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Optimising Sustainable Manufacturing in Ekurhuleni's Small, Medium and Microenterprises through Technological Production Management Tools

Keywords:
Sustainable manufacturing, SMMEs, production management tools, technology adoption barriers, dynamic capabilities

Abstract

This research examines how Small, Medium, and Micro Enterprises (SMMEs) in Ekurhuleni Municipality can optimise sustainable manufacturing practices through the adoption and effective utilisation of technological production management tools. The research surveyed 300 manufacturing SMMEs through an online questionnaire using Google Forms from a total population exceeding 4,000. The research team used SPSS v28.0 to evaluate the responses. A total of 223 responses (74.3%) indicated agreement or strong agreement with the need for access to technological production manufacturing tools, showing that the majority recognise the importance of technological production management tools despite challenges in full utilisation. The survey tool evaluated how well SMMEs access technological resources and their effectiveness difference between what manufacturers value in technological tools and their current ability to access these resources. The research results show that numerous businesses understand the value of these tools, yet they do not have the necessary infrastructure or skills to deploy them. The research results identify three main obstacles that prevent technological adoption through high implementation expenses, insufficient digital skills and insufficient policy backing.

The research results provide essential guidance for developing strategies to increase technological adoption in the manufacturing sector.

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1. Introduction

Multiple industries now focus on the increasing complexity and interconnectedness of production systems metrics (Feng et al., 2020). The productivity ratio between system outputs and their corresponding input requirements define these metrics (Feng et al., 2020). Furthermore, productivity exists as a mathematical relationship that connects output quantities to input quantities (Davies et al., 2021). The measurement helps nations determine their ability to convert production resources, including labour and capital, into desired output results (Deng et al., 2022). The assessment of national performance through productivity plays an essential role in economic development and global market competitiveness (Osaulenko et al., 2020). Productivity emerges through the commercial application or institutional adoption of new concepts (Juhász et al., 2024). Production management systems need institutional frameworks to monitor operations and guide product and service development and market entry (Fuertes et al., 2020). Managing production requires organisations to integrate innovation management (Lopes et al., 2022). Organisations use production management as a strategic approach to create and spread innovative practices and systems and products throughout their entire operations (Hegab et al., 2023). The implementation of new business practices for operational enhancement and task restructuring and innovation development defines productivity management (Nour & Arbussà, 2024; Buriak et al., 2022). Organisations enhance their operational performance through the implementation of new products and processes and organisational practices, which include innovative goods and manufacturing methods and distribution systems and raw material acquisition and business models (Abdulkader et al., 2020). A productivity management system functions as an organised framework that controls the development, manufacturing and market launch of innovative business solutions, and products and services (Butt, 2020). The competitive nature of modern markets requires SMMEs operating in Ekurhuleni Municipality to adopt innovative technologies for survival (Mashau, 2023). The restricted availability of technological production management systems to SMMEs creates an existential threat for their future development and expansion (Naradda Gamage et al., 2020). Research has examined how SMMEs view these tools while determining which obstacles prevent them from using these tools for sustainable manufacturing (Alayón et al., 2022). The development of specific support programmes requires solutions to these problems to build a sustainable manufacturing sector in Ekurhuleni (Khaisi, 2022). The manufacturing sector depends on SMMEs to drive economic expansion and employment growth in its modern development (Serumaga-Zake & van der Poll, 2021).

The technological integration of production management tools has become essential for Ekurhuleni-based businesses to achieve sustainability targets and increase their operational performance (Netshishivhe, 2021). The production tools help businesses achieve sustainable manufacturing by helping them reduce waste and improve operational efficiency and resource utilisation (Hegab et al., 2023; Dubey et al., 2024). SMMEs face major challenges when trying to obtain and deploy these technologies (Telukdarie et al., 2023). The combination of financial restrictions and insufficient training and insufficient knowledge about technological advantages hinders SMMEs from competing effectively in international markets (Indrawati et al., 2020). The process of adoption of technology becomes more difficult because organisations need to match their internal operations with external market requirements (Saghafian et al., 2021). The majority of Ekurhuleni manufacturing SMMEs face obstacles to technological production management tool adoption because they lack proper training and access to these innovations (Bimha & Primrose, 2021; Murairwa, 2022; Mashau, 2023). Studies demonstrate productivity and innovation management value, but there are insufficient data concerning the adoption of SMME technological production tools in the manufacturing sector (Mittal, 2020; Gaglio et al., 2022; Matekenya & Moyo, 2022; Kgakatsi et al., 2024). Furthermore, the specific obstacles that manufacturing SMMEs encounter when attempting to match their internal operations with market requirements remain unclear in sustainable manufacturing contexts (Sahoo, 2020; Azevedo & Almeida, 2021; Kazantsev et al., 2022; Krishnan, 2024). This research aim to examine how SMMEs in Ekurhuleni Municipality can optimise sustainable manufacturing practices through the adoption and effective utilisation of technological production management tools. To achieve this research objective the study will respond to the following research questions: (1)To what extent do manufacturing SMMEs in Ekurhuleni currently have access to technological production management tools? (2) How effectively are these tools being utilised to support sustainable manufacturing operations?. The research results will help create strategic programmes that boost the competitiveness and sustainability of local businesses operating in the manufacturing sector.

