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Research Paper

The Role of Fourth Industrial Revolution on Small and Medium Size Enterprises in South Africa

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Abstract

The Fourth Industrial Revolution (4IR) offers both transformative opportunities and significant challenges for Small- and Medium-Sized Enterprises (SMEs) in South Africa. The purpose of this study is to examine how 4IR technologies, such as robotics, the Internet of Things, and artificial intelligence (AI), affect the development and performance of SMEs in South Africa. With the use of a quantitative research methodology, this study meticulously investigates the connection between business outcomes and SME adaptation to 4IR. Using a descriptive single cross-sectional design and a nonprobability convenience sample technique, 50 SME owners and managers from the Eastern Cape province of South Africa were chosen to represent the entire nation. Version 27.0 of the Statistical Package for the Social Sciences (SPSS) was used to assess the collected information. The findings reveal a significant positive association between perceived business growth and SME adoption of 4IR technologies. Most businesses experienced improved operational efficiency and competitiveness after just a year of adaptation. However, opinions on 4IR adoption are greatly influenced by the characteristics of small enterprises, including their industry and location. Small business enterprises in more developed industries and urbanized locations are more likely to use 4IR technologies than SMEs in traditional or rural sectors, where issues like low levels of digital literacy, inadequate digital infrastructure and restricted access to finance still exist. However, all SMEs in South Africa must ultimately have fair access to 4IR technologies to promote long-term sustainability, competitiveness, and socioeconomic growth in the global digital economy.

Keywords *Transformation; challenges; enterprises; technology; digital economy*

INTRODUCTION

The Fourth Industrial Revolution (4IR) represents a transformative period marked by the integration of advanced technologies such as artificial intelligence (AI), blockchain, the Internet of Things (IoT), and robotics into economic and social systems. 4IR has sparked previously unheard-of levels of innovation worldwide, encouraging automation, data-driven decision-making, and the creation of intelligent systems that boost productivity in a variety of sectors. New digital ecosystems have emerged as a result of this upheaval, which has drastically changed established industries, including manufacturing, healthcare, and finance (Gonçalves et al., 2021).

The 4IR has sparked changes in the nature of labor, with a focus on retraining and adaptation to technologically advanced settings. However, 4IR has drawbacks, such as growing inequality and the requirement for moral frameworks to properly govern data privacy and AI implementation. The 4IR has become a challenge and opportunity for South Africa. The nation must use 4IR to alleviate socioeconomic inequalities because of its dual economy, which is made up of both a sizable informal sector and modern sectors. To increase productivity and worldwide competitiveness, important industries like financial services, mining, and agriculture have embraced automation and smart technologies (Ayodele & Kajimo-Shakantu, 2021). South Africa has established itself as a pioneer in the development of renewable energy. To fully realize the potential of 4IR, the nation must overcome issues such as poor Internet infrastructure, a lack of skilled workers, and significant unemployment. To ensure equitable and sustainable growth, government initiatives such as the

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Presidential Commission on 4IR highlight attempts to match technical breakthroughs with national development goals.

The current workforce in SMEs will need to retrain and upgrade their skills in light of the changes brought about by 4IR technologies, which also creates job opportunities in developing industries like digital marketing and data analysis. Through automation, real-time monitoring, and predictive maintenance, SMEs can reach higher operational efficiency thanks to technologies like AI and IoT. Mabotja (2018) noted that in South Africa, the use of 4IR technologies by SMEs varies greatly in terms of uptake. Factors such as firm size, sector, and geographical location play a key role in this difference.

While some SMEs in technologically advanced and urban sectors have embraced 4IR solutions with great enthusiasm, adoption remains significantly hindered for others, especially in rural areas or traditional industries. Melo et al. (2023) denote that some SMEs find it difficult to adopt 4IR solutions due to a lack of digital literacy, infrastructure deficiencies, and restricted access to funding. To ensure that 4IR technologies are widely adopted and that the advantages of the revolution are fairly distributed across SMEs nationwide, it is imperative that these challenges be addressed. To help SMEs overcome obstacles to technology adoption, initiatives focused on enhancing digital infrastructure, providing financial incentives, and providing training programs are crucial. To motivate SMEs to investigate and incorporate 4IR technologies into their operations, an innovative and entrepreneurial culture must be fostered.

With the convergence of digital, physical, and biological systems, the 4IR promises revolutionary advances that will cause a great upheaval in the way enterprises operate. There are two sides to this transformation for SMEs in South Africa. Even though it presents previously unheard-of opportunities for creativity, effectiveness, and market expansion, the difficulties it presents should not be undervalued, especially in the context of emerging economies where there are significant differences in access to resources and technology. Sheik (2023) assumed that the digital gap is one of the main issues that South African SMEs face in the context of the 4IR framework. The nation continues to struggle with unequal access to digital infrastructure and technology despite major developments; this difference is based on both socioeconomic and geographic factors. Cant and Wiid (2016) contend that the continued struggle of SMEs in South Africa is due to the fact that many SMEs operate in rural and impoverished metropolitan regions, which frequently have poor internet connectivity and a dearth of digital tools, making it difficult for small companies to participate in the digital economy. Their possibilities for expansion are restricted by the digital divide, which also hinders their capacity for innovation and large-scale competition.

