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The Impact of the Fourth Industrial Revolution on Operations Management: Evidence from a Namibian Telecommunications Company

Hilda Kundai Chikwanda
Department of Engineering and Technology Management
University of Pretoria, Pretoria
South Africa
Hilda.chikwanda@up.ac.za

Johanna Shipena
Department of Engineering and Technology Management
University of Pretoria, Pretoria
South Africa
joanashipena@gmail.com

Abstract

The Fourth Industrial Revolution (4IR) is characterised by the convergence of physical and digital systems, driven by advanced, disruptive technologies such as automation, artificial intelligence, and data analytics. This transformation is reshaping operations management across industries, including the telecommunications sector. This study investigates the influence of 4IR on operations management within a Namibian telecommunications company, with a particular focus on operational benefits, challenges, and the evolving skill requirements. A qualitative, exploratory research design was employed, utilising semi-structured interviews, questionnaires, organisational reports, and publicly available documents as primary and secondary data sources. Data were analysed through content analysis. The findings indicate that digital transformation enables enhanced customer service, reduced time-to-market, improved data accessibility, process automation, and increased competitiveness. However, the study also identifies significant barriers to implementation, including budgetary constraints, inadequate infrastructure, technical incompatibilities, cybersecurity risks, change management challenges, and skills shortages. Despite substantial initial investment requirements, the results suggest that the long-term adoption of 4IR technologies can drive operational efficiency and cost reduction. The study contributes to the existing body of knowledge by providing empirical insights into the operational implications of 4IR within the telecommunications sector in an emerging market context.

Keywords

Fourth Industrial Revolution, Digital Transformation, Operations Management, Telecommunications, Emerging Technologies.

1. Introduction

In an era of escalating market pressures and rapid technological advancement, organizations across the globe are increasingly compelled to adopt digital transformation initiatives to remain competitive. The telecommunications sector, in particular, is undergoing a profound transformation driven by emerging technologies, evolving customer expectations, and intensified competition. In Namibia, telecommunications firms face similar pressures, requiring continuous improvements in operational strategies and the adoption of advanced technologies to meet dynamic

customer demands. The complexity of this environment necessitates the restructuring of internal processes to enhance agility, responsiveness, and operational efficiency.

Recent advancements in Information and Communications Technology (ICT) have accelerated the global integration of digital technologies across industries. These developments have enabled unprecedented connectivity between machines, people, and systems, facilitating seamless information exchange and enabling machine-to-machine communication through cyber-physical systems. The integration of such technologies into operational contexts has given rise to what is widely known as the Fourth Industrial Revolution (4IR) or Industry 4.0. This paradigm encompasses a suite of advanced technologies, including the Internet of Things (IoT), Cyber-Physical Systems (CPS), the Internet of Services (IoS), big data analytics, cloud computing, additive manufacturing, autonomous robotics, and augmented reality, all of which enable the automation, digitization, and optimization of core business processes (Qin et al., 2016; Tay et al., 2018).

The adoption of 4IR technologies is fundamentally reshaping production and operational processes across economic sectors, with evidence linking these technologies to significant improvements in organizational performance and competitiveness (Lehmacher, 2017; Mohamed, 2018). While considerable research has explored the components, benefits, and barriers to Industry 4.0 implementation, there remains a gap in understanding the specific implications of 4IR for operations management at the firm level, particularly within the telecommunications sector in emerging markets. Critical questions persist regarding how 4IR adoption affects operational efficiency, what practical benefits and challenges organizations encounter, and what skills are essential for successful technology integration.

This study seeks to address these knowledge gaps by investigating the operational impact of the Fourth Industrial Revolution on a telecommunications company in Namibia. The study aims to contribute to a deeper understanding of the strategic, operational, and human capital considerations associated with 4IR adoption in the sector.
Research Objectives

1.1 Objectives

The specific objectives of this study are to:

- Assess the extent of 4IR technology adoption within the company.
- Investigate the impact of 4IR on operations management.
- Identify the benefits and challenges associated with 4IR adoption.
- Evaluate the effect of 4IR on operational costs.
- Determine the skills required for operations management in the 4IR era.
- Identify relevant 4IR technologies applicable to the telecommunications sector.

By addressing these objectives, the study provides empirical insights into how digital transformation is reshaping operations management in the telecommunications sector, with particular emphasis on the Namibian context.

2. Literature Review

2.1 Defining the Fourth Industrial Revolution and Its Relevance to Telecommunications

The Fourth Industrial Revolution (4IR), also referred to as Industry 4.0, has become a focal point of academic and industrial discourse due to its transformative implications across sectors. It is widely recognized for ushering in a new era of automation, digitalization, and intelligent data utilization across interconnected systems. While the core concept centers around the integration of advanced digital technologies into industrial operations, its definition varies across scholarly literature.

Tay et al. (2018) define 4IR as the integration of physical and digital systems to modernize manufacturing processes, enhance precision, manage operational risks, and enable real-time data sharing. Lu (2017) characterizes it as an integrated, optimized, service-oriented, and interoperable manufacturing framework that leverages a broad array of advanced technologies. Kagermann (2013), in one of the seminal contributions to the field, defines Industry 4.0 as the deployment of communication technologies and digital innovations to accelerate industrial growth and productivity.
Building on these definitions, the 4IR can be conceptualized as a technological paradigm shift characterized by increasing digitization and automation of industrial systems. It involves the creation of digital value chains that foster seamless interaction among products, environments, and organizational stakeholders. Key enabling technologies include Cyber-Physical Systems (CPS), the Internet of Things (IoT), cloud computing, artificial intelligence (AI),

robotics, and big data analytics. These are typically implemented through vertical integration (within the organization), horizontal integration (across the value chain), and end-to-end integration (across the product lifecycle).