2. Literature Review

Importance of Production Management in SMMEs

Production management at organisations requires the creation of operational frameworks that convert initial materials into finished products and services (Adams, 2022; Kazantsev et al., 2022). The field stands as a fundamental component of business innovation strategy (Kgakatsi et al., 2024), yet SMMEs use it less than larger organisations do (Khaisi, 2022). SMMEs perform more non-manufacturing activities, yet their production activities remain significant for business operations (Krishnan, 2024). The frequency of innovation exists across all business sizes, but SMMEs have higher innovation rates (Lopes et al., 2022). Production management is a critical operational strategy that helps businesses achieve better competitiveness and operational efficiency (Makondo, 2021). Research studies have not fully explored how production management software functions in actual business operations (Mangwana, 2020). The link between innovation and economic performance and organisational success remains strong, especially for SMMEs (Mashau, 2023). The combination of production management with innovation enables businesses to create market-driven products that help them reach their financial targets (Kazantsev et al., 2022).

Barriers to Technological Adoption

SMMEs generate significant R&D-driven innovation, but their creative output stems from multiple sources (Matekenya & Moyo, 2022; Maziriri et al., 2025; Mbonyane, 2022). Managers today focus on product and service quality improvement because they want to increase productivity and maintain business sustainability (Mbonyane et al., 2023). The limited deployment of technological production systems acts as a barrier that restricts SMMEs from achieving their full potential (Mbuyane, 2020). Organisations need to implement both technological and non-technological innovations to succeed in today's competitive market environment (Mittal et al., 2020). The ability of SMMEs to perform incremental innovation well through their agility becomes more powerful when they implement organisational improvements (Mulligan et al., 2024). SMMEs use global best practices as their innovation approach, but this approach should not be confused with creating original innovations (Murairwa, 2022). The link between innovation and survival strategies remains critical for SMMEs operating in competitive markets (Naradda Gamage et al., 2020). The challenges impacting the growth of SMMEs textile enterprises highlight the importance of innovation adoption (Netshishivhe, 2021).

Strategic Integration of Production Processes

This section explores innovation-driven production typologies, which are essential for understanding how organisations enhance productivity and competitiveness through varying degrees of innovation. Production practices are broadly classified into two categories: radical production, which involves the development of entirely innovative technologies, and knowledge that significantly transforms organisational capabilities and incremental production, which focuses on gradual improvements to existing products or processes through low-risk, cost-effective modifications. By distinguishing between these typologies, firms, particularly SMMEs manufacturing sector, can better align their innovation strategies with market demands and operational contexts, fostering adaptability and sustained growth.

Radical production

The production method of radical manufacturing enables organisations to develop completely new products that create new knowledge bases (Ngomana, 2023). It transforms organisational capabilities through the introduction of fundamental innovative technologies and solutions (Nour & Arbussà, 2024). The development process of revolutionary technologies has led to new operational standards that push beyond traditional production limits (Ntuli, 2022). Organisations use their research activities and innovative thinking to develop original concepts that drive their value creation process (Osaulenko et al., 2020). The implementation of radical production requires major resources for research and development, cross-disciplinary teams, and an environment that supports experimentation and risk management (Saghafian et al., 2021). Radical innovations lead to market disruption and new market creation, providing organisations with competitive advantages in demanding business environments (Sahoo, 2020). Organisations that want lasting business expansion through market differentiation should adopt this method because it allows them to create revolutionary products and services that outperform competitors (Ngomana, 2023). Radical innovation also helps organisations develop their ability to learn and adapt, enabling them to manage technological changes and evolving customer requirements (Nour & Arbussà, 2024).

Incremental production

The method of incremental production involves the continuous improvement of existing innovations and methodologies through small-scale modifications (Shang et al., 2020). It focuses on making minimal adjustments to existing products and processes, resulting in fast and affordable outcomes (Telukdarie et al., 2023). The system allows organisations to optimise their operations and redesign components, which improves productivity and performance (Serumaga-Zake & van der Poll, 2021). Incremental innovation helps organisations adapt to market changes and maintain stability during times of disruption, including lockdowns (Bimha & Primrose, 2021). This method provides businesses, particularly SMMEs, with an affordable way to stay competitive because it avoids expensive and risky radical innovation approaches (Setshedi, 2022). Organisations can adapt their products and services through ongoing development based on customer needs, market trends, and regulatory requirements (Alayón et al., 2022). It also promotes employee development through learning and adaptation, allowing staff to detect operational flaws and create solutions for improvement (Bugwandin, 2022). The gradual accumulation of improvements over time produces substantial advantages in terms of operational performance, customer satisfaction, and market agility, establishing incremental production as a fundamental element for business sustainability (Andreoni et al., 2021). Production management serves as a fundamental strategy that helps businesses achieve competitiveness and sustainability by aligning operations with market requirements (Abdulkader et al., 2020). The implementation of modernisation strategies leads to stronger customer loyalty, increased revenue, and improved business performance (Adams, 2022). SMMEs can achieve business expansion and regulatory compliance through process, service, and marketing innovations, as well as the adoption of innovative technologies (Azevedo & Almeida, 2021). Organisations must maintain continuous effort and flexibility to sustain innovative progress and remain competitive globally (Ahmad & Van Looy, 2020). The strategic use of production initiation has become a key factor for competitiveness in manufacturing innovation research (Adla et al., 2020; Buriak et al., 2022).