One major obstacle to the operation of SMEs in the 4IR era is the lack of expertise needed to negotiate the revolution environment. Due to the speed at which technology is developing, SMEs need to have staff that is not only tech-savvy but also flexible enough to work in new environments that may involve automation, artificial intelligence, and data analysis (Asghar et al., 2020). However, current education and training institutions in South Africa are reluctant to adapt to these shifting demands, leading to a skills gap that leaves many SMEs struggling to deploy and use new technology successfully. The competitive global market makes it more difficult to attract and retain personnel with the necessary 4IR capabilities, which worsens the skills gap. Shibiti et al. (2023) asserted that a major obstacle for many SMEs is the financial ramifications of embracing the 4IR age. The initial costs of infrastructure, training, and technology may be unaffordable, particularly for start-ups and smaller businesses with limited budgets. The high rate of technological change means that investments might become obsolete soon, demanding further expenditure to maintain current levels. Due to strict lending requirements and a lack of collateral, South African SMEs frequently struggle to obtain financing, making this financial load very burdensome for them. As a

result, even though the 4IR provides a route to expansion and competitiveness, SMEs in South Africa may find it difficult to overcome the related expenses and financial risks.

This study is notable because it focuses on the often-overlooked role that SMEs, which are the foundation of the South African economy, play in implementing 4IR technology. This research examines how 4IR technologies affect SME productivity, competitiveness, and sustainability in a developing country, in contrast to many earlier studies that focused on multinational firms and global industries. The report examines particular potential and difficulties, including a lack of digital infrastructure, high innovation costs and a skills gap, by placing the global conversation on 4IR within the South African economy. With concrete insights unique to the socioeconomic situation of South Africa, this study delves deeper into doable tactics to improve SME readiness for 4IR, such as financial access, legislative changes, and technology upskilling.

To bridge the gap between technology innovation and SME development, this strategy offers entrepreneurs and policymakers a roadmap for using 4IR to achieve equitable and sustainable economic growth. South African SMEs face both enormous obstacles and game-changing possibilities as a result of the 4IR. SMEs may increase operational effectiveness, expand their market reach, and stimulate economic growth by using technologies such as automation, artificial intelligence, and data analytics. To realize these advantages, though, obstacles including a shortage of skilled workers, limited access to digital infrastructure and budgetary limitations must be removed. To further advance technology, 4IR can boost the South African economy by fostering new business models, operational resilience, and job development. To close the skills gap and ensure the workforce is ready for future demands, this study highlights how important it is for educational institutions and SMEs to cooperate together. The creation of programs that emphasize entrepreneurship, innovation, and digital skills enables graduates to successfully assist 4IR development in SMEs. Therefore, SMEs can strategically position themselves for sustainable success in a world that is quickly digitizing by gaining access to cutting-edge technologies and skills through R&D partnerships.

LITERATURE REVIEW

The research framework of this study is based on analysing how technological adoption, operational effectiveness, and economic sustainability interact. The Technology-Organization-Environment (TOE) framework, which examines how organisational, technological, and environmental settings affect technology adoption decisions, serves as the framework's compass. Understanding how innovations are embraced and incorporated into SME operations is supported by the Diffusion of Innovation (DOI) hypothesis. When combined, these theoretical frameworks offer a strong basis for examining how SMEs deal with the benefits and difficulties presented by 4IR. Based on the research framework, the following hypotheses are proposed:

H1: The adoption of 4IR technologies significantly enhances the efficiency and productivity of SMEs in South Africa.

H2: SMEs that adopt 4IR technologies are more likely to experience sustained competitiveness and growth in the future.

H3: The adoption of 4IR technologies positively impacts employment opportunities within SMEs by creating new roles and upskilling the workforce.

H4: There is a positive relationship between the integration of 4IR technologies and increased productivity levels in SMEs.

H5: The extent of 4IR technology adoption by SMEs is influenced by factors such as financial resources, technological infrastructure, and workforce skill levels.

The Diffusion of Innovation (DOI) theory and the Technology-Organization-Environment (TOE) framework offer complementary viewpoints for analyzing how SMEs adopt 4IR technology.

The technological, organizational, and environmental contexts are the three key factors that the TOE framework highlights as impacting technology adoption. The features of 4IR technologies, including their relative advantages, compatibility, and complexity, are referred to as the technological context (Awa et al., 2017). Internal elements, including SME size, financial resources and staff availability, are all part of the organizational context. Hendricks and Mwapwele (2024) argued that the environmental context looks at outside forces, government regulations, market forces, and competition. These dimensions provide a thorough understanding of the variables influencing SMEs' adoption and use of 4IR technologies. This analysis is further strengthened by DOI theory, which focuses on the diffusion of innovations both within and between organizations. This study highlights the important characteristics of innovations that affect their rate of adoption, including observability, treatability, and perceived usefulness. To better understand how SMEs at various stages of technical readiness react to 4IR technologies, the DOI also proposes adopter types (e.g., innovators, early adopters, laggards). By combining these frameworks, this research can methodically examine how internal and external factors interact and pinpoint strategies for encouraging SMEs to embrace and employ 4IR technology more successfully.