For the purposes of this study, the 4IR is defined as "the convergence of breakthrough technologies such as robotics, artificial intelligence, the Internet of Things, virtual and augmented reality, and additive manufacturing; technologies that are transforming production processes and business models across industries" (Lehmacher, 2017). This definition aligns with the study's objective, which is to explore the implications of 4IR for operations management within Namibian telecommunications companies. While numerous studies have addressed the adoption and impact of 4IR in manufacturing and logistics, limited attention has been paid to its specific effects on operational processes, cost structures, and required workforce capabilities in the telecommunications sector, particularly within the context of developing economies such as Namibia

2.2 The emergence of Industry 4.0

Technological progress in manufacturing and information systems has driven a series of industrial revolutions, each reshaping production methods and operational efficiency (Pereira & Romero, 2017). The First Industrial Revolution (mid-18th century) introduced mechanization through steam and water power, transforming agriculture and manufacturing (Tay et al., 2018a). The Second Industrial Revolution (late 19th century) was marked by the adoption of electricity, mass production, and the use of new materials such as steel and synthetics (Fettermann et al., 2018; Bodrow, 2017). The Third Industrial Revolution (late 20th century) saw the rise of computers and information and communication technologies (ICT), enabling automation through integrated circuits and programmable logic controllers (Ślusarczyk, 2018). The Fourth Industrial Revolution (4IR), first introduced in Germany in 2011, builds on these advances by integrating digital and physical systems through technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, robotics, and cyber-physical systems (Mohamed, 2018; Qin et al., 2016). Unlike previous revolutions, 4IR is occurring globally and simultaneously, characterized by real-time connectivity, intelligent decision-making, and adaptive automation across value chains (Fettermann et al., 2018; Ślusarczyk, 2018).

2.3 Core Digital Technologies Driving the 4IR

Digital technologies are fundamental enablers of organizational transformation, offering tools to streamline business processes, enhance customer engagement, and empower employees (Westerman et al., 2014). When integrated with enterprise data, these technologies can unlock substantial value by enriching products, services, and customer relationships (Sebastian et al., 2020). Martyn et al. (2021) identify nine core technologies that underpin the 4IR. These technologies are increasingly integrated across industrial operations, contributing to enhanced agility, efficiency, and innovation. A brief summary of each is outlined below:

1. Big Data: Refers to the use of advanced data analytics technologies to extract insights from large volumes of structured and unstructured data. Big data enables real-time analysis for forecasting, automation, and both proactive and corrective maintenance (Tay et al., 2018; Fatorachian & Kazemi, 2018; Almada-Lobo, 2015).
2. Cloud Computing: As digital operations expand; cloud storage and processing are becoming essential for scalable and flexible data management. Cloud-based applications support increased computational power, remote access, and real-time collaboration (Oztemel & Gursev, 2020).
3. Cyber-Physical Systems (CPS): CPS are integrations of physical processes with embedded computing and networking capabilities. They enable real-time monitoring and control of assets across physical and digital domains, enhancing system interconnectivity (Almada-Lobo, 2015; Nagy et al., 2018).
4. Internet of Things (IoT): IoT connects intelligent devices via the internet, allowing continuous feedback and communication between machines. This connectivity supports more responsive and efficient service delivery and operational processes (Fatorachian and Kazemi, 2018).
5. Artificial Intelligence (AI) and Simulation: AI is a key general-purpose technology underpinning the Fourth Industrial Revolution (4IR). AI refers to systems and machines capable of replicating human cognitive functions, enabling autonomous decision-making and continuous data analysis (Olsen and Tomlin, 2020). Alongside AI, simulation plays a critical role in operational environments by enabling the virtual modelling of systems and processes to evaluate performance and predict outcomes (Tay et al., 2018b). Simulation facilitates the analysis of process flows, machine configurations, and system designs, allowing organisations to test and optimise operational changes in a controlled virtual environment before implementation in the physical world (Saucedo-Martínez et al., 2018; Tay et al., 2018b)
6. Additive Manufacturing (3D Printing): This technology allows the creation of customized products through

layer-by-layer material deposition. It facilitates co-design with customers, reduces waste, and enables flexible, small-batch production (Dalenogare et al., 2018).

7. Autonomous Robotics: These robots operate independently using AI and sensor technologies. They perform tasks with high precision, within defined time constraints, and are capable of functioning in hazardous or restricted environments (Vaidya et al., 2018).
8. Augmented Reality (AR) is a technology that enhances the physical environment by overlaying computer-generated images, data, or instructions onto live views of real-world objects (Tay et al., 2018). This technology transforms traditional, manual methods of interpreting drawings and instructions by enabling direct interaction between humans and digital information through integrated systems (Filipov and Vasilev, 2016). In operational and maintenance contexts, AR provides significant advantages by supporting predictive maintenance. By delivering real-time, precise information, AR reduces the time required for maintenance tasks, minimises human error, and helps prevent unplanned reactive maintenance (Tay et al., 2018a).
9. Internet of Services (IoS): The Internet of Services (IoS) is a key Fourth Industrial Revolution (4IR) technology that enables service delivery over the internet (Hermann et al., 2016). IoS facilitates seamless data sharing, enhancing digital mobility and accessibility across business models and organisational structures (Tay et al., 2018). By providing both a technical and business foundation for networked service ecosystems, IoS fosters stronger connections between customers, service providers, and suppliers, fundamentally transforming service provision and value chain integration (Pereira & Romero, 2017).

