows the perceived change or lack or change in the societal purpose of the organisation due to the implementation of Industry 4.0.

Table 254: Industry 4.0 impacts the societal purpose of the case organisation

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has changed the purpose of 'The Company'	Experience of organisational change with a link to Industry 4.0 (2)		5	0
Industry 4.0 has not changed the purpose of 'The Company'			3	0
Positive change in the societal role of 'The Company'			2	2
Negative change in the societal role of 'The Company'			2	3
No reply / No opinion on the societal role of 'The Company'			0	0

All statements that relate to the perceived influence that the implementation of Industry 4.0 will have on the case facilities' regions are presented in Table 255 below.

Table 255: Industry 4.0 influences the case organisation's region

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**

Impact of Industry 4.0 on the region			6	3

Table 256 highlights the expected change to the manufacturing sites due to the implementation of Industry 4.0. A particularly strong co-occurrence with additive manufacturing techniques is noted.

Table 256: Change in manufacturing sites due to Industry 4.0 technology

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Expected changes to the form of factories	3D printing (6)	3D printing (5)	17	6
No expected changes to the form of factories	3D printing (5)	3D printing (8)	9	11

<u>Theme 8: The introduction of Industry 4.0 will alter the role of the stakeholder whilst benefitting some stakeholders</u>

The introduction of Industry 4.0 will affect the stakeholders of the organisation. The data on the altering of stakeholder roles due to the introduction of Industry 4.0 is presented in the following tables, with a particular focus on those stakeholders whose roles are positively altered by the introduction of Industry 4.0. In Table 257, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 257: The workforce is positively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on skilled workforce	Negative impact of Industry 4.0 on less-skilled workforce (6)	Negative impact of Industry 4.0 on less-skilled workforce (10)	32	20
Positive impact of Industry 4.0 on less-skilled workforce	Industry 4.0 has or will have a positive effect on the efficiency of the	'The Company' has a responsibility to upskill its workforce, Workers experience an increased scope of	12	10

	organisation's operations. (3)	responsibilities due to Industry 4.0 technologies (2)		

In Table 258, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based on age group.

Table 258: The workforce is positively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on old-aged employees			0	1
Positive impact of Industry 4.0 on young-aged employees			1	5

In Table 259, the staff groups that are positively affected by the introduction of Industry 4.0 are presented based perceived adaptability.

Table 259: The workforce is positively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on persons who are willing to accept change		Negative impact of Industry 4.0 on persons who are not willing to accept change (2)	1	2

Statements with no clear stakeholder identification but highlighting a positive impact on stakeholder are presented in Table 260.

Table 260: Various Stakeholder are affected positively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive impact of Industry 4.0 on undefined workforce		Exposure to changes of work tools (4)	5	14

Positive impact of Industry 4.0 on other stakeholders	Positive financial impact of Industry 4.0 (5)		17	3
No negative impact on stakeholders			2	3
No reply / No opinion on the impact of Industry 4.0 on stakeholders			0	2

Theme 9: The introduction of Industry 4.0 will alter the role of the stakeholder whilst adversely affects some stakeholders

As previously stated, the introduction of Industry 4.0 will affect the stakeholders of the organisation. This can be positive for some stakeholders but could be negative for others. Having presented the perceived internal stakeholders that will benefit from the introduction of Industry 4.0, those that are perceived to be less well-off will now be presented. The data that presents the statements of perceptions of stakeholder roles that will be negatively affected by the introduction of Industry 4.0 is presented in the following tables.

In Table 261, the staff groups that are negatively affected by the introduction of Industry 4.0 are presented based on skill level.

Table 261: The workforce is negatively affected by Industry 4.0 based on skill

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on skilled workforce	Positive impact of Industry 4.0 on skilled workforce (2)		6	2
Negative impact of Industry 4.0 on less-skilled workforce	Positive impact of Industry 4.0 on skilled workforce (9)	Positive impact of Industry 4.0 on skilled workforce (10), Resistance to the introduction of Industry 4.0 (6)	41	36

Table 262 presents, based on age, the staff groups that are negatively affected by the introduction of Industry 4.0.

Table 262: The workforce is negatively affected by Industry 4.0 based on age

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on old-aged employees	Negative impact of Industry 4.0 on less-skilled workforce, Resistance to the introduction of Industry 4.0 (2)		3	6
Negative impact of Industry 4.0 on young-aged employees			0	0

In Table 263, the staff groups that are negatively impacted by the introduction of Industry 4.0 are presented based on perceived adaptability.