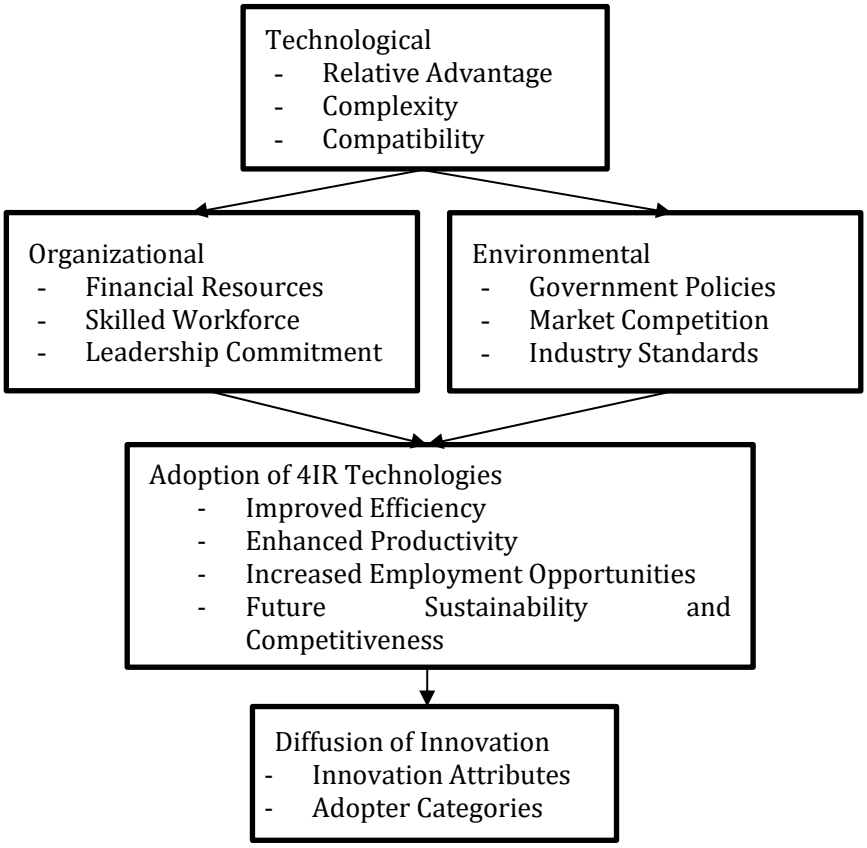

Figure 1. A conceptual visualization of the TOE-DOI integrated framework diagram as it applies to SMEs

This figure offers a comprehensive framework for examining how SMEs use 4IR technologies by elucidating the connections between TOE dimensions, the adoption process, and the innovation dissemination dynamics.

The literature on the effects of 4IR on SMEs in South Africa emphasizes how revolutionary the internal productivity and efficiency of these businesses may be. The revolutionary effects of 4IR technologies, including robotics, the Internet of Things, and artificial intelligence (AI), have been

demonstrated in several studies. These technologies help SMEs perform better overall by streamlining processes and allocating resources optimally. The goal of this literature review is to provide a thorough understanding of the complex effects of 4IR on SMEs by combining findings from many academic sources.

Improved Efficiency and Productivity by 4IR on SMEs

By incorporating digital technologies like automation, IoT, and AI, the Fourth Industrial Revolution (4IR) promises to greatly increase production and efficiency for SMEs in South Africa. Employees can concentrate on strategic and innovative projects by automating monotonous operations, which also lowers labor costs and errors (Smith & Johnson, 2020). Digital devices and sensors allow for real-time data collection on operations, customers, and market trends; thus, data-driven decision-making is a major factor in 4IR's impact on SMEs. SMEs can enhance forecasts, obtain important insights, customize marketing campaigns, and optimize supply chain operations by utilizing big data analytics and machine learning. This leads to increased overall productivity and more accurate and flexible operations (Johnson & Williams, 2019). Further efficiency improvements are fueled by 4IR technologies, which also encourage networking and collaboration among SMEs.

While collaborative platforms enable strategic alliances that pool resources and expertise to address shared challenges and generate new opportunities, cloud computing allows SMEs to access pooled resources and knowledge at an affordable cost (Idris et al., 2020). Innovation, economies of scale, and operational synergies are all encouraged by this ecosystem approach. Additionally, 4IR technologies like CRM systems, AI-powered recommendation engines, and predictive analytics, help SMEs better understand the behavior and preferences of their customers, enabling them to provide customized products and outstanding experiences. Improved customer satisfaction and engagement boost profitability, loyalty, and repeat business, which in turn boosts internal and external growth and competitiveness in a market that is becoming increasingly digital (Garatsa, 2020; Olaitan & Mapanga, 2024).