These technologies, while powerful individually, deliver the greatest value when integrated within a unified digital ecosystem. Their combined application forms the technological foundation of the 4IR, reshaping industries through automation, data-driven insight, and system intelligence.

2.4 Components of the Fourth Industrial Revolution

The 4IR is defined by the integration of digital technologies across three key dimensions: horizontal integration, vertical integration, and end-to-end engineering integration (Pereira & Romero, 2017; Tay et al., 2018a). These components enable the seamless digitalization of value creation processes across and within organizations

- Horizontal integration facilitates the exchange of data and services across firms, business partners, and geographically dispersed sites by integrating information and communication technologies. It supports the development of global value networks and collaborative ecosystems (Tay et al., 2018a; Gilchrist, 2016).
- Vertical integration involves linking information and automation technologies across different hierarchical levels of an organization. This enables smart, real-time control of production systems, efficient handling of disruptions, and improved responsiveness through the use of cyber-physical systems and big data (Dalenogare et al., 2018; Gilchrist, 2016).

- End-to-end integration connects all stages of the product lifecycle—from initial customer requirements to design, production, and after-sales services—into a cohesive, data-driven process. This approach promotes customization, efficiency, and the reuse of product information throughout the value chain (Bodrow, 2017; Tay et al., 2018a).

Together, these integration dimensions aim to minimize operational costs, increase flexibility, and enable intelligent manufacturing through the digital convergence of systems and processes.

2.5 Design Principles of Industry 4.0

Industry 4.0 is built on six core design principles that guide the development of smart, connected manufacturing systems: interoperability, virtualization, decentralization, real-time capability, service orientation, and modularity (Hermann et al., 2016; Lom et al., 2016).

- Interoperability enables seamless communication between machines, systems, and humans via standardized protocols, forming the foundation of connected operations.
- Virtualization allows for the creation of digital twins through Cyber-Physical Systems (CPS), facilitating real-time monitoring and simulation of physical processes.
- Decentralization empowers CPS to make autonomous decisions, supporting flexible, responsive production with reduced reliance on centralized control.
- Real-time capability ensures systems can instantly process data and react to changes, enhancing productivity and enabling dynamic decision-making.
- Service orientation leverages the Internet of Services to offer customizable, user-centric services both

within and across organizational boundaries.
- Modularity provides adaptability by enabling systems to be reconfigured in response to demand shifts or evolving requirements.

These principles collectively enhance agility, efficiency, and responsiveness in modern industrial environments.

2.6 Impacts of the Fourth Industrial Revolution

The 4IR is revolutionizing manufacturing and operations through digitalization, real-time data use, and automation. Its impacts span six areas:

- Industry: Decentralized, autonomous production enhances efficiency and shifts from mass production to mass customization (Pereira and Romero, 2017).
- Products and Services: Smart technologies improve quality, reduce costs, and accelerate innovation (Fetterman et al., 2018).
- Business Models: New technologies enable service-oriented, flexible, and competitive models (Müller et al., 2018).
- Economy: 4IR boosts supply chain agility, reduces costs, and promotes global growth (Hofmann and Rüsch, 2017).
- Workforce: Automation reshapes jobs and work environments, requiring new roles and approaches to employment (Maisiri et al., 2019).
- Skills: Success in 4IR depends on both technical and soft skills, data analytics, problem-solving, adaptability, and digital literacy (Pereira and Romero, 2017).

2.7 Challenges to Technological Advancement

While technological innovation is critical to organizational growth and competitiveness, the implementation of 4IR technologies introduces significant challenges. As noted by Lehmacher et al. (2017), the growing interconnectivity and rapid evolution of digital technologies have the potential to transform products, manufacturing architectures, and operational processes, creating complex demands across the entire value chain (Fettermann et al., 2018).

The decision to adopt 4IR technologies remains a strategic one, often constrained by high capital investment and associated risks. Despite the availability of enabling technologies, such as networking infrastructure, IoT devices, communication protocols, and data analytics tools, their deployment requires significant automation, raising concerns about workforce displacement and job security (Marcon et al., 2017).

Brunetti, F., Matt, D.T., Bonfanti, A., De Longhi, A., Pedrini, G. and Orzes, G., (2020) identify three core technical barriers to digital transformation:

1. Managing and exchanging large volumes of data,
2. The need for advanced and compatible IoT technologies, and
3. The implementation and maintenance complexity of cloud-based systems.

Mohamed (2018) emphasizes that 4IR adoption is hindered not only by technical and economic issues but also by scientific, social, and political constraints. The infrastructure needed to support real-time data access and high-volume data traffic is often lacking, and the substantial upfront capital costs deter many organizations from investing (Fettermann et al., 2018).

A critical technical challenge is system compatibility,specifically, integrating new digital solutions with existing legacy systems and transforming them into foundations for new business models (Ślusarczyk et al., 2019). This requires significant reengineering and investment in scalable, flexible architectures. Further complications arise from organizational challenges, such as the absence of a clear strategic vision, weak digital leadership, and uncertainty around the return on investment in digital technologies (Dohale and Kumar, 2018). Infrastructure standardization, data security, and workforce training are ongoing concerns that require coordinated solutions.

Security vulnerabilities also pose a major risk. As noted by Fatorachian and Kazemi (2018), increased connectivity exposes systems to cyber threats, necessitating robust cybersecurity frameworks, including network protection and hardware-level encryption.

Finally, regulatory and governance issues remain a barrier. Existing communication and technology regulations often lag behind technological advancement, and unified legal frameworks for 4IR technologies have yet to be developed.