Production Management Processes

Production management processes involve strategic resource management, workflow optimisation, and technology implementation to convert raw materials into valuable end products with maximum efficiency (Butt, 2020). A properly designed organisational structure and productivity management system enables operational efficiency through task alignment with organisational targets, which simultaneously boosts team and individual performance (Fuertes et al., 2020). The framework unites planning systems with execution and monitoring systems to maintain production activities at consistent levels with high quality and flexibility (Dubey et al., 2024). It establishes operational excellence and continuous improvement throughout departments through its fundamental role (Deng et al., 2022). Organisations need to identify multiple production methods because productivity research requires understanding how organisations generate value through different approaches (Feng et al., 2020). Outputs include physical products, services, and knowledge-based solutions (Davies et al., 2021). Production managers who understand these differences can create customised strategies for operations, whether in standard manufacturing or complex knowledge work (Didonet, 2020). This expanded view of production management extends its application beyond conventional manufacturing facilities to diverse business settings (Gaglio et al., 2022). Productivity includes incremental and radical innovation, process efficiency, product effectiveness, and organisational and marketing function productivity (Dossou-Yovo & Keen, 2021). Incremental production methods improve existing processes, whereas radical innovations create new value delivery approaches (Dubey et al., 2024). Assessing marketing and organisational structure productivity helps organisations understand how internal systems and external relationships affect overall performance (Fuertes et al., 2020). Production management has evolved into a complete field that enables organisations to achieve sustainable competitiveness through its integrated approach to innovation (Gaglio et al., 2022).

Innovation and Flexibility in SMMEs

This section explores innovation-oriented production practices as a multidimensional framework for enhancing organisational performance, competitiveness, and adaptability. It examines three distinct yet interrelated forms of production: technological, non-technological, and organisational. The successful delivery of products to markets requires efficient systems because it determines production success (Butt, 2020; Fuertes et al., 2020). Businesses need to implement innovative production methods because globalisation and technological progress require them to remain competitive and relevant in the market (Davies et al., 2021). SMMEs encounter additional innovation obstacles because they lack sufficient resources and experience (Deng et al., 2022). They maintain their position as innovative organisations because they operate with less bureaucracy and greater flexibility than larger companies do (Didonet, 2020; Dossou-Yovo & Keen, 2021). Their flexibility enables them to create innovative technologies, marketing approaches, and business models (Dubey et al., 2024). The innovation process at SMMEs often operates through basic human-based methods that use unstructured approaches instead of complex systems (Feng et al., 2020). The innovation potential of SMMEs depends on their ability to maintain cost efficiency and deliver customer satisfaction while following regulations and building their reputation (Gaglio et al., 2022). Organisations that implement multiple innovation approaches that combine products, processes, and services enhance their market performance and risk management (Fuertes et al., 2020).

Technological production

The production of technology requires multiple tools, equipment, systems, and instruments to create automated solutions, cloud-based platforms, and advanced data analytics (Hegab et al., 2023). These technologies function to optimise production operations within organisational systems (Indrawati et al., 2020). Technological production is defined as the method organisations use to create new products, services, and procedures through strategic development (Juhász et al., 2024). Academics are now devoting more attention to technological progress because of its increasing importance in production research (Kazantsev et al., 2022). The development of structured R&D initiatives with sufficient resources occurs mainly in capital-intensive industries, even though these initiatives come with substantial expenses (Kgakatsi et al., 2024). The success of R&D activities determines how well organisations maintain their technological capabilities and achieve higher productivity levels and market dominance (Khaisi, 2022). Innovative technology development affects performance indicators that drive business expansion and economic development (Krishnan, 2024). Organisations use technological production to decrease infrastructure requirements while obtaining competitive advantages (Lopes et al., 2022). Organisational transformation depends heavily on technological production, enabling enhanced operational performance and competitive advantage, which makes it a popular choice for businesses that want to stay competitive in fast-changing markets (Makondo, 2021; Mangwana, 2020; Mashau, 2023; Matekenya & Moyo, 2022).

Non-technological production

Non-technological production is defined as the implementation of marketing-related activities used to establish an organisation's credibility and reputation externally rather than generating value from within (Maziriri et al., 2025). Employing these methods increases the likelihood that an organisation will meet its objectives more quickly than one that does not (Mbonyane, 2022). The addition and augmentation of technological breakthroughs by Non-technological improvements is equally important (Mbonyane et al., 2023). In addition to conventional R&D and technological innovations, Non-technological production research is gaining popularity and is increasingly being considered (Mbuyane, 2020). Non-technological production increases a company's ability to compete in the market and benefits both the customer and the business (Mittal et al., 2020). It serves dual purposes because it creates strategic advantages while simultaneously building customer relationships and brand loyalty (Mulligan et al., 2024). Organisations can establish market differentiation through external-facing initiatives such as marketing campaigns, customer relationship management, and reputation-building efforts (Murairwa, 2022). The commercialisation of technological innovations receives support from these practices, which increases their impact by helping customers understand and appreciate the organisation's products (Naradda Gamage et al., 2020). Businesses need Non-technological production to maintain their market position because consumer demands and digital transparency require organisations to build trust and achieve sustainable growth (Maziriri et al., 2025).

Organisational production

Organisational production operates differently than technological production because it focuses on transforming organisational culture, policies, and norms instead of adopting innovative technologies (Netshishivhe, 2021; Ngomana, 2023). The process requires organisations to adopt new management approaches and operational redesigns that affect workplace structures, external partnerships, workflow systems, and human resource management practices (Nour & Arbussà, 2024; Ntuli, 2022). It emphasises institutional development through administrative and managerial innovations that directly influence organisational routines (Osaulenko et al., 2020). Organisational production functions as a framework enabling companies to execute structural changes for technological progress and works together with technological innovations to achieve implementation goals (Saghafian et al., 2021). It serves as a critical element for businesses to achieve successful product commercialisation in today's fast-paced global market (Sahoo, 2020; Serumaga-Zake & van der Poll, 2021). The implementation of organisational production leads to better business results, expanded operations, market dominance, decreased operational expenses, higher staff satisfaction, and enhanced resource management (Setshedi, 2022; Shang et al., 2020). Selecting an appropriate organisational production model becomes challenging because of its complexity when trying to achieve maximum results from product innovation (Telukdarie et al., 2023).