The Future Effects of 4IR on SMEs

The Fourth Industrial Revolution is expected to have revolutionary effects on SMEs in the future, transforming entrepreneurship and business operations. SMEs will increasingly use 4IR technologies to spur innovation, competitiveness, and long-term growth as they become more widely available (Hansen & Bøgh, 2021). These technologies include automation, artificial intelligence, and the Internet of Things (IoT). The democratization of technology and market access will be among 4IR's most significant effects. SMEs from various sectors and geographical areas can obtain cutting-edge tools without having to make large upfront expenditures by using open-source platforms, software-as-a-service (SaaS), and cloud computing. By lowering entrance barriers and allowing SMEs to compete with larger businesses on an equal basis, this democratization will promote economic growth, innovation and entrepreneurship (Rane, 2023).

The rapid adoption of these technologies will enable SMEs to create and provide innovative goods and services more effectively, changing their capacity to prosper in a cutthroat global marketplace. In a rapidly evolving business climate, 4IR technologies will help SMEs become more agile, adaptable, and resilient. SMEs will acquire important insights into consumer preferences and market trends through predictive modeling, machine learning algorithms, and real-time data analytics. This will help them make proactive decisions and better anticipate obstacles (Dahmani, 2024). Innovations in cybersecurity and risk management will help SMEs protect their resources and minimize risks in a world that is becoming more digitally connected. Furthermore, as corporate goals shift due to increasing expectations for transparency from investors, customers, and

regulators, the societal and environmental ramifications of 4IR will highlight sustainable and responsible business practices (Etikan, 2024). SMEs will be able to monitor supply chains, cut waste, and lessen their environmental effect thanks to technologies like the Internet of Things and sustainable energy solutions. SMEs can improve their reputation, reduce risks, and seize opportunities for innovation, cost reduction, and income generation by integrating sustainability into their operations (Roblek et al., 2020).

The 4IR and The Creation of Employment Opportunities in SMEs

Due to 4IR, the employment landscape in SMEs is changing significantly, posing both opportunities and difficulties for job development. Although there are worries about possible automation-related job losses, 4IR technologies also open up new work prospects, improve current ones, and promote entrepreneurship. There is a greater need for specialized skills in areas like data science, machine learning, cybersecurity, and digital marketing as SMEs increasingly adopt technologies like artificial intelligence (AI), robotics, and data analytics (Olaitan et al., 2021). These positions encourage innovation and productivity in SMEs by allowing people to retrain, upskill, and participate in the digital economy. Employees can acquire a variety of skills and pursue a range of career pathways because SMEs' collaborative character frequently encourages learning and experimentation (Nhede et al., 2022).

SMEs can increase worker productivity and generate higher-value jobs by utilizing 4IR technologies. AI and automation make monotonous chores easier, freeing staff members to concentrate on strategic, innovative, and customer-focused work. AI-powered solutions, for example, can automate data processing and inventory management, allowing staff members to focus on creativity and problem-solving (Serumaga-Zake & Poll, 2021). Additionally, by expanding market opportunities, encouraging innovation, and reducing entry barriers, 4IR promotes entrepreneurship. With the use of digital technologies and platforms like social media, crowdfunding, and e-commerce, SMEs can generate money, expand their operations, and reach international markets with little outlay of funds (Olaitan et al., 2021). The growth of remote work and the gig economy further diversifies the SME sector by giving people the opportunity to undertake business endeavors and augment their income on flexible terms.

Impact of 4IR Technology on Productivity of Small and Medium Size Enterprises

Through technological advancements like IoT and AI, the Fourth Industrial Revolution (4IR) is changing the productivity environment for SMEs and allowing for previously unheard-of increases in operations, resource allocation, and profitability (Xu et al., 2018). SMEs can now analyze enormous volumes of data thanks to AI and machine learning, which can reveal insights into market trends, operational inefficiencies, and customer behavior (Fatorachian & Kazemi, 2021). By streamlining supply chain operations, demand forecasting, and marketing campaigns, this data-driven strategy improves operational efficiency. AI also increases efficiency and creativity by automating repetitive operations, freeing staff members to concentrate on strategic value-added work.

The Internet of Things (IoT) facilitates real-time communication between linked devices, which adds another level of productivity improvement. Benefits for SMEs include predictive maintenance, energy optimization, and remote equipment monitoring, all of which enhance production efficiency, inventory control, and quality control while lowering expenses and downtime (Sorooshian & Panigrahi, 2020). Additionally, 4IR technologies streamline cross-border transactions and international trade by improving transaction security, transparency, and efficiency. These developments simplify intricate procedures, reduce fraud, and boost stakeholder trust. SMEs can gain a competitive advantage by proactively incorporating 4IR technologies into

their business models as they become more widely available and reasonably priced. SMEs must make investments in personnel development and adjust to the cultural changes brought about by digital transformation to fully take advantage of these opportunities (Koh et al., 2019).