2.8 The Fourth Industrial Revolution and operations management

Operations Management (OM) plays a central role in modern organizations, focusing on the design, execution, and optimization of processes for delivering products and services (Fettermann et al., 2018). In the telecommunications sector, OM encompasses the management of network operations and service delivery to ensure optimal performance and minimal disruptions. Key activities include fault detection, billing and revenue assurance, service provisioning, network planning, fraud management, and maintenance.

With the integration of 4IR technologies, operations management is undergoing a fundamental transformation. Real-time interconnectivity between digital and physical systems, enabled by technologies such as IoT, cyber-physical systems, and big data analytics, is reshaping how operational processes are designed and managed (Olsen et al., 2020). These changes challenge traditional priorities such as quality, speed, flexibility, and cost, necessitating a redefinition of operational strategies.

Industry 4.0 enhances process efficiency through the use of simulation models and digital twins, enabling end-to-end supply chain optimization. Vertical and horizontal integration across systems and partners allows for reduced lead times, faster time-to-market, and agile response to fluctuating customer demands (Müller et al., 2018). The ability to gather and analyze data throughout the product lifecycle also supports continuous product improvement and service personalization (Lu, 2017).

Emerging research confirms that Industry 4.0 technologies contribute positively to operational performance, encouraging greater adoption across industries (Saucedo-Martínez et al., 2018; Schlechtendahl et al., 2015). These technologies provide managers with increased control, visibility, and adaptability in managing operations (Lachance, 2019). Moreover, integrated systems reduce waste, improve productivity, and support real-time decision-making through enhanced data accessibility (Lehmacher, 2017).

Thus, the 4IR presents significant opportunities to optimise operations management by enabling more connected, intelligent, and responsive organisational systems.

2.9Telecommunications in the Fourth Industrial Revolution

The telecommunications industry is a foundational enabler of the Fourth Industrial Revolution (4IR), primarily through its provision of high-speed broadband connectivity that underpins digital innovation. Telecommunications infrastructure, including internet technologies, mobile networks, and broadband services, facilitates the seamless integration, communication, and coordination among systems, people, and machines (Manda and Ben Dhaou, 2019). A robust and reliable telecommunications network is essential for the effective implementation of 4IR technologies. It supports real-time data exchange, interconnectivity, and remote operation, all of which are critical for enabling smart systems and intelligent automation across industries (Manda and Ben Dhaou, 2019).

As the primary driver of digital connectivity, the telecommunications sector plays a strategic role in linking the broader 4IR ecosystem comprising individuals, enterprises, and machines, at the necessary speed and scale. However, despite its central role, the sector has struggled to capture a proportional share of the economic value generated by digital transformation and emerging business models built around connectivity and data services.

According to Javaid (2022), digital transformation within the telecommunications industry involves the adoption of advanced digital technologies by service providers to enhance operational efficiency and expand service offerings.

Key benefits include improved customer experience, real-time data analytics, agile network management, and the automation of routine processes.

3. Methods

This study employed a qualitative exploratory case study approach to investigate the impact of the 4IR on operations management in a Namibian telecommunications company. This approach was chosen to gain in-depth, contextual insights into a real-world organisational setting.

Purposive sampling was used to select a telecommunications company that met the following criteria: more than 15 years of operation in Namibia and over 250 employees. Participants were purposely selected to provide relevant knowledge on 4IR and its influence on operations management.

Data were collected through semi-structured interviews, questionnaires, participant observation, and document analysis. Interviews were conducted both face-to-face and virtually. Participation was voluntary, with all ethical considerations addressed.

The collected data were analysed using qualitative content analysis, allowing for systematic organisation, interpretation, and extraction of meaning from the textual data.

4. Results and Discussion

4.1 4IR Adoption in a Namibian Telecommunications Company

The findings revealed that the organisation is still at the early stage of digital transformation. The organisation has incorporated a few of the transformation strategies of the Fourth Industrial Revolution into the company's Integrated Service Business Plan. The company made investments in several areas, such as security and customer experience. The company implemented partial automation in the collection of data, and the skills are available in some areas to pursue the 4IR. This means that the company had not implemented its digital transformation strategy fully and had not integrated it into the organisational strategy. Furthermore, the company had not invested much in the equipment that supports the Fourth Industrial Revolution. In terms of skills, the organisation did not have adequate skills required for the 4IR, and therefore, they should produce development programmes to upskill the employees. The findings obtained aligned with the assessment criteria of the VDMA assessment tool.

The results show that the majority of respondents (50%) reported having limited knowledge of the 4IR, while 31% indicated a high level of awareness. Notably, 19% of respondents reported no awareness of 4IR. These results highlight a general knowledge gap regarding 4IR, underscoring the need to promote awareness, particularly in the context of operations management (Figure 1).

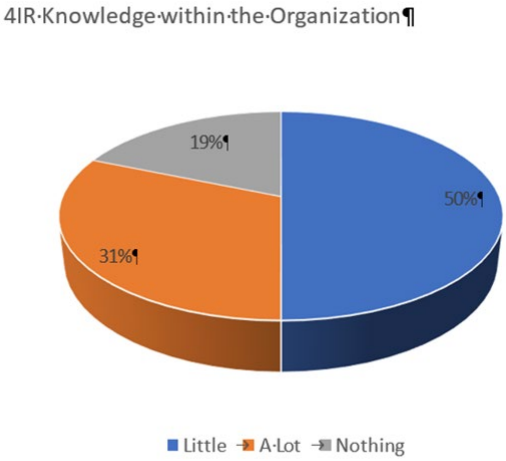

Figure 1. Status of the fourth Industrial Revolution awareness within the organization

Beyond creating new opportunities, digital transformation is reshaping organizational competitiveness by exposing future operational challenges. To assess the state of 4IR readiness in Namibia, this study employed the VDMA Industry 4.0 Readiness Assessment Tool, selected from existing, validated frameworks for evaluating organizational preparedness for 4IR implementation.

