EXPLORING SMART MANUFACTURING TOOLS AND INNOVATIVE LEADERSHIP STRATEGIES IN SMALL MANUFACTURING ENTERPRISES

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Abstract

Small and medium-sized enterprises (SMEs) play a pivotal role in an emerging economy, leveraging their agility and market penetration to foster economic growth (Peter et al., 2023). Understanding the dynamics of their growth and sustainability is paramount, particularly in the context of adopting smart manufacturing processes and innovative leadership (Bello et al., 2024). This study aims to investigate the utilisation of smart manufacturing tools and innovative leadership practices among manufacturing SMEs in KwaZulu-Natal, South Africa. A quantitative research approach was employed, utilising census sampling of 102 manufacturing SMEs registered in the Msunduzi Municipality database. The findings revealed a stark limitation in the adoption of robotic technology among manufacturing SMEs, with minimal utilisation of the Internet of Things (IoT) and artificial intelligence technologies. Thus, it indicates that the integration of smart manufacturing processes in KwaZulu-Natal's SMEs is still in its nascent stage. However, amidst these challenges, the study unearthed a significant presence of innovative leadership practices within the SMEs operating in the manufacturing sector. This presents a unique opportunity for these enterprises to propel the smart manufacturing agenda forward through effective, innovative leadership strategies.

Keywords: Small Manufacturing Enterprises, Smart Manufacturing, Innovative Leadership, Emerging Economy, South Africa

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1. INTRODUCTION

The evolving landscape of technology continually shapes the operational framework of firms, particularly within the manufacturing sector, influencing cost structures, operational processes, and control mechanisms (Sahoo & Yadav, 2018; Javaid et al., 2022). To ensure their longevity and competitive position in the industry, manufacturing firms must constantly explore techniques that confer a competitive advantage, embracing innovative manufacturing processes tailored to their

specific requirements. Small and medium-sized enterprises (SMEs) constitute pivotal drivers of social and economic development, not only in South Africa but globally (Abdullrazak & Alyamani, 2019). However, the growth and survival rates of SMEs in South Africa remain relatively low, largely attributed to inadequate technological integration (Bag et al., 2023; Sichoongwe, 2023). The absence of technology adoption hampers the competitiveness and developmental trajectory of small organisations, hindering their ability to thrive in an increasingly technology-driven landscape (Ngibe & Lekhanya, 2019a; Sichoongwe, 2023).

In response to the transformative impact of internet technology, the Internet of Things (IoT), cloud computing, and artificial intelligence, manufacturing processes have undergone significant evolution, prompting a global embrace of smart manufacturing paradigms (Bello et al., 2024). Smart manufacturing heralds a future characterised by high-volume production and highly customizable products, facilitated by agile and responsive manufacturing operations (Cai et al., 2017; Peter et al., 2023). Smart manufacturing is a way of making industrial processes smarter and more connected, utilising a variety of technologies and solutions (Rahman, 2018). Hence, the adoption of smart manufacturing tools by SMEs enables these businesses to be more efficient, lucrative, and long-term viable (Owalla et al., 2019). Using these tools, SMEs can tap into new and emerging markets by creating high-quality, low-cost, complicated, and customised goods (Ayandibu & Houghton, 2017; Bag et al., 2023).

Despite the widespread acknowledgment of the importance of innovation and entrepreneurship in SMEs, the dearth of technology constrains organisations' ability to meet quality standards necessary for competitive positioning in both local and international markets (Littlewood & Holt, 2018). Additionally, advancements in internet technology, IoT, cloud computing, and artificial intelligence (AI) underscore the pivotal role of technological expertise in fostering innovation and competitiveness within the manufacturing sector (Telukdarie et al., 2023). However, accessing and harnessing such technical expertise poses a significant barrier for manufacturers seeking to embark on the journey of smart manufacturing (Owalla et al., 2019). Industry-specific IT infrastructure, quality-monitoring capabilities, and proficiency in production development and operations management constitute indispensable components for effectively managing and executing business-related functions (Javaid et al., 2022). These technical proficiencies are not only essential for the day-to-day operations of manufacturing SMEs but also serve as the cornerstone for their growth and expansion initiatives (Sichoongwe, 2023).

Concurrently, a persistent challenge lies in the dearth of innovative leadership within these organizations, particularly in the South African context (Ngibe & Lekhanya, 2019b; Peter et al., 2023). The manufacturing industry in South Africa contends with a pronounced deficiency in innovation culture, primarily stemming from inadequate leadership characterised by a lack of comprehension of effective leadership practices (Bello et al., 2024; Sichoongwe, 2023). This deficiency in leadership profoundly impacts the sector's capacity for business management development, compounded by factors such as insufficient market knowledge, inadequate education and training, and a lack of technological orientation, all of which are indispensable for navigating today's competitive landscape (Yang et al., 2023). Moreover, the absence of essential business skills inhibits personal effectiveness, impeding the creative and innovative potential of employees within SMEs (Sekhametsi, 2017).

Therefore, this study investigated the utilisation of smart manufacturing tools and innovative leadership practices among manufacturing SMEs in the province of KwaZulu-Natal, South Africa. The research objectives were:

1) To determine the smart manufacturing tools used by manufacturing SMEs.