Production Management Models

This section presents essential production management models that guide operational strategies throughout different industrial sectors. The production process includes four main categories: job production, batch production, flow production, and the manufacturer business model. The production models present different methods for organising work activities because they start with individualised client orders in job production and end with continuous mass production in flow production. The batch production method combines efficient production with flexible output levels through defined quantity production. The manufacturer business model generates value by uniting raw materials with operational systems and market delivery systems. Organisations use these models to create complete systems for production management, which helps them respond to them (see Figure 1).

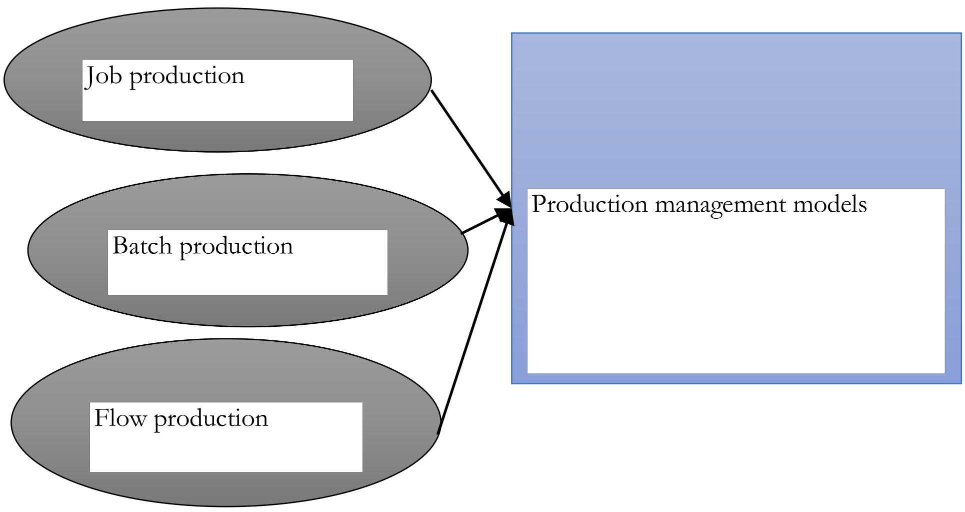

Figure 1: Production management models (Author Construction)

Job production

Job production involves making a small number of customised products that fulfil individual customer needs (Hegab et al., 2023). This method allows businesses to transform their operations through direct customer need fulfilment (Indrawati et al., 2020). Research has demonstrated that job production requires organisations to modify operational elements for new products and services until they match customer requirements (Juhász et al., 2024). The concept includes product and market development alongside design innovation and component modernisation or substitution (Kazantsev et al., 2022). The institutional renewal process depends on combining internal organisational abilities with external specialised knowledge (Kgakatsi et al., 2024). The strategic value of job production remains understudied within Sub-Saharan African emerging economies because researchers have not fully examined its application by SMMEs (Khaisi, 2022). Current research focuses on large companies and technological businesses while overlooking how SMMEs in emerging markets use this approach to develop innovative products and maintain market leadership in resource-constrained settings (Krishnan, 2024). Job production enables SMMEs to achieve adaptive growth, market differentiation, and sustainable competitiveness (Indrawati et al., 2020). This research expands the knowledge about production types and their influence on SMMEs' innovation development (Hegab et al., 2023).

Batch production

The manufacturing process of batch production involves creating identical products in large batches at one time instead of making individual products. Manufacturers maintain control over production output and resource management by setting batch quantities and production schedules (Bugwandin, 2022). The system implements advanced methods to increase operational flexibility, reduce expenses, and improve product and service quality (Buriak et al., 2022). Batch production becomes vital for achieving operational efficiency and service consistency once product design is complete (Butt, 2020). Despite its advantages, the operational benefits of batch production have not received sufficient research attention regarding its application in the developing economies of SMMEs (Davies et al., 2021). Most research has focused on large-scale industrial applications, overlooking how SMMEs use batch production to manage restricted resources and adapt to changing market requirements (Deng et al., 2022). This study investigates Ekurhuleni Municipality SMMEs that adopt batch production to achieve cost effectiveness, product excellence, and business expansion under constrained market conditions (Didonet, 2020; Dossou-Yovo & Keen, 2021). The findings provide detailed knowledge about production methods suited to the operational needs of businesses in developing markets (Dubey et al., 2024; Feng et al., 2020).