4.2 Awareness and Status of the Digital Transformation Strategy

The findings reveal a limited awareness among respondents regarding the status of the organization's digital transformation strategy. Over half (56.3%) of the participants indicated that the organization does not have a digital transformation strategy in place. A small proportion (12.5%) reported that pilot initiatives had been launched, while another 12.5% stated that the strategy had been formulated. Additionally, 12.5% indicated that the strategy is still under development. Only 6.3% confirmed that the strategy has been formally adopted (Figure 2)

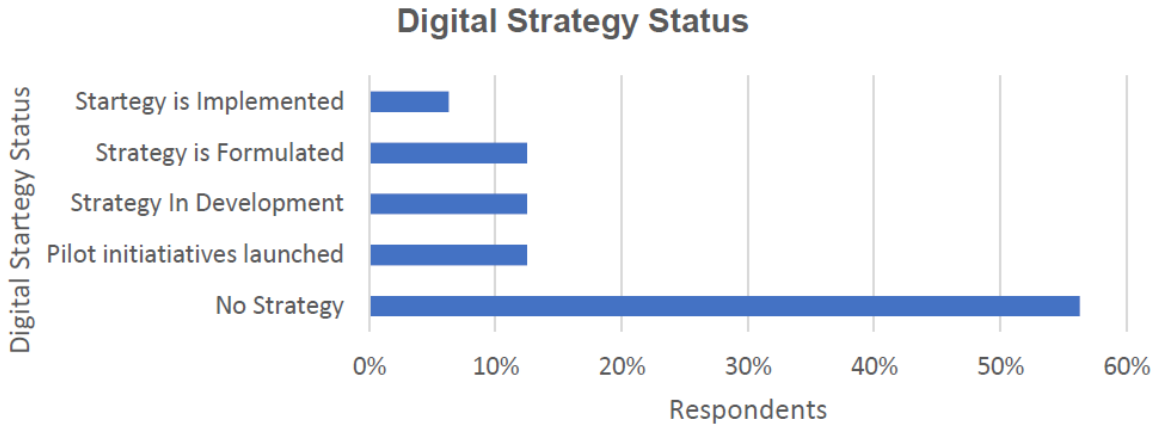

Figure 2. Digital Strategy Status

Qualitative responses from interview participants corroborate this uncertainty. For instance, P-1 noted, *"We are still in the early phases. The strategy is in development, but we have a vision to become a digital organization and leader."* Similarly, P-2 stated, *"The organization has started the journey. We are in the early stages with various plans and strategies in place."* P-5 emphasized the iterative nature of digital transformation, stating, *"Digital transformation is not a once-off process. Strategies must be revisited and refined continuously."* Meanwhile, P-6 highlighted that *"Several digital transformation initiatives have been integrated into the company's Integrated Service Business Plan."*

Readiness for Smart Operations: - The organization's readiness for 4IR adoption in smart operations was assessed using the VDMA Industry 4.0 Readiness criteria, which include cloud usage, IT security, information sharing, and autonomous processes (Maisiri and van Dyk, 2021).

Information Sharing and Autonomous Processes: - Most respondents reported that the organization has systems capable of communicating with each other to exchange and collect information, supporting effective information flow. Furthermore, the majority indicated that certain organizational processes can automatically respond in real-time to changes in operational conditions. These responses suggest that initiatives to develop autonomous, responsive processes are underway as part of the organization's broader digital transformation efforts.

Cloud Usage: - Respondents confirmed that the organization currently utilizes cloud technologies for data storage. However, cloud-based data analysis has not yet been implemented, although there are plans to incorporate this capability in the future.
IT Security: - There was mixed feedback regarding the status of IT security. Approximately 44.4% of respondents indicated that IT security systems are already implemented, while another 44.4% stated that implementation is still in progress. A further 11.1% reported that IT security solutions remain in the planning phase. This lack of clarity may

be attributed to the centralized structure of the organization's IT department, which is based at its headquarters and may not effectively communicate security developments across all business units.

Readiness for Smart Infrastructure: - The organization's readiness for 4IR adoption in smart infrastructure was assessed using the VDMA Industry 4.0 Readiness criteria, which include digital modelling, equipment functionality, and equipment adaptability.

The extent to which business processes are digitally modelled and controlled through ICT systems remains unclear. Respondents provided mixed feedback: some indicated that processes are digitally modelled and ICT-controlled to a considerable extent, while others reported only limited digital modelling and control. These responses suggest that while certain processes are digitally managed through ICT systems, many are not yet fully digitized or integrated.

In terms of equipment functionality, respondents confirmed that most systems within the organization can be controlled through ICT to some extent. However, some machines still lack the ability to communicate directly with other machines (machine-to-machine communication). Despite these limitations, respondents noted that system integration and collaboration with other machines are possible for the majority of equipment.

Readiness for Data-Driven Services: - The organization's readiness for adopting data-driven services within the context of the 4IR was assessed using the data usage and analysis criterion from the VDMA Industry 4.0 Readiness framework. The results revealed a strong consensus among respondents regarding the importance of data in the organization. All participants agreed that the collection, usage, and analysis of data, specifically customer, product, and system-generated data, are critical to the organization's business model. Continuous data monitoring and analysis were emphasized as essential for maintaining competitiveness and driving innovation.