2) To examine innovative leadership practices applied in manufacturing SMEs.

The rest of this paper is structured in the following manner. Section 2 presents a literature review that discusses the theoretical framework supporting the study and investigates the implementation of smart manufacturing strategies and innovative leadership practices in small manufacturing enterprises. Section 3 provides a comprehensive explanation of the research methodology, specifically highlighting the utilisation of a quantitative research approach. Section 4 provides an overview of the study's outcomes, highlighting the discoveries obtained from the survey conducted among SMEs. Section 5 presents a detailed discussion of the main findings. It includes an analysis of the implications of these findings and how they relate to the existing body of knowledge on smart manufacturing tools and innovative leadership in SMEs. Section 6 provides conclusions, practical recommendations for implementing smart manufacturing and innovative leadership practices in SMEs, specifically in response to the rapidly changing business environment.

2. LITERATURE REVIEW

2.1. Theoretical framework

In exploring the adoption of smart manufacturing tools among manufacturing SMEs, this study employed a hybrid approach by amalgamating the diffusion of innovations theory (DIT) and the technology acceptance model (TAM). TAM, widely utilised in studies concerning technology adoption, has proven effective in elucidating users' acceptance of information technology (Smith, 2022; Turner & Baker, 2017; Anderson et al., 2014). Hence, TAM serves as a foundational framework for understanding the adoption of smart manufacturing tools by SMEs. However, while TAM offers valuable insights, its adequacy for comprehensively capturing the adoption of technological tools remains uncertain. To address this limitation and gain deeper insights into the rapid changes in information dynamics, researchers have proposed integrating TAM with other theories, notably DIT (Smith, 2022). DIT, recognised for its efficacy in delineating innovation characteristics and explaining user adoption behaviour, enhances our understanding of why individuals embrace innovations (Gerlich, 2023). It presents a comprehensive social-psychological framework aimed at predicting human adoption of new inventions by identifying adoption behaviours and delving into their organisational implications (Yildirim & Demirbag, 2020).

In examining the innovative leadership practices within manufacturing SMEs, this study embraced complexity leadership theory (CLT). This theory emerged in response to the recognition of a need for a new leadership paradigm from a systemic viewpoint, acknowledging the intricate interrelationships within organisations that traditional leadership approaches often overlook (Alblooshi et al., 2021; Baltaci & Balci, 2017; Turner & Baker, 2017). By adopting a perspective that views organisations as complex adaptive systems, CLT enables leaders to cultivate innovative leadership effectively. This approach empowers leaders to develop a strategic and systemic framework for fostering innovation, recognising the interconnectedness of various organisational elements. The CLT suggests using a complex adaptive system approach, which stresses the importance of combining leadership actions and business results to fully understand how innovation works (Alblooshi et al., 2021; Baltaci & Balci, 2017). This framework emphasises the interconnectedness of an organization's functional resources, highlighting the need for leaders to navigate and leverage these interconnections to drive innovation effectively. By embracing CLT, organisations can foster a culture of innovation that permeates throughout the organisational ecosystem, ultimately contributing to enhanced performance and the successful implementation of initiatives such as smart manufacturing practices.

2.2. Smart manufacturing challenges facing SMEs in South Africa

Despite the widely recognised advantages that SMEs confer upon economic growth, entrepreneurship, and local technological advancement, small businesses across Africa have struggled to meet their full potential due to a myriad of challenges (Sichoongwe, 2023). SMEs operating in Africa confront a multitude of obstacles that stifle their expansion. This sentiment is echoed by Sinsel et al. (2020), Ritala and Almpanopoulou (2017), who assert that despite their pivotal role in fostering growth, SMEs encounter numerous hurdles that impede their sustained viability. To thrive, small enterprises require access to resources and support services, a responsibility that may fall on both business owners and governmental entities. Infrastructure deficiency has long been identified as a significant impediment to economic progress across Africa. Javaid et al. (2022), Peter et al. (2023) highlight the deteriorating state of infrastructure, which has left vast areas underdeveloped and disrupted economic activities.

Below, we delve into the intricate challenges that confront SMEs in South Africa within the realm of smart manufacturing.

2.2.1. Skills shortage

Lichtenthaler (2016) underscores the critical nature of the skills shortage, which profoundly impacts the performance, development, and advancement of commercial enterprises, particularly in the realm of smart manufacturing. The scarcity of skilled labour significantly undermines the competitiveness of smart manufacturing SMEs in the market. According to Javaid et al. (2022) and Cai et al. (2017), smart manufacturing SMEs equipped with the requisite skills and a proficient workforce exhibit enhanced effectiveness. Smith (2022) and Walliman (2017) further corroborate this assertion, emphasizing that companies in the domain of smart manufacturing with robust human resource capabilities tend to outperform their counterparts.