Flow production

The production method known as flow production, or continuous production, enables manufacturers to produce products sequentially through an assembly line (Abdulkader et al., 2020). The system maintains continuous product movement between stages, resulting in large-scale production of identical items over time (Adams, 2022). Flow production implements risk management through its structured, collaborative, and adaptive operational framework (Adla, 2020). The strategic model of flow production requires organisations to develop service delivery systems continually to improve customer satisfaction (Ahmad & Van Looy, 2020). It emphasises deploying new or enhanced services that create business value by fulfilling changing customer requirements (Alayón et al., 2022). The commercial impact of flow production depends on its ability to improve operational management and service delivery mechanisms, generating value for stakeholders, including employees, customers, partners, and public entities (Andreoni et al., 2021; Azevedo & Almeida, 2021). Academic studies examine flow production through two approaches: linking it to technological advancement and viewing it as a service-based production system (Bimha & Primrose, 2021). Organisations use either process-based or outcome-based approaches to create new value propositions (Saghafian et al., 2021). Successful adoption depends on aligning internal operational systems with market forces and environmental elements (Sahoo, 2020). Customer feedback becomes essential for organisational success, as resource provision enables customers to increase their personal value generation (Serumaga-Zake & van der Poll, 2021). Major companies such as IBM and Starbucks have implemented flow manufacturing to fulfil customer requirements (Setshedi, 2022). However, the long-term sustainability of flow production faces uncertainty because evolving markets force businesses to modify operations and product lines to remain competitive (Shang et al., 2020). Current research largely investigates large corporations in stable markets while failing to explain how SMMEs use flow production to increase agility, customer service, and operational performance. This study investigates how South African SMMEs implement flow production models to maintain competitiveness while delivering value in dynamic business environments (Telukdarie et al., 2023).

3. Theoretical Framework for SMMEs Technological Production Management

Dynamic capability theory (DCT) explains how barriers and enablers affect innovation results in SMMEs. Modern technological systems prevent revolutionary innovation from occurring, but managers who focus on modernisation will achieve better results through incremental innovation (Mbuyane, 2020; Mbonyane et al., 2023; Adams, 2022). Organisations can adopt new innovations that fulfil customer needs by implementing technological changes and organisational structure modifications and marketing strategy development (Mittal et al., 2020; Azevedo & Almeida, 2021). The combination of the technological, organisational and marketing domains results in superior performance because it connects production management to innovation operations (Fuertes et al., 2020; Dossou-Yovo & Keen, 2021). The production management system functions as an integrated system that helps organisations manage market instability and competitive demands (Dubey et al.,2024; Ahmad & Van Looy, 2020). The combination of incremental innovation provides budget-friendly solutions for stability, but radical innovation enables market differentiation through disruptive market entry (Ngomana, 2023; Sahoo, 2020). Organisations need to maintain ambidexterity because it enables them to achieve lasting market competitiveness (Andreoni et al., 2021; Bimha & Primrose, 2021). The development of production management as a dynamic capability enables SMMEs to manage resource limitations while building organisational resistance (Makondo, 2021; Naradda Gamage et al., 2020). The framework identifies production management as the core organisational system, which helps businesses identify market potential and execute operational changes for growth (Kazantsev et al.,2022; Gaglio et al.,2022). DCT establishes a unified method to study how SMMEs maintain their long-term success through a mix of incremental development and revolutionary innovation.

4. Research Methodology

The research used quantitative methods through an online survey in which directors and senior staff members from manufacturing SMMEs in Ekurhuleni Municipality completed the survey. It used a positivist approach as its methodological foundation. The South African Black Automotive Chamber of Commerce and Industry (2021) reported that Ekurhuleni contains 4,000 manufacturing businesses, 1,260 of which are classified as SMMEs. The majority of these businesses operate at a lower level, with one owner running the business and maintaining a workforce under 20 employees. This research used simple random sampling to build its sample frame by extracting data from manufacturing firm databases that showed active and current operations. The researchers selected 300 participants from the 4,000 companies through probability-based random sampling to achieve a 95% confidence level. The survey instrument used closed-ended questions with 5-point Likert scale measurements, which experts from academia validated before distribution. The survey link reached participants through email messages, which stated that only manufacturing firm owners and managers and professionals should participate in the survey. A total of 223 valid responses were obtained, which produced a 74% response rate that Rubin and Babbie (2011) considered suitable for analysis. The research team obtained ethical approval before starting data collection, while participants received a study description and survey access through an information sheet. The study provided participants with complete freedom to exit the research at any point. The data were exported to Microsoft Excel before being transferred to SPSS version 28.0 for analysis. Exploratory factor analysis was used to check construct validity, and Cronbach's alpha was used to measure internal reliability.

5. Results and Discussions

The survey results concerning technological production management tool availability and usage in Figure 2 show how respondents view these tools in their organisations. The survey results revealed that 17% to 21% of the participants chose neutral answers, which indicates that they had mixed feelings about the situation. The survey results revealed different levels of agreement between participants who answered between 29.6% and 65%, while the total agreement rate reached 32.3%. The survey results show that only 29.6% of the participants agreed or strongly agreed with statement B1, which indicates their doubts about complete tool utilisation. The survey results show that more than half of the participants agreed or strongly agreed with statements B4 through B13, but only 29.6% agreed with statement B1 about full tool utilisation in production management. Research that demonstrates that these innovation types work together to increase productivity reveal that Ekurhuleni manufacturing SMMEs use both technological and non-technological instruments for their operations (Hegab et al., 2023; Indrawati et al., 2020). The survey results show that 42.2% of the participants implemented radical innovation through new product and process development and that 41.7% of the participants acquired production management tools. The survey results revealed that 41.7% of participants faced difficulties when trying to obtain these tools, which matches common obstacles found in resource-limited settings (Juhász et al., 2024; Kazantsev et al., 2022). The research results show that SMMEs focus more on service and product development than on business and process development, which aligns with previous studies on SMME operational preferences (Kgakatsi et al., 2024; Khaisi, 2022). The statistical evaluation confirmed that between 17% and 65% of the participants provided neutral answers and that the total agreement percentage reached 32.3%. The low level of support for statement B1 might stem from the fact that SMME owners and managers directly experience production tool capabilities and restrictions during their daily work activities.