The Extent of Adoption of 4IR Technologies by SMEs

Depending on factors such as financial availability, technological literacy, industry-specific dynamics, and legal frameworks, the adoption of 4IR technologies by SMEs varies greatly between industries, regions, and organizational types. The high expenses of digital transformation, such as technology procurement, staff training, and process modifications, can be a significant obstacle for many SMEs due to financial restrictions (Agostini & Nosella, 2020). For 4IR technologies to be implemented successfully, a workforce that is both technologically literate and skilled is essential. However, a skill deficit in cutting-edge fields like cybersecurity, big data analytics, and artificial intelligence, presents difficulties for many SMEs (Chaka, 2023). Comprehensive education and training programs are necessary to close this gap, as are institutional and governmental initiatives to promote a culture of ongoing learning and adaptation.

The adoption of 4IR technologies is further influenced by regulatory frameworks and sector-specific considerations. Higher adoption rates are found in sectors such as manufacturing, logistics, and retail, where the advantages of technology such as supply chain optimization and operational efficiency are more obvious. On the other hand, these technologies are typically adopted more slowly by industries that have less direct contact with tangible commodities or supply chains (Adegbite & Govender, 2021). Adoption can be slowed down or accelerated by regulatory frameworks. Although restrictive rules may discourage SMEs from investing in 4IR technologies, supportive policies, such as data privacy legislation, intellectual property protections, and digitization incentives, may encourage them to do so (Khin & Kee, 2022). Despite these obstacles, the revolutionary potential of 4IR technologies is driving SMEs to investigate and integrate these innovations more and more to improve productivity, efficiency, and competitiveness.

RESEARCH METHOD

The literature review technique of the study comprised a methodical analysis of scholarly works, industry reports, and policy documents that addressed 4IR and its effects on SMEs. This review identified several key constructs by which SMEs have adopted 4IR technology. To comprehend the factors that promote and hinder the adoption of new technologies, this approach also involved investigating theoretical frameworks like the Diffusion of Innovation (DOI) theory and the Technology-Organization-Environment (TOE) framework. The constructs guided the design of the questionnaire and served as a basis for creating the conceptual framework of the study. The study used proven measurement scales and customized them for the South African SME setting in order to operationalize these components into survey questions. The research questions for this study were structured using frameworks such as TOE and DOI to ensure thorough and nuanced responses. The constructs were further developed into multiple-choice items and open-ended questions. The research questions that were originally developed for this study:

1. How does the adoption of 4IR technologies influence the operational efficiency of SMEs in South Africa?
2. What 4IR technologies are most effective in improving the productivity of SMEs in South Africa?
3. To what extent does 4IR technology adoption contribute to the competitive advantage of SMEs in South Africa?
4. How does the adoption of 4IR technologies impact the long-term growth trajectories of SMEs in South Africa?

5. What new employment roles are created within SMEs by adopting 4IR technologies?
6. How does the adoption of 4IR technologies facilitate workforce upskilling in SMEs?
7. What is the relationship between 4IR technology integration and measurable productivity increases in SMEs?
8. How do SMEs with high 4IR technology integration compare with those with low integration levels?
9. How do financial constraints affect the adoption of 4IR technologies by SMEs in South Africa?
10. What role does workforce skill level play in facilitating or hindering the adoption of 4IR technologies in SMEs?

The study comprises a literature review and an empirical investigation. This study adopts a quantitative research approach, which is pertinent because it assumes a more formal framework that is less complex to deal with and adheres to a descriptive cross-sectional research design. According to Saah (2023), quantitative studies have the advantage of significantly reducing bias issues in a studies. An empirical research study on the impact of the 4IR on SMEs in South Africa was conducted by collecting and evaluating data from surveys of SMEs to assess the influence of the revolution on small businesses. The specific population considered suitable for the study comprised owners and managers of SMEs in the Eastern Cape province of South Africa, including both males and females. These small businesses were expected to be tech-savvy and inclined toward leveraging new technologies for business operations and growth. Given the unique economic and business situation of the country, the study specifically focused on South African SMEs in the Eastern Cape, with the understanding that the results might have broader relevance for small businesses in other provinces of the country. Using a non-probability sampling technique, 50 small business owners and managers comprised the sample size. Purposive sampling was used to establish a sample size of 50 participants, with an emphasis on SMEs currently using or aiming to use 4IR technology. This size guarantees a reasonable yet varied representation of companies from different industries and geographical areas in South Africa, enabling in-depth quantitative insights while preserving the viability of data collection and analysis within the parameters of the study. Survey data revealed trends between sizable groups and respondents' assessments of the role of 4IR on SMEs in South Africa.