2.2.2. Access to reliable information

A prevalent challenge facing African smart manufacturing SMEs revolves around the dearth of reliable business information sourced from service providers and governmental entities (Yang et al., 2023). This challenge emanates from an inadequate information ecosystem characterised by underdeveloped technology and communication infrastructure, coupled with insufficient business support (Sichoongwe, 2023). Establishing a robust information and communication infrastructure, including essential technological support networks such as software and hardware, facilitates the practicality and reliability of smart manufacturing enterprises, thereby reducing operational and production costs. Governments and relevant stakeholders must prioritise investments in information and communication infrastructure to bolster the pivotal role of SMEs in driving economic growth (Peter et al., 2023; Telukdarie et al., 2023).

2.2.3. Management competency and capability

A glaring deficiency in management expertise, skills, and knowledge poses a significant hurdle for numerous SMEs. Yang et al. (2023), Quartey et al. (2017) highlight the lack of creativity and leadership as major impediments hampering fully integrated, collaborative smart manufacturing SMEs in the realms of management and technical proficiency. Ineffective management practices compound this challenge, as many smart manufacturing SME operators or managers lack the requisite managerial competence (Sekhametsi, 2017). The absence of proper management skills and expertise inhibits the ability of business owners to implement best practices, leading to suboptimal performance and limited long-term vision (Muriithi, 2017). This deficiency in managerial and leadership capabilities stifles the growth and success potential of SMEs, both in developed and developing countries (Telukdarie et al., 2023).

2.2.4. Access to financing

The expansion of fully integrated, collaborative smart manufacturing in Africa hinges on access to adequate financial resources. Woldie et al. (2018) underscore the lack of funding as a significant barrier to growth in this sector. Quartey et al. (2017) further elaborate on the challenge, citing the high cost of new technology machines as a barrier to access to credit. Berisha et al. (2018) note that Africa's financial systems are often small, shallow, and costly, with limited reach, constraining the availability of financing options for smart manufacturing SMEs. Consequently, some enterprises are compelled to self-finance or rely on informal sources of funding from friends and colleagues (Rahman, 2018).

2.3. Key smart manufacturing tools adopted by SMEs and their benefits

Smart manufacturing leverages a range of innovative tools and processes to enhance efficiency, sustainability, and adaptability in the manufacturing sector (Gerlich, 2023; Schein & Schein, 2017). Key smart manufacturing tools include advanced data analytics, predictive engineering, resource sharing, sustainability-driven practices, and innovations in value chains and product development.

2.3.1. Data-driven manufacturing

Data collection and analytics are essential in smart manufacturing, where sensors, wireless devices, and advanced data analytics enable manufacturers to gather insights from various sources, including materials, process parameters, and even consumer and supplier feedback (Schein & Schein, 2017; Adamczyk et al., 2020). This data is foundational for improving decision-making, allowing manufacturers to anticipate and address future challenges through predictive applications, which provide competitive advantages. SMEs benefit from data-driven insights that can highlight inefficiencies, reduce downtime, and predict maintenance needs, ensuring a smoother and more cost-effective production process (Sartal et al., 2022; Gerlich, 2023; Rahman, 2018).

2.3.2. Predictive engineering

Predictive engineering, a significant advancement in smart manufacturing, allows for high-fidelity digital simulations or digital twins that model potential future scenarios. This proactive approach helps companies become more competitive by exploring a range of technological possibilities, some of which may not yet exist (Schein & Schein, 2017; Ngibe & Lekhanya, 2019a). By simulating production and market conditions, predictive engineering helps manufacturers optimize production, reduce risks, and maintain an agile response to changes (Owalla et al., 2019).

2.3.3. Resource sharing and networking

The rise of shared resource models allows manufacturers to optimize resources, including machinery, software, and expertise, in a collaborative digital environment. Digital-physical separation is becoming common, enabling even competing companies to share manufacturing resources to boost efficiency (Ayandibu & Houghton, 2017). This networking model facilitates innovation by leveraging a broader base of expertise and technology, reducing costs while fostering industry collaboration (Inyang et al., 2023; Shivajee et al., 2019). Therefore, smart manufacturing tools facilitate enhanced network connectivity throughout the logistics chain, enabling swift adjustments to orders and minimising delays (Sekhametsi, 2017). By fully integrating and collaborating with suppliers, manufacturers can streamline operations, reduce waste, and identify opportunities for product innovation (Kusiak, 2018).

2.4. The adoption of innovative leadership by SMEs

Innovation entails engaging in activities that deviate from the ordinary or conventional (Alharbi, 2021; Alblooshi et al., 2021). It represents a forward-looking mindset, transcending the present to envision and shape the future. When wielded effectively, innovation serves as a potent tool, method, or control mechanism for organisations (Inyang et al., 2023; Ritala & Almpanopoulou, 2017). At its core, innovation involves inventing and synthesising ideas to bridge current achievements with past research aimed at tackling future challenges. Often associated with technological breakthroughs, innovation exerts a significant influence on the global economy (Rahman, 2018). It provides organisations with a competitive edge over rivals, fostering revenue generation and sustaining competitiveness in the business landscape. In the business realm, innovation assumes paramount importance, facilitating revenue generation while ensuring competitiveness. There exists a symbiotic relationship between innovation, job creation, wealth generation, and overall living standards (Inyang et al., 2023; Sayal & Banerjee, 2017). Novel products, substances, techniques, and services serve as avenues for innovators to collaborate and propel organisational growth.