The study results might have been affected by participants' optimistic views or unrealistic expectations because they did not take place in an actual operational environment. This research highlights a fundamental knowledge gap because most studies on production management focus on theoretical aspects and strategic applications, yet few have investigated how SMMEs actually use these tools. This research provides detailed operational insights into production management in restricted environments through survey results, which demonstrate the need for additional field-based research. While the survey highlights the realities confronting manufacturing SMMEs in Ekurhuleni, it simultaneously reveals a broader empirical blind spot within production-management scholarship. A substantial portion of the literature fixates on frameworks and abstract theoretical models (Mangwana, 2020; Kgakatsi et al., 2024), yet there remains a dearth of inquiry into how these instruments are truly adopted, tweaked or even contested in practice. The gap between theory and practice aligns with what innovation scholars have observed: SMMEs often out-innovate their rivals. They tend to struggle with systematically integrated tools (Lopes et al., 2022). The survey not only highlights the day-to-day realities of Ekurhuleni's manufacturing SMMEs but also reveals a broader empirical gap in the production-management literature. Although studies have focused on frameworks and theoretical constructs (Mangwana, 2020; Kgakatsi et al., 2024), only a few of them have examined how these instruments are reshaped or even resisted in everyday practice. This theory-practice gap echoes findings from the innovation literature, which points out that SMMEs often out-pace them in generating ideas yet struggle to embed such tools into a coherent systematic routine (Lopes et al., 2022). The survey findings feed into an expanding body of research that underscores how production management underpins the edge of SMMEs. Scholars such as Makondo (2021) and Mashau (2023) contend that production management is far more than a routine and functions as a catalyst for innovation and economic performance. The modest uptake of tools in real-world settings highlights a pressing need for field-based investigations that go beyond purely theoretical prescriptions.

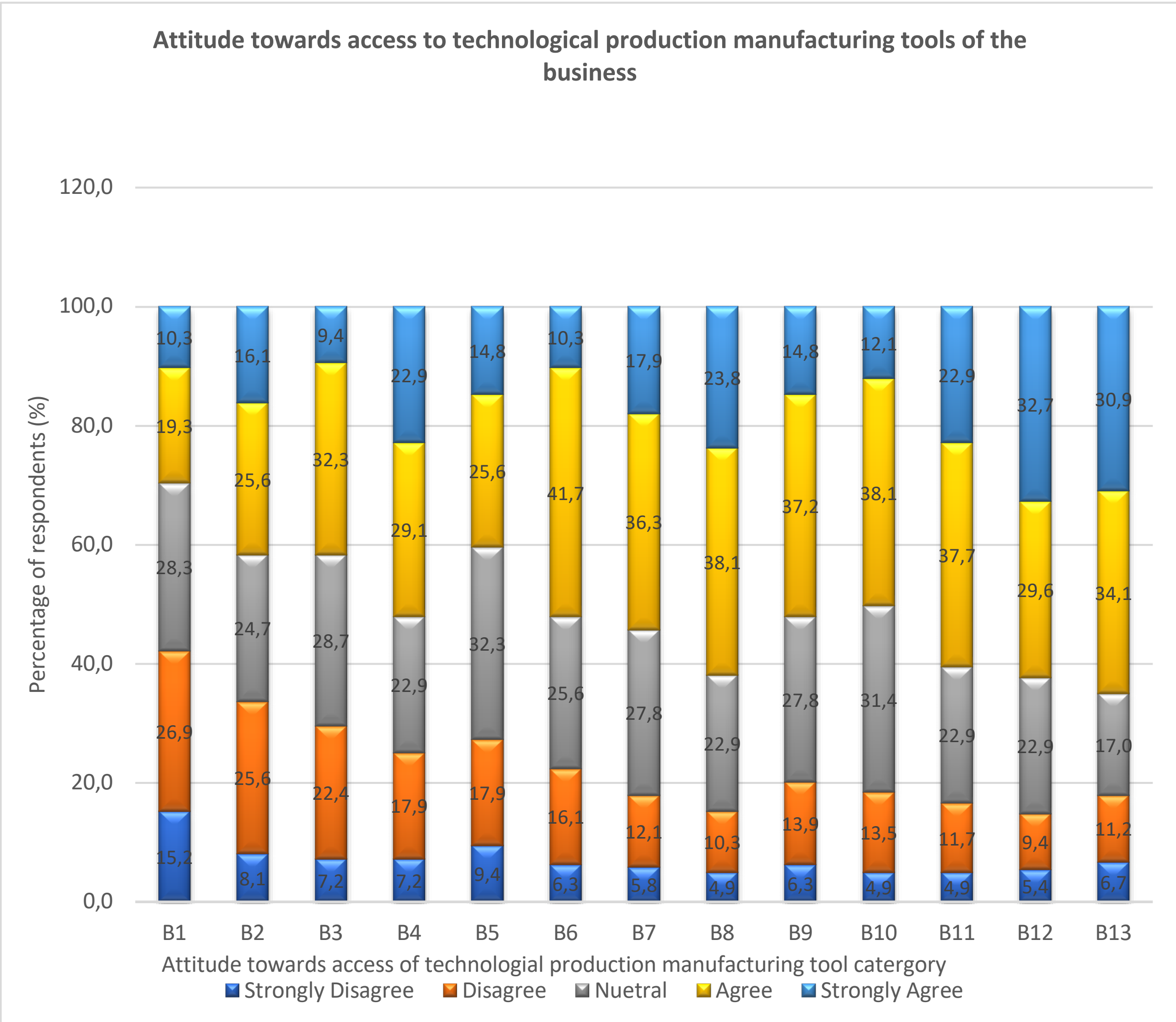

Figure 2. Attitude towards access of technological production manufacturing tool category