Small business owners and managers in the Eastern Cape province who were either actively using or considering implementing 4IR technologies, such as automation, artificial intelligence, and the Internet of Things, were the main focus of the study. SMEs had to be between 10 and 250 employees, operate in major 4IR-adopted industries, such as manufacturing, retail, and services, and meet South African regulatory size requirements. SMEs had to have been in operation for at least two years to guarantee that the insights of the participants were based on pertinent operational experience. Participants were expected to be decision-makers who directly influenced the strategic and technological directions of their organizations. Businesses that had fewer than ten workers, operated informally, or had no interest in 4IR technology were not included. Purposive sampling was employed to choose 50 SMEs that could offer in-depth, targeted insights into the prospects and difficulties of 4IR adoption given the exploratory nature of the study. The context-specific objectives of the study and practical limitations, such as the small number of eligible SMEs in the area, make this non-probability sampling strategy appropriate. The main method for gathering data for the quantitative study design was the use of structured, self-administered questionnaires. Managers and owners of the 50 SMEs that were chosen were given a questionnaire, which was created using components found in the literature. To assess the degree of 4IR adoption, its impact on business performance, and the variables promoting or impeding technology adoption, statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS), Version 27.0. To guarantee solid insights, statistical, descriptive, validity, and reliability analyses were used.

Furthermore, SPSS made it easier to profile participants and analyze their answers to survey questions, allowing for a thorough comprehension of the effects of 4IR adoption on SMEs in the Eastern Cape. The findings provided insightful direction for creating focused plans to promote 4IR adoption and aid in the expansion of SMEs in South Africa.

FINDINGS AND DISCUSSION

The utilization of statistical analysis proved instrumental in evaluating the impact of 4IR on SMEs in South African. This comprehensive examination facilitated insights into the degree of 4IR acceptance, its consequential effects on business performance, and the multifaceted variables influencing the adoption of 4IR technologies. The gathered data, acquired through the administration of questionnaires to respondents, underwent rigorous analysis utilizing SPSS. The demographic Information of the respondents, the reliability of the scales, Fleiss Multirater Kappa, descriptive statistics and correlation analysis served as a means of interpreting the nuanced relationships between various factors, thereby enhancing the comprehensiveness and depth of understanding regarding the interplay between 4IR and SMEs within the South African economic landscape.

Demographic Information of the Respondents

To effectively integrate the given demographic details into the analysis, a tabular format can offer a thorough perspective of the respondents' sociodemographic attributes. Here is an illustration of how demographic details, such as age, income level, educational background, employment situation, and marital status, can be organized, as depicted in table 1:

Table 1. Demographic Information of Respondents

Demographic Category	Subcategories	Percentage (%)
Gender	Male	43.7
	Female	56.3
Age Group	18–25 years	15.2
	26–35 years	38.4
	36–45 years	32.6
	46+ years	13.8
Income Level	Below R10,000	27.1
	R10,000–R20,000	42.3
	Above R20,000	30.6
Education Background	Secondary School Certificate	19.8
	Diploma/Certificate	25.7
	Bachelor's Degree	38.5

Demographic Category	Subcategories	Percentage (%)
	Postgraduate Degree	16.0
Employment Status	Employed	48.9
	Self-employed	37.6
	Unemployed	13.5
Marital Status	Single	45.8
	Married	41.2
	Divorced/Widowed	13.0

Analysis and Implications

Gender, a higher percentage of women (56.3%) highlighted their active involvement in adopting 4IR technologies, a step toward gender inclusivity in traditionally male-dominated industries. Age distribution of the respondents aged 26–35 years represented the largest segment (38.4%), indicating that young professionals drive 4IR adoption.

Income and employment of Most respondents (42.3%) fell within the middle-income range (R10,000–R20,000), suggesting that 4IR technologies are accessible to SMEs across different financial strata. The high percentage of self-employed individuals (37.6%) underscores entrepreneurship's role in technology adoption.

Education, a significant proportion (38.5%) of respondents hold a bachelor's degree, reflecting the importance of formal education in fostering technological literacy. For the marital status, the nearly balanced distribution between single (45.8%) and married (41.2%) respondents suggests that both groups are equally represented in the adoption of 4IR technologies.

By integrating these factors, this study can offer a nuanced understanding of how sociodemographic characteristics influence 4IR technology adoption by SMEs in South Africa.

The reliability of the scales.

Table 2. Case Processing Summary

		N	%
Cases	Valid	46	92.0
	Excluded[a]	4	8.0
	Total	50	100.0

Table 3. Fleiss Multirater Kappa Overall Agreement[a]

		Asymptotic			Asymptotic 95% Confidence Interval	
	Kappa	Standard Errorz		Sig.	Lower Bound	Upper Bound
Overall Agreement	-.069	.073	-.936	.349	-.213	.075

a. Sample data contains 47 effective subjects and 2 raters.

The reliability analysis demonstrated low internal consistency in the data, as reflected by a

Cronbach's alpha coefficient of 0.393, indicating a weak relationship between variables. Out of 50 total cases, 46 were valid (92.0%), while 4 cases (8.0%) were excluded, potentially further affecting reliability. The Fleiss Multirater Kappa for overall agreement is -0.069, with an asymptotic standard error of 0.073 and a 95% confidence interval ranging from -0.936 to 0.349. The overall agreement was not significant ($p > 0.05$). These findings suggest low agreement among the raters and weak internal consistency, limiting the dataset's reliability for conclusions or generalizations.