Innovative leadership is the method of promoting innovation by creating an initiative-friendly environment and establishing a plan of action that directs and increases trust among workers (Alblooshi et al., 2021; Rahman, 2018). This type of leadership is vital for growing new products, supporting market competitiveness, and maintaining economic growth (Akkumol et al., 2019). An innovative leader's ability to discover and implement improvements is necessary to be able to adapt to constantly changing technology and consumer preferences, thereby enhancing worker creativity. According to Ngibe and Lekhanya (2019b), innovation is more than just transforming an idea into a product; it must also be based on marketplace understanding and be a suitable management skill.

Leadership within SMEs presents unique challenges, necessitating leaders endowed with qualities conducive to fostering organisational growth and adaptability to internal and external challenges (Sichoongwe, 2023). According to Vakili et al. (2016), leadership attributes encompass the capacity for creative and strategic thinking, coupled with the assurance of corporate development and sustainable growth. Transformational leadership, which aims to extract the best from employees for the benefit of both the company and its workforce, is paramount (Lecuna et al., 2016). Management, defined as the art of influencing and guiding individuals towards the attainment of corporate objectives, plays a pivotal role in this regard. To foster innovative leadership, organisations can adopt several strategic approaches. Firstly, they can directly align innovation with senior executives' strategic planning objectives. Secondly, promoting the establishment of active innovation networks can facilitate the harnessing of untapped potential for innovation without necessitating radical reform programs. Thirdly, fostering an innovative culture grounded in employee empowerment and risk management can stimulate innovative behaviour among staff (Kahle et al., 2020). However, it's worth noting that, despite the potential benefits, SMEs do not actively encourage or practise innovative behaviour (Bello et al., 2024).

3. METHODOLOGY

In this particular study, a quantitative research approach was employed due to its suitability for measuring research objectives using numerical estimates and for comparing, describing, and connecting features (Hossain et al., 2024; Khumalo, 2019). This method aimed to provide a concrete and

quantifiable response to a specific research inquiry (Bell et al., 2018). Through descriptive analysis, researchers could identify, group, compare variables, and discern aspects relevant to the study (Gogo & Musonda, 2022; Farrelly et al., 2017; Fisher & Bloomfield, 2019).

The research focused on owners and managers of SMEs within the manufacturing industry in Pietermaritzburg, the capital city of KwaZulu-Natal, South Africa. According to the Msunduzi Municipality database, there are 142 registered manufacturing SMEs in this region. Given the population size in the Msunduzi Municipality database, census sampling was employed. Census sampling involves including all members of the population in the study to provide comprehensive information on the population as a whole (Berndt, 2020).

Primary data were obtained by sending questionnaires and electronic communications to a heterogeneous cohort of owners and managers. A 5-point Likert scale was used in the questionnaire to measure respondents' perceptions and attitudes toward innovative leadership and the use of smart manufacturing tools within SMEs. The Likert scale, ranging from "1" — "strongly disagree" to "5" — "strongly agree", is a widely accepted method for gauging the intensity of respondents' opinions and is effective in quantitative research for capturing attitudes and beliefs (Sekaran & Bougie, 2016; Berndt, 2020). This scale facilitated the analysis of various factors influencing leadership strategies and smart manufacturing adoption, providing a standardized way to compare responses. Although the survey initially targeted 142 manufacturing SMEs, only 103 participated, resulting in a response rate of 72.5%. This is seen as an appropriate rate of response since it was greater than 65%, which is regarded as significant in order for an analysis to be carried out (Gogo & Musonda, 2022; Sekaran & Bougie, 2016). Iqbal et al. (2020) adds that a response rate of 50% or more in a survey is considered excellent.

Statistical analysis was conducted using SPSS computer software version 25, employing inferential and frequency analysis to determine the reliability and evaluation of innovative leadership in smart manufacturing. The reliability of the research instrument was assessed using Cronbach's alpha coefficient, yielding a satisfactory coefficient of 0.865 (Etikan & Bala, 2017). Pre-testing was conducted to confirm the questionnaire's content validity, ensuring that the questions accurately addressed the research objectives (Gogo & Musonda, 2022; Sekaran & Bougie, 2016).

Moreover, each questionnaire was accompanied by an ethical clearance letter from the Durban University of Technology's Faculty Research Committee. Participants were required to provide consent before participating, and they were reassured that their sensitive information would remain confidential, adhering to standard research practices.

In addition to the quantitative research approach employed in the study, there are several alternative research methods that could be suitable for conducting similar research. These methods would offer different perspectives and insights into the research objectives:

Qualitative research approach: A qualitative approach could be employed to explore deeper insights into the experiences and perspectives of SME owners and managers within the manufacturing industry. This method is suitable for understanding the why and how behind decision-making and leadership strategies, focusing on subjective experiences rather than quantifiable data. In-depth, semi-structured interviews with SME owners and managers could be used to gather rich, detailed narratives about innovative leadership and smart manufacturing tools. Focus groups could facilitate group discussions that allow participants to interact and share their experiences collectively (Maisiri et al., 2021). Data collected from interviews and focus groups could be analyzed through thematic analysis to identify patterns, themes, and trends within the narrative responses (Sekaran & Bougie, 2016). This approach allows for a more nuanced understanding of the challenges and opportunities SMEs face and can provide insights into the contextual factors influencing their decisions.