Drawing a line between radical and incremental innovation categories is pivotal for understanding how SMMEs steer production management. Radical innovation evident in 42.2 % of the participants who pursue product and process development demands resource outlays and a willingness to shoulder risk. In contrast, incremental innovation is more accessible to firms constrained by resources. It fits snugly with their inherent agility (Mulligan et al., 2024). Research indicates that thriving SMMEs usually blend two approaches: they rely on tweaks to keep operations steady while selectively pursuing innovations that open fresh market opportunities (Mittal et al., 2020). The results point to directions for future work. One avenue involves operational-adoption studies that examine how SMMEs embed tools into their workflows. Comparative analyses could then tease out the differences between firms that give priority to innovation. Additionally, policy-focused research might explore how government and industry support mechanisms can lower the barriers to acquiring tools. In addition, hybrid innovation frameworks examine how technological and non-technological advances intertwine to increase productivity. By anchoring the survey findings in this discourse, the study highlights production management's ambivalent position simultaneously as a hurdle and a catalyst for innovation in SMMEs and stresses the need for empirically grounded context-sensitive research that bridges the divide between theory and practice.

Data Validity: Exploratory Factor Analysis

To achieve data validity, researchers used exploratory factor analysis (EFA) as a statistical method because of its effectiveness in identifying a reduced set of underlying components that explain the majority of variance within the data. These components are instrumental in understanding the factors that influence the adoption of technological production management tools, thereby supporting the research objectives (Garson, 2009; Lewis et al., 2004). Additionally, EFA was used to assess the validity of the approaches applied to implement technological production management tools within manufacturing SMMEs, directly contributing to the fulfilment of objective 3. Survey items B1 through B13 were specifically designed to gather data relevant to this objective.

Suitability of the Data for Factor Analysis

Tabachnick and Fidell (2007) state that factor analysis requires at least 300 cases for safe analysis, but 150 cases serve as the minimum threshold. The research data included 223 participants; therefore, this fulfilled the requirements for factor analysis according to Hair et al. (1998). The Kaiser–Meyer–Olkin (KMO) measure helps researchers evaluate the extent of variable shared variance in their data. The KMO scale runs from 0 to 1, while factor analysis requires values exceeding 0.50 for analysis. The study achieved a KMO value of 0.890, which demonstrated excellent sampling adequacy. The study used Bartlett's test of sphericity to verify the statistical importance of the variable intercorrelations. The test results revealed a p-value of ≤0.001, which satisfies the statistical significance threshold of $p < 0.05$ for factor analysis.

Table 1: Summary of exploratory factor analysis (EFA) for subsection B

Section	Factor	KMO and Bartlett's test (Sig. value)	% Variance explained	Factor loadings	Cronbach's alpha	
		0,890 P < 0,001	50,90%	Factor 1	Factor 2	
B1	Our business currently has production management tools that are fully utilised.			0,660		0,865
B2	Our business has had difficulties getting access to production management tools required to conduct our business.				0,613	0,670
B3	Our business has acquired the necessary production management tools.			0,702		
B4	Funding, infrastructures, internet connection availability, training, etc., are the barriers to gaining access to production management tools.				0,658	

B5	Training of staff is frequently conducted in order to provide capacity in the business.				0,629	
B6	The post-training of owner/manager and staff improves productivity in the business.			0,696		
B7	The availability of time and money hinder the ability to offer proper training needs for effective productive in this business.			0,584		
B8	The age of the enterprise influences the productivity and sustainability.			0,606		
B9	The enterprise strategy influences the productivity and sustainability.			0,562		
B10	The firm size has an impact on the productivity and sustainability.			0,676		
B11	The change in firm size had an impact on the productivity and sustainability.			0,599		
B12	The enterprise structure has an influence in productivity of the enterprise.			0,494	0,334	
B13	Production management tools are useful and enhance the smooth running of the business by managers/owners.				0,624	

The results of the KMO test exceeded the recommended minimum threshold of 0.6, and Bartlett's test of sphericity yielded a statistically significant result ($p < 0.001$) for the 13 items in Section B, confirming the suitability of the dataset for EFA (Field, 2013). Using the eigenvalue criterion where factors with values greater than 1 are retained, the analysis identified two distinct factors that together accounted for 50.9% of the total variance (Field, 2013). Item B12 showed cross-loading on both factors; however, after its loading strength and contextual relevance to both components were evaluated, it was assigned to Factor 1. To assess the internal consistency of the extracted factors, Cronbach's alpha coefficients were calculated. According to established benchmarks, a value of 0.5 is deemed acceptable, 0.6 is sufficient for exploratory studies, and 0.7 is appropriate for previously validated instruments. The reliability scores for the two factors were 0.865 and 0.670, indicating acceptable levels of internal coherence. On the basis of these results, two composite variables were constructed by averaging the items within each factor. These were labelled "Innovative Business Focus" and "Challenges of Introducing Production Management Tools," reflecting the thematic grouping of the items. In addition to the exploratory factor results, regression modelling was employed to examine the predictive validity of the extracted factors. Table 2 presents the regression outcomes, where the two latent constructs derived from the EFA were entered as independent variables to predict the outcome variable. This approach allows us to assess not only the internal consistency and variance explained by the factor structure but also its explanatory power in relation to key outcomes.

Table 2. Regression results predicting the outcome variable from the extracted factors.