Table 4. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Race	47	1	5	1.60	1.056
Gender	48	1	2	1.56	.501
The has been growth in my enterprise since the introduction of 4IRThe has been growth in my enterprise since the introduction of 4IR	50	1	5	3.46	.973
The 4IR has enabled my business to be able to create more job opportunities than before	50	1	5	3.40	1.010
It did not take more than 12 months for my business to adapt to the 4IR	50	1	5	3.18	1.207
We as a business have established data security measures to ensure protection against cyber threats related to 4IR Technologies	50	1	5	3.44	1.033
We have enrolled our staff in certain training programmes for the to be able to exploit this new technology	48	1	5	3.38	1.214
The introduction of Artificial Intelligence (AI), Internet of things (IoT) and big data analytics has enabled decision making in my business	48	1	5	3.21	1.010
Since we adopted to 4IR my enterprise has been able to process and analyse data quickly and make informed decisions that can enhance operational efficiency	48	1	5	3.44	.965
Valid N (listwise)	44				

This study highlights variability in participants' perceptions of 4IR technology adoption. Business growth since the 4IR introduction had a mean score of 3.46, with some participants reporting higher growth levels. Increased job opportunities were associated with a mean score of

3.40, while the average adaptation time to 4IR technologies was 3.18, with some indicating a longer transition. Participants emphasized the significance of data security measures and staff training programs, as indicated by a mean score of 3.44. These findings indicate differing levels of awareness, understanding, and implementation of 4IR technologies among the participants.

Correlation Coefficients among Different Variables

The demographic data of the race of the SME owners and managers who participated in the questionnaire reflect the experiences of the small enterprises regarding the 4IR in South Africa. The analysis begins with an examination of the demographic information, which subsequently leads to a correlation analysis. The correlation coefficients among the various variables in the questionnaire are delineated below. These coefficients signify the interrelationships observed within the experiences of SMEs during the 4IR. The analysis, which is rooted in the perspectives of the participants, is methodically structured and is depicted in Table 5.

Table 5. Correlation Analysis

		Race	**Gender**	**Successfully embraced 4IR**	**4IR-driven growth in my enterprise**	**Adaption to 4IR within 12 months**
Race	Pearson Correlation	1	.320*	.129	-.006	.051
	Sig. (2-tailed)		.032	.387	.967	.734
	N	47	45	47	47	47
Gender	Pearson Correlation	.320*	1	.359*	.266	.173
	Sig. (2-tailed)	.032		.012	.068	.241
	N	45	48	48	48	48
My business has adopted well with the introduction of the 4IR	Pearson Correlation	.129	.359*	1	.700**	.381**
	Sig. (2-tailed)	.387	.012		<.001	.006
	N	47	48	50	50	50
The has been growth in my enterprise since the introduction of 4IRThe has been growth in my	Pearson Correlation	-.006	.266	.700**	1	.588**
	Sig. (2-tailed)	.967	.068	<.001		<.001
	N	47	48	50	50	50

		Race	Gender	Successfully embraced 4IR	4IR-driven growth in my enterprise	Adaption to 4IR within 12 months
enterprise since the introduction of 4IR						
It did not take more than 12 months for my business to adapt to the 4IR	Pearson Correlation	.051	.173	.381**	.588**	1
	Sig. (2-tailed)	.734	.241	.006	<.001	
	N	47	48	50	50	50

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

This table shows the correlation coefficients between different variables. The variables included are "Race," "Gender," "There has been growth in my enterprise since the introduction of 4IR," and "It did not take more than 12 months for my business to adapt to the 4IR." The correlation coefficients range from -0.006 to 0.700. The significance levels (Sig.) indicate the statistical significance of the correlations. For example, there is a significant positive correlation (0.700) between "There has been growth in my enterprise since the introduction of 4IR" and "It did not take more than 12 months for my business to adapt to the 4IR." The correlation coefficients range from -0.006 to 0.320. The significance levels (Sig.) indicate the statistical significance of the correlations. For example, there is a significant positive correlation (0.320) between "Race" and "Gender."

This correlation analysis explores the relationships between gender and perceptions of the impact of 4IR on small businesses, as well as the interplay between business growth, adaptation, and decision-making. The analysis indicates a significant positive correlation between gender and the opinion of small business adoption of the 4IR ($r = .320$, $p = .032$), suggesting that gender may influence the perceptions of how small businesses embrace 4IR technologies. Although the relationship between gender and perceived business growth following 4IR implementation is positive, it is not statistically significant ($r = .266$, $p = .068$). The analysis also revealed a strong positive correlation between perceived business growth and SME adaptation to 4IR ($r = .700$, $p < .001$), indicating that small businesses that are perceived to be growing are also adapting well to 4IR. The capacity to utilize AI, IoT, and big data analytics for informed decision-making showed a significant positive correlation with small business adaptation to 4IR ($r = .588$, $p < .001$), emphasizing the critical role of these technologies in the successful adaptation of small businesses to the demands of 4IR.