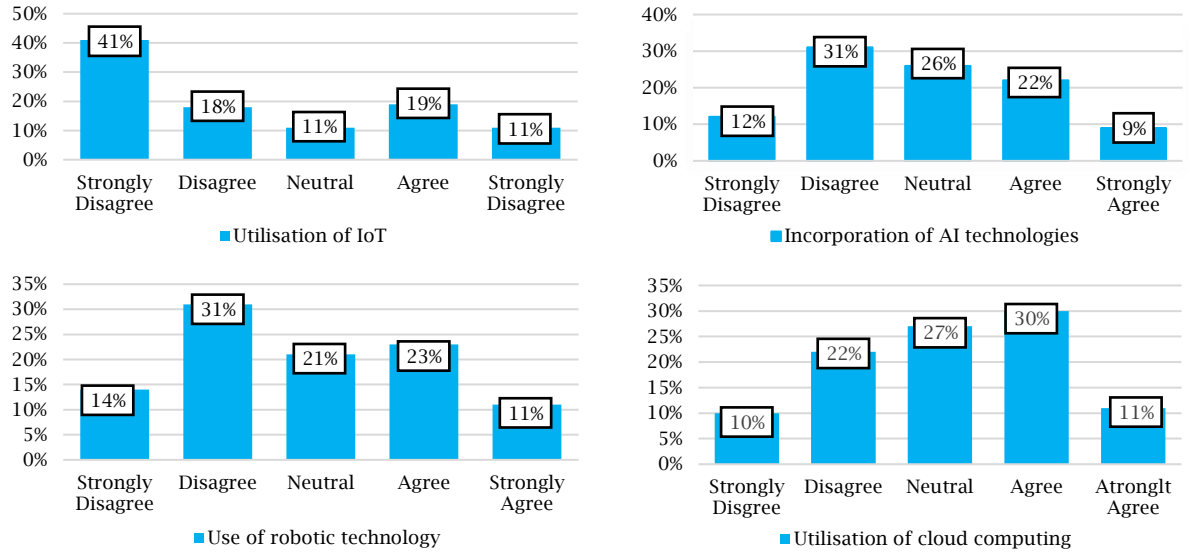
Mixed-methods approach: A mixed-methods approach combines both quantitative and qualitative techniques to provide a comprehensive view of the research problem. This method balances the strengths of both approaches, offering both numerical data and in-depth, contextual insights. In this approach, quantitative data could be collected first, using surveys or questionnaires similar to the original study. Following the analysis of these results, qualitative interviews or focus groups could be conducted to explore the findings in more detail (Gogo & Musonda, 2022). This allows for a deeper understanding of any unexpected results from the quantitative analysis.

4. RESULTS

The results of this research study are structured around two key components: the assessment of smart manufacturing tool utilisation and the analysis of innovative leadership practices among the investigated manufacturing SMEs. Figure 1 depicts the use of smart manufacturing technologies by SMEs in KwaZulu-Natal, illustrating both the adoption levels and potential impacts on organizational processes. The results show that manufacturing SMEs do not extensively use IoT technology in their production processes. This finding is concerning, given that smart manufacturing aims to maximize resource effectiveness and process efficiency through the integration of information and communication technology (Sinsel, 2020; Bello et al., 2024). Further statistical analysis was conducted, which shared deeper insights into these findings. For example, a t-test comparing IoT adoption between male and female respondents showed no statistically significant difference ($p = 0.216$), suggesting that *gender* is not a determining factor for IoT adoption within these SMEs. Furthermore, an Analysis of Variance test examining cloud computing adoption across different age categories also indicated no significant differences ($p = 0.508$). These results imply that demographic factors, such as *gender* and *age*, may not play a substantial role in the adoption of certain technologies within these SMEs.

The low adoption of AI technologies, as indicated by Figure 1, may be attributed to various barriers, such as a lack of awareness, financial constraints, and/or expertise. The correlation analysis supports this finding by demonstrating moderate positive correlations between AI and IoT adoption ($r = 0.63$), indicating that SMEs integrating one technology are more likely to consider adopting others. However, the limited uptake of AI and other advanced technologies like robotics (also highlighted in Figure 1) points to systemic challenges within these SMEs, potentially due to financial or resource limitations.