The majority of respondents reported that collected data is primarily utilized to support the development of new products and services. In addition, data is also used for preventive maintenance, operational process optimization, customer service improvement, and resource utilization enhancement.

These findings were further supported by qualitative responses. For instance, Participant 5 stated: "The usage and analysis of data are fundamental to the company's business model. A few years ago, a Business Intelligence (BI) and Data Warehouse environment was introduced to support this, and it is continuously enhanced to align with evolving business needs and technological advancements."

Skills Readiness for the Fourth Industrial Revolution: - The results highlight that existing workforce skills are a critical factor in the adoption and effective use of new technologies. Respondents consistently indicated that the organization currently lacks the necessary skills to deploy, operate, and support advanced technologies associated with the Fourth Industrial Revolution (4IR).

Participant 3 emphasized this gap, stating: "We have an aging workforce that does not necessarily possess the skills required for the Fourth Industrial Revolution, and they are often resistant to acquiring new skills." However, opportunities for improvement were also identified. As noted by Participant 2, "There is room for improvement through upskilling and reskilling."

Overall Maturity Assessment: - Based on the findings, the organization's overall 4IR maturity was assessed at intermediate (Level 2). This indicates that, while a few Industry 4.0 initiatives have been incorporated into the company's strategy, such as investments in cybersecurity, customer experience, and partial automation of data collection, full digital transformation has not yet been achieved. Furthermore, the organization has made limited investment in 4IR-enabling infrastructure and equipment.

In terms of human capital, significant skills gaps persist, particularly in areas critical for 4IR readiness. Addressing these gaps through targeted employee development programs is essential.

4.3 Impact of the Fourth Industrial Revolution on Operations Management

To study the impact of 4IR on operations management within a Namibian telecommunications company, the following research question was posed: "How does the adoption of Fourth Industrial Revolution technologies impact operations management in the telecommunications industry?"

All respondents confirmed that automation and disruptive technologies have already influenced operations management within their organization. Specifically, participants reported improvements in customer service, increased productivity, reduced human error, enhanced operational efficiency, and better task management as key outcomes of adopting these technologies. In addition to these operational benefits, respondents identified other external factors that have shaped organizational operations over the past five years. These include declining demand for traditional revenue streams, increased market competition, economic challenges, and the effects of the COVID-19 pandemic. Moreover, respondents, including Participants 3, 4, and 5, emphasized that the speed of technological innovation and the rapid rate of change present ongoing challenges for operations management. These findings highlight both the transformative potential and the operational pressures associated with 4IR adoption in the telecommunications sector

4.4 Benefits of Digital Transformation in Operations Management (11 font)

The adoption of 4IR technologies presents significant operational benefits for Namibian telecommunications companies, consistent with global research (Kagermann, 2013). The key benefits identified in this study include process automation, improved data availability and analytics, enhanced competitiveness, better customer service, faster time to market, data-driven decision-making, and reduced operational costs (Figure 3)

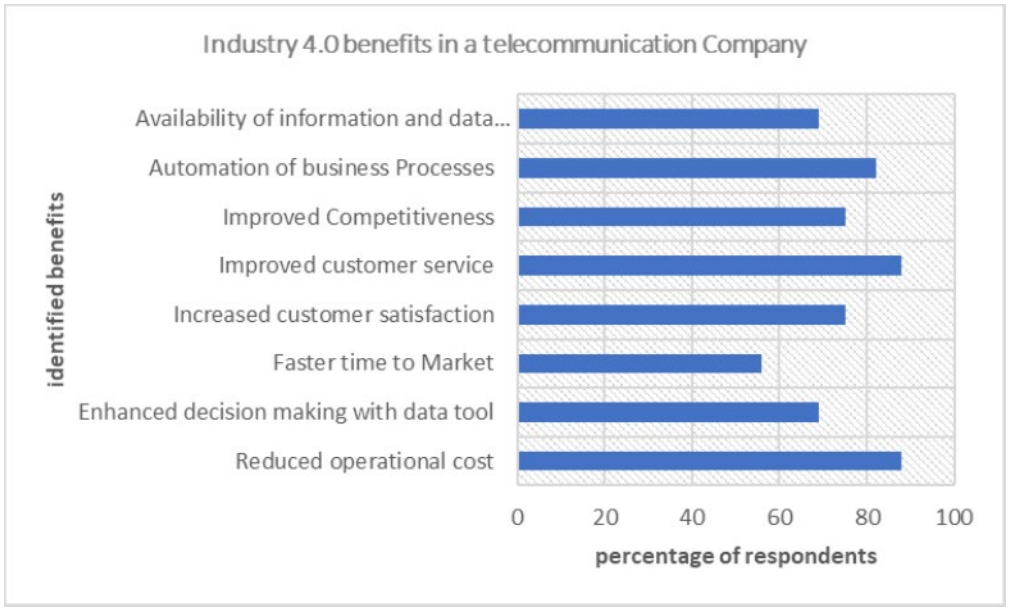

Figure 3. Perceived Digital Transformation Benefits

Respondents emphasized that digital transformation enhances customer understanding, enabling proactive service delivery and product innovation based on customer data and behavioural trends. The integration of advanced analytics allows for co-creation with customers, improving satisfaction and providing a competitive advantage. The ability to deliver products and services more quickly was identified as a key competitive benefit. Participants highlighted that

data analytics and automation reduce product development cycles and enable faster response to customer demands, which is critical in a saturated telecommunications market.