Table 263: The workforce is negatively affected by Industry 4.0 based on adaptability

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on persons who are not willing to accept change			0	2

Not all statements in the interviews make direct reference to stakeholder groups but instead highlight negative implications on stakeholders. These are presented in Table 264.

Table 264: Various Stakeholder are affected negatively by the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Negative impact of Industry 4.0 on undefined workforce	Positive financial impact of Industry 4.0 (16)	Positive financial impact of Industry 4.0 (8)	29	30

Negative impact of Industry 4.0 on other stakeholders	Positive impact of Industry 4.0 on other stakeholders (2)		3	0

Theme 10: The perceived pace of implementation of Industry 4.0 is not uniform

Tables 265 to 267 present the codes and respective frequency of statements and co-occurrence of statements relating to the perceived pace of the implementation of Industry 4.0 technology at the respective facilities of this study. Table 265 shows the data for the perception of a fast implementation.

Table 265: Fast paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was fast			8	10

In Table 266, statements that are contrary to the assertions of Table 265 are shown.

Table 266: Slow paced implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Implementation of Industry 4.0 was slow	Resistance to the introduction of Industry 4.0, Lack of resources to implement Industry 4.0, Communication of Industry 4.0 related changes (2)		14	11

Some statements may not conform to the requirements of Tables 265 or 266 Statements that indicate no knowledge of the pace of implementation or statements that indicate an interviewee declines to comment on this are presented in Table 267.

Table 267: The rate of implementation of Industry 4.0 is not identifiable

CODE	Frequent co-occurrence	Grounded

	Management	Non-management	M	N-M
No reply / No opinion on the rate of change			2	3

Theme 11: Employee experience of implementation of Industry 4.0

In the following section, employee experience of the implementation of Industry 4.0 is presented. This relates to the association of the implementation of Industry 4.0 in the respective region and outside organisations, the link of organisational change and the introduction of Industry 4.0 and possible resistance to the implementation of Industry 4.0.

Table 268 presents statements which identify outside organisations.

Table 268: Entities associated with the implementation of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Drivers of change towards Industry 4.0	Positive financial impact of Industry 4.0 (5)	Positive financial impact of Industry 4.0 (3)	36	27
Supportive external influencers on the implementation of Industry 4.0	Non-supportive external influencers on the implementation of Industry 4.0, TicketManager (3)	Non-supportive external influencers on the implementation of Industry 4.0 (3)	30	26
Non-supportive external influencers on the implementation of Industry 4.0	Supportive external influencers on the implementation of Industry 4.0 (3)	Supportive external influencers on the implementation of Industry 4.0 (3)	14	10
No reply / No opinion on external influencers of the implementation of Industry 4.0			0	9

Statements on the perceived change within the case organisation and the case facilities are presented in Table 269. A differentiation is made between statements that link such changes with the implementation of Industry 4.0, and those that do not.

Table 269: Change in the organisation is identifiable

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Experience of organisational change with a link to Industry 4.0	Communication of Industry 4.0 related changes, Dedicated resources for Industry 4.0, Expected changes to the form of factories, Industry 4.0 has changed the purpose of 'The Company', TicketManager (2)	Communication of Industry 4.0 related changes (5)	23	25
Experience of organisational change with no link to Industry 4.0			19	15

Table 270 is of note in this study. It presents the number of statements and the co-occurrence of statements in the case facilities that indicate that a resistance to the introduction of Industry 4.0 is perceived or not perceived.

Table 270: Resistance to the change towards Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Resistance to the introduction of Industry 4.0	Communication of Industry 4.0 related changes (10)	Communication of Industry 4.0 related changes (21)	38	45
No resistance to the introduction of Industry 4.0	Exposure to changes of work tools (2)		11	3

No reply / No opinion on possible resistance to change			0	1

Theme 12: Industry 4.0 is introduced through the use of change communication

This section presents the data that is linked to the implementation of Industry 4.0 and the communication perceived to facilitate this process. In Table 271, the prevalence of statements relating to the use of communication channels in the communication of the implementation of Industry 4.0 are presented.

Table 271: A variety of communication channels are utilized to communicate the changes associated with the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Channels utilised to communicate changes	Communication of Industry 4.0 related changes (71)	Communication of Industry 4.0 related changes (77), Resistance to the introduction of Industry 4.0 (13)	74	74

Table 272 presents the statements and co-occurrence of statements relating to the communication of change.

Table 272: Messaging towards staff during the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Communication of Industry 4.0 related changes	Channels utilised to communicate changes (71)	Channels utilised to communicate changes (77), Resistance to the introduction of Industry 4.0 (21)	91	88

Several statements are identified that highlight perceived communication shortcomings of the introduction of Industry 4.0. Such statements are grouped in Table 273 and presented with the respective co-occurrence of statements.