Figure 1. Utilisation of smart manufacturing technologies by SMEs

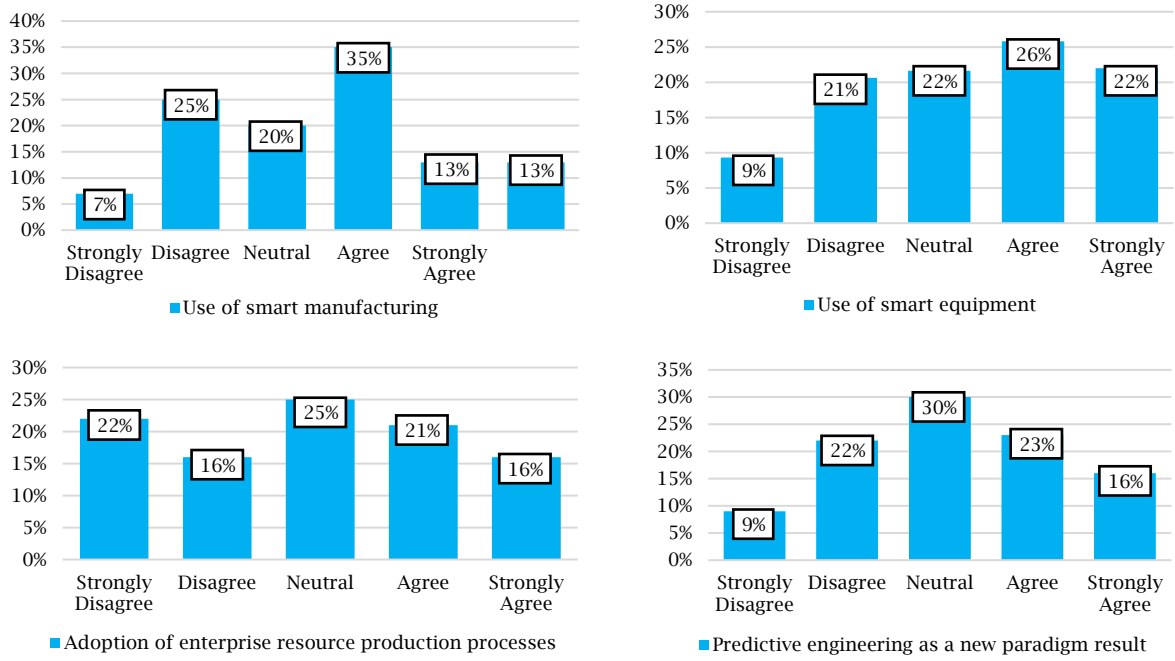


Source: Authors' elaboration.

Conversely, many companies are incorporating cloud computing into their production processes. Cloud computing's flexibility and cost-effective pay-as-you-go structure are responsible for its widespread adoption (Shivajee et al., 2019). The regression analysis reinforces this finding, as cloud computing emerged as a notable, though not statistically significant, predictor of innovative leadership practices. This aligns with prior research showing that cloud computing can foster leadership innovation by enhancing access to shared resources and data-driven decision-making.

Additionally, Figure 2 illustrates the utilization of various smart manufacturing processes among the investigated SMEs. The results suggest a gradual shift toward the fourth industrial revolution as companies transition from traditional manual production methods to modern, smart production techniques. Notably, the study found that nearly half of the respondents are utilizing predictive engineering, which represents a new paradigm for constructing high-fidelity models in business. Correlation analysis highlighted a moderate relationship ($r = 0.21$) between predictive engineering and innovative problem-solving practices, suggesting that SMEs adopting predictive engineering are more likely to implement structured approaches to innovation. This finding supports Liu's (2023) assertion that predictive engineering enables businesses to create high-fidelity simulations, providing valuable insights and predictive capabilities to enhance production processes.

Figure 2. Utilisation of smart manufacturing processes by SMEs



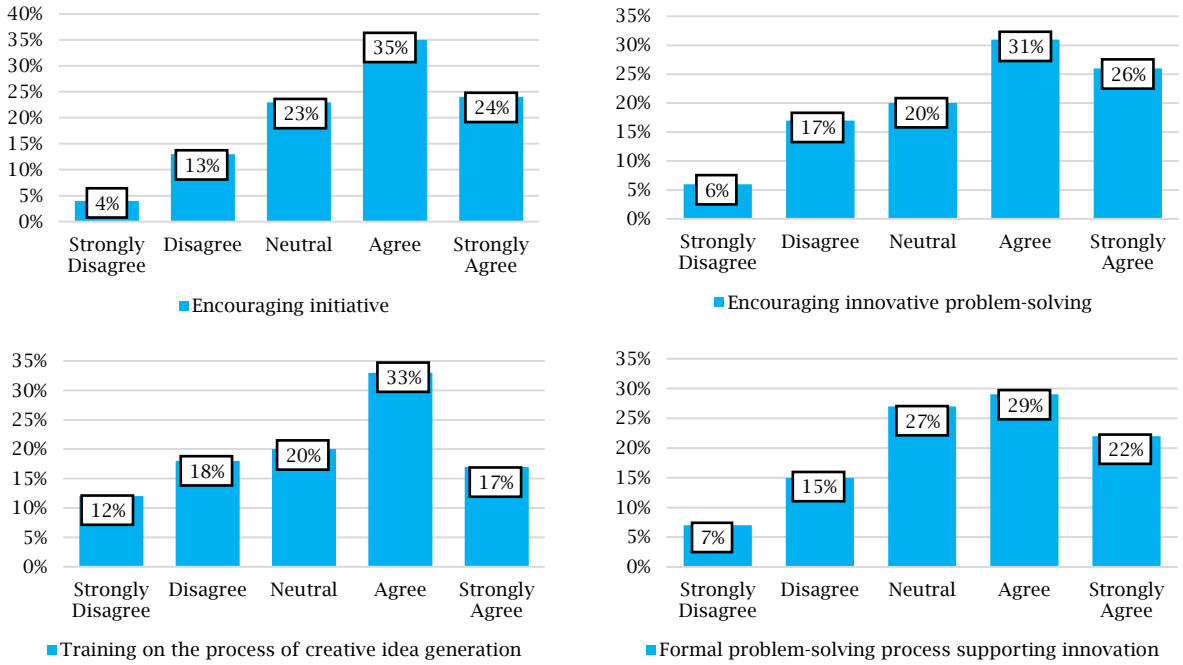
Source: Authors' elaboration.