The organization has invested in data infrastructure, including business intelligence tools and data warehouses, to support decision-making. Respondents noted that 4IR technologies facilitate the collection, integration, and analysis of large datasets, providing insights into customer behaviour, product performance, and operational efficiency. Automation of processes was seen as critical for enhancing efficiency, reducing costs, and improving service quality. Participants reported ongoing efforts to automate workflows, including customer service systems, with the aim of reducing human error and improving real-time decision-making.

Participants acknowledged that adopting 4IR technologies is essential to maintain competitiveness in the dynamic Namibian telecommunications sector. Digital transformation enables organizations to respond more rapidly to market changes, customer needs, and technological advancements, ensuring long-term sustainability.

4.5 Challenges to the Adoption of the Fourth Industrial Revolution

The main challenges identified are presented in Figure 4.

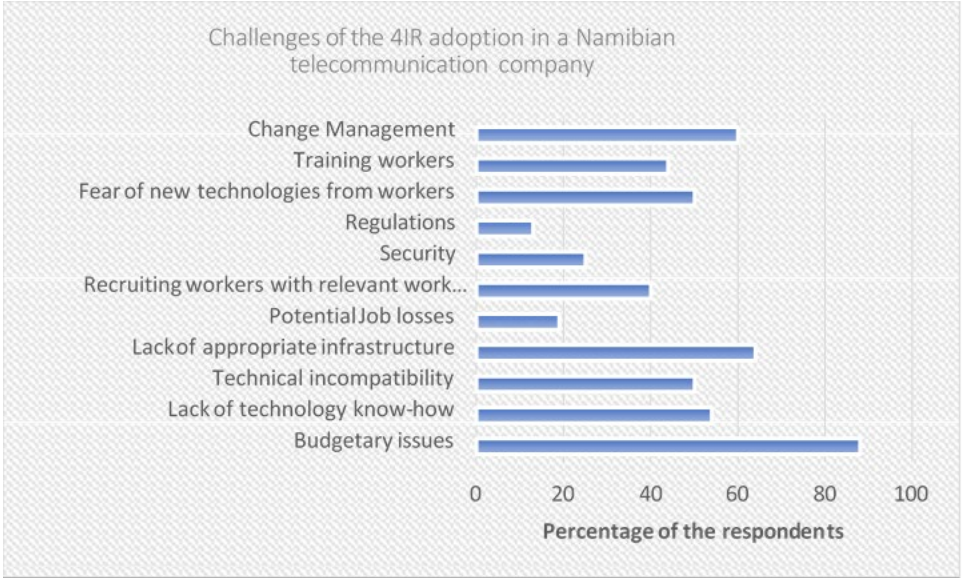

Figure 4. Challenges of the Fourth Industrial Revolution adoption

The most significant barrier identified was limited funding. 87.5% of respondents consider financial resources as a major obstacle to adopting new technologies. Interviewees confirmed that high costs are a constant concern:

- "The cost is always the first consideration when running a business. Investments in new technologies must be justified." (P-5)
- "Implementing new technologies is expensive. It's not a simple process." (P-4)
- "Funding will always be a challenge." (P-2)

These findings indicate that the cost of 4IR technologies remains a critical limitation for successful digital transformation.

The research revealed that existing infrastructure is outdated and insufficient to support advanced technologies. Legacy systems remain in use, with respondents expressing concern about compatibility with emerging 4IR solutions:

- "We've got some outdated systems as well." (P-2)

The organization lacks a modern, integrated, and scalable infrastructure required for automation and other disruptive technologies, limiting its readiness for full-scale digital transformation.

Security was highlighted as a major barrier to 4IR adoption. Increased interconnectivity exposes the organization to greater cybersecurity risks:

- "Our main concern is security. Are these technologies secure enough to independently run business processes without being tampered with?" (P-6)
- "Security will be the biggest challenge." (P-7)
- "It will be difficult to select technologies that are secure and robust. We risk buying inferior technologies that compromise security." (P-4)

These concerns stress the need for stringent security frameworks and careful technology procurement processes.

Successful digital transformation depends heavily on effective change management. The transition to new business models and technologies requires organizational readiness and employee buy-in:

- "The challenge is ensuring employees adapt to new ways of working that digital transformation introduces." (P-1)
- "Change management will be a challenge. We need appropriate initiatives to prepare employees." (P-4)
- "People often resist change, even before considering costs." (P-7)
- "We risk leaving employees behind if we don't deliberately support them." (P-8)

These findings underscore that addressing employee resistance and fostering adaptability are critical for successful 4IR implementation.

The lack of technical skills within the workforce is a significant barrier. Respondents emphasized that employees often lack the expertise to use, deploy, and maintain advanced technologies:

- "Skills are critical. You need skilled people to implement and maintain these systems." (P-6)
- "We have an aging workforce that lacks 4IR skills and is unwilling to learn." (P-2)
- "There is room for improvement through reskilling and upskilling." (P-3)

The organization has initiated targeted training programs, including ISACA certifications (COBIT, CISM, CGEIT, CRISC) to build internal capacity in areas such as Data Security, Risk Management, IT, and Data Governance.

4.5 Identified 4IR Technologies used for Operations Management in Telecommunication Companies

The respondents revealed that only two key digital transformation technologies were in use: cloud technology and big data (Figure 5). On which technologies they intend to use in the future and which technologies will have the most profound impact on operations in the organization, the findings revealed; cloud technology and the Internet of Things, big data, and artificial intelligence as the 4IR technologies that will have the most profound impact on operations in a telecommunication company in Namibia.