Consistent with previous research, this study validates the transformative potential of Fourth Industrial Revolution (4IR) technology for SMEs. It emphasizes how adopting 4IR is positively correlated with better results like employment generation and business growth. Peretz-Andersson et al. (2024) assert that SMEs have the capacity to be changed in size, and competitiveness is improved by technologies like automation, artificial intelligence (AI), and the Internet of Things (IoT). Disparities in adoption rates, however, continue to exist because of obstacles such as limited financial resources and low technology literacy, which are similar to issues noted in earlier

research. This study adds dimension to the conversation by relating perceptions of 4IR adoption to demographic factors, especially gender. This shows that views of business development following the implementation of 4IR and gender have a positive but statistically insignificant relationship. The Technology-Organization-Environment (TOE) concept, which stresses organizational characteristics such as worker diversity and leadership in influencing technology adoption, is consistent with these findings. The Diffusion of Innovation (DOI) hypothesis is also supported by this study, which emphasizes how adoption rates are influenced by individual decision-makers' characteristics.

By showing that 4IR adoption creates competitive benefits, allowing SMEs to predict trends, manage massive data sets, and expedite operations, the study further supports DOI theory. The relevance of organizational resources, technical readiness and external support networks is shown by the variation in adoption rates. Insights from the TOE framework highlight the necessity of easily available training and funding to establish favorable circumstances for the broad adoption of 4IR. The report highlights customized solutions to address adoption gaps from a practical perspective. It is essential to implement inclusive solutions that address organizational characteristics, contextual issues and gender-specific impediments. Ramasimu et al. (2023) found that SMEs can overcome obstacles and exchange best practices with the support of programs like focused training, financial incentives, and cooperative ecosystems. This paper offers a solid theoretical basis for workable ways to optimize 4IR benefits for SMEs by combining TOE and DOI concepts.

The present study supports earlier research, demonstrating how Fourth Industrial Revolution (4IR) technologies have a revolutionary effect on SMEs, especially in terms of boosting competitiveness and growth. This reinforces generally held beliefs in the literature by confirming previous findings that 4IR adoption is favorably correlated with business outcomes such as scalability and job generation. This study goes deeper by examining gender-specific viewpoints and identifying obstacles to 4IR adoption, such as lack of funds and skills. These revelations add to earlier research and provide a new perspective on how demographic factors affect adoption procedures. This study adds to a more sophisticated conversation about these issues by examining the differences in adoption rates. This study verifies the significance of the Diffusion of Innovation (DOI) and Technology-Organization-Environment (TOE) theories in understanding the uptake of new technologies. By highlighting the necessity of focused assistance, cooperative ecosystems, and inclusive tactics to bridge adoption gaps and assist SMEs in realizing the full potential of 4IR technologies, this study expands on earlier research.

CONCLUSIONS

This study provides fresh insight into how 4IR technologies can improve the competitiveness, efficiency, and production of SMEs in the global marketplace. This demonstrates how innovations and growth are being spurred by technologies like automation, Internet of Things, and artificial intelligence, which are transforming the business environment for SMEs in South Africa. Notwithstanding these advantages, this study finds differences in the uptake of 4IR technologies, which are caused by budgetary limitations, a lack of skills, and difficulties unique to the sector. However, if the proper infrastructure, policy support, and training are made accessible, the results highlight the bright future for SMEs through the democratization of technology and the strategic integration of 4IR tools.

This study finds a critical connection between SMEs' ability to innovate, generate employment, and maintain economic growth in a rapidly changing digital economy and their level of technological preparedness. The significant influence of 4IR technologies on SME growth and adaptation was one of the main findings of this study. Within a year of implementing these cutting-edge tools, most SMEs achieved notable adaptation, demonstrating a clear trend toward business

growth and job creation. This quick integration demonstrates how SMEs can use technologies like automation, AI, and IoT to overcome operational obstacles and maintain their competitiveness. However, given the disparities in adoption rates among SMEs, specific interventions are needed to overcome obstacles such as infrastructure shortage and the lack of skilled workers. To guarantee that all SMEs can prosper in the 4IR era, this study highlights the necessity of consistent support through targeted innovation, legislative frameworks, and training programs. This new understanding supports a more inclusive approach to technology adoption to close current disparities in the digital marketplace and confirms the close relationship between technological flexibility, corporate success, and economic growth.

LIMITATION & FURTHER RESEARCH

There are some limitations to this study that could influence how its conclusions are interpreted. First off, generalization of the study to a larger population of SMEs is limited by its reliance on a quantitative methodology and a non-probability convenience sample. Although this sample selection is helpful for obtaining information from easily reachable participants, it cannot accurately reflect the range of experiences and preparedness levels of SMEs in various industries and geographical areas. In addition, the cross-sectional approach only records data at one particular moment in time, failing to take into consideration how the 4IR changes over time or how it may affect SMEs in the long run. As a result, the results only offer a partial picture of how SMEs have integrated 4IR technology. According to these design features, more research should fill these gaps by using longitudinal studies and a variety of sampling techniques to gain a deeper understanding of the evolving potential and constraints of 4IR for SMEs.

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