The study also delves into innovative leadership practices adopted by the surveyed SMEs, as depicted in Figure 3. A key finding is the encouragement of teamwork, initiative, and problem-solving creativity among employees, essential factors for fostering an innovative and flexible work environment (Peter et al., 2023; Sichoongwe, 2023). The data indicates a high level of support for problem-solving creativity, as evidenced by the majority of SMEs actively encouraging workers to use such strategies. Correlation analysis reveals a strong correlation ($r = 0.64$) between teamwork and clarified responsibilities, suggesting that companies that encourage teamwork are also more likely to provide employees with a clear understanding of their individual responsibilities.

Additionally, the regression analysis suggested a possible relationship between clarified responsibilities and cloud computing adoption ($p = 0.058$), though not statistically significant. This could suggest that SMEs with clearly defined roles and responsibilities could benefit more from the collaborative capabilities of cloud computing, but more research is required to validate this connection.

Based on the results shown in Figure 3 and the analysis that goes with them, the main conclusion of the study, which was to look into innovative leadership practices, is that small and medium-sized businesses in the manufacturing sector are becoming more likely to use innovative leadership. Practices such as fostering a conducive working environment, actively supporting creative problem solving, and engaging in training activities to enhance idea-generation skills are central to this trend. Moreover, a notable proportion of the surveyed SMEs have implemented formal problem-solving procedures to facilitate innovation within their organizations.

Figure 3. Innovative leadership practices



Source: Authors' elaboration.

5. DISCUSSION

The first objective of this study was to determine the smart manufacturing tools utilised by manufacturing SMEs in Pietermaritzburg. The following variables are discussed in conjunction with the study's findings.

5.1. Use of IoT technologies

Bello et al. (2024) assert that manufacturing processes are significantly affected by advances in internet technology, specifically IoT. However, the study revealed that there is a limited adoption of IoT technology among manufacturing SMEs, despite its pivotal role in the ongoing shift from traditional to digital industrial practices. Manufacturing as a sector is in the midst of the fourth industrial revolution. IoT technologies are playing an important role in the shift of industrial practices from traditional to digital. Embracing these technologies is crucial for maintaining competitiveness in the manufacturing sector amidst the fourth industrial revolution, as they facilitate optimised resource utilisation and enhanced process productivity (Sichoongwe, 2023).

5.2. Incorporation of AI technologies

The findings indicate that the majority of SMEs are still not utilising AI technologies in their manufacturing process. AI holds potential for reducing machine downtime by enabling intelligent systems to predict maintenance needs (Shivajee et al., 2019). However, the reluctance of SMEs to adopt AI may stem from financial constraints and a lack of expertise in implementing such advanced technologies. Innovation within SMEs in the manufacturing sector, particularly in developing economies, is constrained by the high costs associated with information and communication technology (ICT) advancements (Ngibe & Lekhanya, 2019b).

5.3. Use of robotic technology

The results of this study suggest a limited adoption of robotics technology, despite its widespread application in improving manufacturing techniques and productivity across various industries. Manufacturing firms stand to benefit from employing robots for tasks such as welding, assembly, transportation, inventory management, and packaging, as automation streamlines processes and reduces time and costs (Bag et al., 2023). Additionally, autonomous robots enhance efficiency by optimising production time, resource utilisation, and product quality (Peter et al., 2023). Therefore, prioritising digitisation is essential for manufacturing SMEs in Sub-Saharan Africa to remain competitive and drive growth.

5.4. Utilisation of cloud computing

The study findings highlight the widespread adoption of cloud computing among manufacturing SMEs, attributed to its flexibility and cost-effective pay-as-you-go structure. Cloud computing enables modern manufacturing by facilitating remote data access, eliminating the need for on-premises infrastructure and software. Manufacturing firms leverage cloud computing to capture machine data and store it for subsequent analysis in their smart manufacturing setups.

In addressing the second objective, which aimed to analyse innovative leadership practices adopted by SMEs in the manufacturing sector, the study uncovered several key findings. Firstly, SMEs are typically managed by individuals exhibiting initiative and enthusiasm traits. These traits signify a genuine interest and drive to achieve objectives, coupled with a willingness to explore new and unconventional approaches to reach those goals. Moreover, organisations demonstrate an understanding and appreciation for innovative problem-solving techniques by actively encouraging employees to implement them. These findings align with the research conducted by Sahoo and Yadav (2018), who concluded that effective leaders in smart manufacturing SMEs prioritise staff skill development, leading to enhanced employee involvement in creative activities. Specifically, the study found that SMEs prioritise training as the primary method for enhancing employees' creative idea-generation skills.