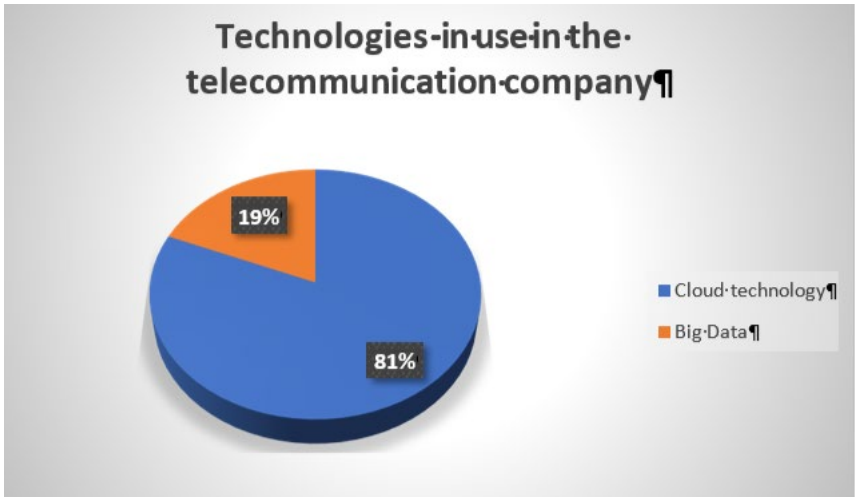

Figure 5. 4IR Technologies used by a Telecommunication Company in Namibia

Another objective was to identify the key 4IR used for Operations Management in Telecommunication Companies. Four technologies were identified to be driving digital transformation in the Namibian Telecommunication Companies: Big Data, Cloud Technologies, Internet of Things, and Artificial Intelligence. They also intend to use these in the next five years. The benefits of these 4IR technologies are improved customer experience, data analysis, operational efficiency, improved time to market, and reduced operational costs.

4.6 Types of skills required for operations in the telecommunication companies

The study examined the skills required for effective operations management in the 4IR era within a Namibian telecommunication company. Findings revealed significant skills gaps, particularly in areas such as information technology, data security, data analytics, systems thinking, innovation, creativity, and teamwork. Both technical and soft skills, including problem-solving, critical thinking, and emotional intelligence, were identified as essential for successful 4IR adoption.

Participants further emphasized the importance of skills in emerging technologies such as the Industrial Internet of Things (IIoT), robotics, cloud computing, and big data analytics. Notably, agility, the ability to rapidly adapt to new technologies, was highlighted as a critical competency beyond specific technical skills. The study underscores the need for a balanced skill set within the organization, as a combination of technical expertise, soft skills, and adaptability is considered key to realizing the full benefits of digital transformation and automation in the 4IR context.

4.7 Impact of the 4IR on operational costs.

The study explored the perceived impact of the Fourth Industrial Revolution (4IR) on operational costs within the telecommunication company. The majority of respondents indicated that, while the initial implementation of 4IR technologies may lead to increased costs due to investment in new systems and solutions, these costs are offset over time by significant operational efficiencies. Interviewees emphasized that although digital transformation requires substantial upfront investment, long-term reductions in operational costs are expected as a result of automation, improved data management, and systems integration. The findings highlight that organizations view the adoption of 4IR technologies as a strategic trade-off, where short-term cost increases are justified by long-term efficiency gains and overall cost reductions.

6. Conclusion

This study examined the impact of the 4IR on a Namibian telecommunication company, with a focus on the opportunities, challenges, and organizational readiness for digital transformation. The findings demonstrate that digital transformation offers substantial benefits, including improved customer service, enhanced data analytics capabilities, process automation, and increased competitiveness. However, realizing these benefits requires a willingness to adapt business models and invest in enabling technologies.

The research also highlighted several challenges hindering 4IR adoption, notably budgetary constraints, inadequate infrastructure, technical incompatibilities, cybersecurity concerns, regulatory limitations, and a shortage of relevant skills. The successful implementation of digital transformation is further influenced by employee perceptions and the organization's ability to manage change effectively.

Core technologies such as Cloud Computing, Big Data, Artificial Intelligence, and the Internet of Things were identified as key enablers of digital transformation, with applications ranging from process automation to customer experience enhancement and data-driven decision-making. Importantly, the organisation must also address the critical skills gap, ensuring a balanced mix of technical expertise, soft skills, and agility to adapt to evolving technological demands.

Finally, while the initial investment in 4IR technologies may be significant, the study confirms that these costs are offset over time by improved operational efficiencies and reduced long-term operational expenses. The findings underscore the need for a strategic, skills-driven, and well-resourced approach to digital transformation to fully leverage the benefits of the Fourth Industrial Revolution in the Namibian telecommunications sector.

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Biography

Hilda Kundai Chikwanda is a distinguished Professor of Engineering Technology Management with over 35 years of experience in metallurgical engineering and operations management. Complemented by an MBA, her expertise spans both the technical and business aspects of the field. Professor Chikwanda has dedicated her career to advancing production efficiencies and fostering innovative practices in academic and industrial settings. She earned her PhD in Engineering and her MBA from leading institutions, equipping her with a unique blend of technical insight and managerial acumen. This dual expertise enables her to seamlessly bridge cutting-edge research with real-world applications, preparing her students to navigate the complexities of modern engineering challenges. A passionate educator and mentor, Hilda is committed to inspiring the next generation of engineers and managers. She emphasizes the critical importance of continuous improvement and innovation as drivers of industrial success. Her extensive publication record further underscores her influence and contribution to the fields of metallurgical engineering and operations management.