Table 273: Identified shortcomings of communicating the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Perceived change communication shortcomings		Communication of Industry 4.0 related changes (10)	0	20

Theme 13: Changes in internal communication are experienced by staff

Communication is used to facilitate the implementation of Industry 4.0, but this research shows that the perception of the introduction of Industry 4.0 is also linked to the change in communication due to the introduction of the novel technology at the case facilities.

Table 274 highlights the perception in change of face-to-face conversation, the increased use of communication means and other changes in internal communications due to increased digitalisation of the workplace.

Table 274: Human communication is shaped by the introduction of Industry 4.0

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Face-to-face communication	Use of digital communication means (8)	Use of digital communication means (8)	21	22
Use of digital communication means	Change in communication as a result of digitalisation (11)	Change in communication as a result of digitalisation (10)	43	48
Change in communication as a result of digitalisation	Use of digital communication means (11)	Use of digital communication means (10)	40	31

A further change to be addressed in the presentation of data is the changing availability of co-workers and superiors and the change in access to these persons due to Industry 4.0. This is presented in Table 275.

Table 275: Digital communication has affected the accessibility of co-workers in the work environment

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased accessibility of co-workers due to digital communication		Use of digital communication means (6)	4	16
Decreased accessibility of co-workers due to digital communication		Change in communication as a result of digitalisation(3)	1	5

The perceived change in the formality of communication at the respective case facilities is presented below in Table 276.

Table 276: Digital communication has affected the formality of communication at the workplace

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased formality in communication due to digitalisation			1	0
Decreased formality in communication due to digitalisation	Positive experience with home office (3)	Increased accessibility of co-workers due to digital communication (2)	11	2
No change in formality of communication due to digitalisation			3	3

Table 277 presents the number of statements and the co-occurrence of statements that relate to the change in internal communication due to digital communication at the case facility.

Table 277: Digital communication has changed internal communication

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Industry 4.0 has a positive effect on communication		Use of digital communication means (3)	1	6
Industry 4.0 has a negative effect on communication		Change in communication as a result of digitalisation, Use of digital communication means (2)	1	5

Data transparency is a critical element of Industry 4.0. Below, Table 278 presents the codes and co-occurrences of changes in the transparency of data within the organisation and its supply chain due to the introduction of Industry 4.0.

Table 278: Digital communication has influenced the transparency of data

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Increased transparency of data due to digital communication	Big Data (11)	Big Data, Industry 4.0 has or will have a positive effect on the efficiency of the organisation's operations. (7)	24	19
Decreased transparency of data due to digital communication			1	1
Willingness to share data within the supply chain	Positive impact of Industry 4.0 on the supply chain (6)		18	0

Theme 14: Employees are perceiving a change towards the virtual workplace

The interviews were conducted in 2020 and 2021, during a time when travel and physical presence at the workplace was difficult for some. Many interviewees have worked from home, but not all. Below, in Table 279, the data on positive and negative experiences of interviewees at all facilities in regard to the home office is presented.

Table 279: Experience with home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive experience with home office	Outlook on the future of home office, Interviewee has been in home office (4)	Use of digital communication means (4)	27	12
Negative experience with home office	Positive experience with home office (3)		8	2

Industry 4.0 is expected to change the manner in which work is performed. In Table 280, the frequent co-occurrence of codes that highlight the possibility or the impossibility of home office work for factory staff is presented along with the relevant codes.

Table 280: Expectation towards the future implementation of home-office

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Positive outlook on the possibility of home office for production staff		Outlook on the future of home office (3)	12	22
Negative outlook on the possibility of home office for production staff	Outlook on the future of home office (3)		16	9
Outlook on the future of home office	Face-to-face communication (5)	Positive outlook on the possibility of home office for production staff (3)	34	22

Table 281 highlights the statements that indicate whether an interviewee has been in the home office or not.

Table 281: Employee experience of home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee has been in home office	Positive experience with home office (4)		11	8
Interviewee has not been in home office			3	18

Last, Table 282 illustrates the interviewees desire to perform their work tasks from a home office setting or if the interviewees of the regions prefer an office in a traditional setting.

Table 282: Employee attitude towards home-office work

CODE	Frequent co-occurrence		Grounded	
	Management	**Non-management**	**M**	**N-M**
Interviewee wants to work from home		Outlook on the future of home office, Positive experience with home office (2)	1	11
Interviewee does not want to work from home			0	7

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