This finding corroborates earlier research by Kahle et al. (2020), highlighting the importance of skills development and training for fostering innovation and long-term growth in manufacturing SMEs. As the demand for higher-order thinking skills such as innovation, production, and analytical abilities continues to rise, investing in skill development becomes increasingly imperative for SMEs operating in the manufacturing sector.

The study's overall conclusion supports the existence of innovative leadership practices among SMEs in the manufacturing sector. These practices, including task orientation, encouraging initiative, and promoting innovative problem-solving, serve as crucial mechanisms for advancing the smart manufacturing agenda within these organizations. By fostering a culture of innovation and continuous improvement, SMEs can enhance their competitiveness and adaptability in an ever-evolving business landscape.

6. CONCLUSION

This study offers valuable insights into the adoption of smart manufacturing tools and innovative leadership practices among SMEs in an emerging economy. The findings have several practical and theoretical implications for the SME sector, policymakers, and future research.

Practical implications for SMEs: The study reveals that while there is a limited adoption of advanced technologies like IoT, AI, and robotics, there is a notable adoption of cloud computing. This suggests that SMEs are more inclined to integrate cost-effective, scalable technologies that do not require extensive infrastructure investments. SMEs can leverage this insight to prioritize investments in cloud computing and similar technologies that align with their budget constraints while gradually exploring avenues for implementing more advanced technologies as they become more accessible.

Leadership and organizational implications: The presence of innovative leadership practices among SMEs demonstrates a willingness to encourage creativity and problem-solving within their organizations. However, for smart manufacturing adoption to advance further, SME leaders must continue fostering an innovative culture and consider investing in training programs to build technical skills within their teams. This will allow SMEs to overcome barriers to adopting more complex technologies, thus strengthening their competitive position in the industry.

Policy implications: The low adoption of certain smart manufacturing tools underscores the need for supportive policies and incentives that promote digital transformation in the SME sector. Policymakers could develop initiatives to subsidize the cost of advanced manufacturing technologies and provide technical support and training for SMEs. Such support could accelerate technology adoption, thereby boosting productivity and long-term viability in the manufacturing sector.

Theoretical implications: By employing the DIT, TAM, and CLT, the study adds to the theoretical understanding of technology adoption and leadership practices in small manufacturing firms. The findings suggest that the integration of these theories can effectively explain the challenges and facilitators of smart manufacturing adoption, offering a robust framework for future studies on technological and leadership innovations in SMEs.

Despite its contributions, this study has certain limitations, which provide opportunities for further research. The study focused solely on manufacturing SMEs, which limits the generalizability of the findings to other sectors within the SME sphere. Future research could expand to include SMEs in diverse sectors, such as services, retail, or agriculture, to examine whether the adoption patterns and leadership practices observed in this study are consistent across different industries. Additionally, the study was conducted in KwaZulu-Natal, South Africa. As such, the findings may not fully represent SMEs in other regions, especially those with varying access to resources, infrastructure, and market dynamics. Future studies could conduct comparative analyses across regions or conduct cross-country studies to understand the role of contextual factors in smart manufacturing adoption and leadership practices. Moreover, this research utilized a quantitative approach, which, while useful for gathering broad

insights, limits the depth of understanding regarding the experiences and perspectives of SME owners and managers. Future research could employ a mixed-methods approach, combining quantitative surveys with qualitative interviews or focus groups. This would allow researchers to explore the motivations, challenges, and experiences of SME leaders in more detail, providing richer insights into the adoption of smart manufacturing and innovative leadership.

Ideally, all business owners, managers, and decision-makers have a common objective, which is to maximise profits and increase stakeholders' value while ensuring the sustainable growth of the business. This means that these stakeholders need to adopt innovative leadership to improve and maintain their business performance. To remain relevant and constantly upgrade their manufacturing processes in the present ever-changing environment, it is important that they incorporate contemporary innovative leadership into their business strategies. This will help to enhance their business performance, strengthen their competitive edge, and improve their market value, allowing the business' stakeholders to formulate better strategies for ensuring sustainable growth and thus helping to reduce the currently unacceptably high business failure rate amongst these entities.

The study only focused on smart manufacturing SMEs and did not consider other sectors within the sphere of SMEs. Therefore, it is recommended that future studies encompass other sectors within the SME sphere and investigate the adoption of innovative leadership in those enterprises. The findings of this study revealed that innovative leadership is still a new phenomenon but is considered relevant and has been adopted by some manufacturing SMEs, especially given the rapidly changing environment. This suggests that a comparable study should be conducted to examine the relevance of innovative leadership to the business performance achieved in other sectors. The study employed a quantitative research method. Thus, it is proposed that another study could utilise a mixed-methods approach to gather a broader spectrum of data and expand the body of knowledge in this field.

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