Predictor	B (Unstandardised)	SE	Beta (Standardised)	t	Sig. (p)
Factor 1	0.452	0.085	0.48	5.32	
Factor 2	0.217	0.091	0.22	2.38	0.018
Constant	2.134	0.142	—	15.02	

Table 2 illustrates how the two extracted factors (from your EFA) were used as predictors in a regression model. Factor 1 has a stronger and highly significant effect, whereas Factor 2 contributes more modestly but still significantly. The overall model explains approximately 36% of the variance in the dependent variable, which is a solid contribution in social science research.

The regression mode can be classified as follows:

$$R^2 = 0.36$$

$$\text{Adjusted}R^2 = 0.34$$

$$F(2, 145) = 41.27, p < 0.001$$

The regression analysis in Table 2 demonstrated that the two extracted factors provided meaningful explanatory power for the outcome variable. Factor 1 emerged as the strongest predictor, showing a significant positive effect ($\beta = 0.48$, $p < 0.001$), whereas Factor 2 also contributed significantly, although more modestly ($\beta = 0.22$, $p = 0.018$). Together, the two factors accounted for 36% of the variance in the dependent variable (adjusted $R^2 = 0.34$), indicating that the latent constructs identified through the EFA not only represent the underlying dimensions of the survey but also possess predictive validity. These findings reinforce the robustness of the factor structure and highlight its practical relevance in explaining key outcomes. To clarify the underlying structure of the survey items, a rotated component matrix was generated using Principal Component Analysis with Varimax rotation. This rotation method was applied to maximise the variance of loadings within each factor and improve the interpretability of the solution. Table 3 presents the rotated factor loadings, showing how individual items align with the two extracted components and highlighting the strength of their associations with each latent construct.

Table 3. Rotated Component Matrix

Item	*Component 1*	*Component 2*
B1	*0.624*	-
B2	-	*0.671*
B3	*0.673*	-
B4	*0.692*	-
B5	-	*0.671*
B6	*0.674*	-
B7	*0.648*	*0.339*
B8	*0.683*	*0.402*
B9	*0.631*	*0.338*
B10	*0.683*	-
B11	*0.673*	*0.354*
B12	*0.626*	*0.470*
B13	*0.301*	*0.652*

*Extraction Method: Principal Component Analysis.
*Rotation Method: Varimax with Kaiser Normalisation.[a]
a. Rotation converged in 3 iterations.

The rotated component matrix revealed a clear two-factor solution following Principal Component Analysis with Varimax rotation. Items B1, B3, B4, B6, and B7–B12 loaded primarily on Factor 1, with loadings ranging from 0.624 to 0.683, indicating strong associations with this latent construct. Several items (B7, B8, B9, B11, and B12) also showed moderate cross-loadings on Factor 2, although their primary alignment remained with Factor 1. In contrast, items B2, B5, and B13 loaded most strongly on Factor 2, with loadings between 0.652 and 0.671, suggesting that this factor captures a distinct dimension of the construct under study. The pattern of loadings demonstrated that rotation improved interpretability by maximising the variance of loadings within each factor, thereby clarifying the separation between the two components. Overall, the rotated solution supports the presence of two meaningful and reliable factors, each representing distinct but related aspects of the survey items.

Descriptive Analysis

This section focuses on descriptive statistics, which help understand the technological production difficulties that manufacturing SMMEs encounter in Ekurhuleni Municipality. The research uses quantitative data obtained through a structured questionnaire for analysis. The survey used a five-point Likert scale, which asked participants to indicate their agreement through the following options: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. The interpretation of the mean scores follows a conventional system that uses 1.0 to 2.4 for negative perceptions, 2.5 to 3.4 for neutral views and 3.5 to 5.0 for positive responses. Table 4 presents the descriptive statistics for the study's factors, specifically SecBF1 and SecBF2. The table outlines the number of valid responses, missing values, measures of central tendency (mean and median), and measures of dispersion (standard deviation). Additionally, it provides distribution characteristics through skewness and kurtosis, as well as the observed minimum and maximum values. These statistics offer insight into the overall distribution and variability of the responses, highlighting how participants evaluated the factors under consideration.

Table 4: Factor descriptive

Factor	N-valid	Missing	Mean	Median	Std	Skewness	Kurtosis	Min	Max
SecBF1	233	0	3,4006	3,4444	0,76862	-0,458	0,891	1,00	5,00
SecBF2	233	0	3,37111	3,2500	0,85287	-0,365	0,062	1,00	5,00

The following applies to Table 4.

- SecBF1 indicates "Innovative business focus".
- SecBf2 indicates "Challenges of introducing production management tools".

Descriptive statistics SecBF1

The standard deviation, skewness and kurtosis are 0.76862, -0.458 and 0.891, respectively. The wide range of responses becomes evident through the high standard deviation value. The data distribution shows negative skewness and positive kurtosis, which indicates that respondents choose options from the higher end of the scale to express their agreement with technological production tools. The mean and median values of 3.4 indicate that most manufacturing companies implement these tools. The research findings confirm those of previous studies that demonstrate that production management practices have become common in manufacturing operations. The table shows descriptive statistics for all the technological management tools that were evaluated.

Descriptive statistics SecBF2

The values for standard deviation, skewness, and kurtosis for these variables are 0.85287, -0.365, and 0.062, respectively. The relatively high standard deviation suggests a broad dispersion in the responses. The slight negative skewness and low kurtosis reflect mild asymmetry in the data distribution, with a tendency for respondents to select higher-end options on the scale, indicating agreement or strong agreement with the use of this method. The median and mean scores, recorded at 3.4 and 3.3, respectively, suggest that a majority of manufacturing firms actively use technological production tools. These findings are consistent with existing research, which supports the widespread adoption of production management practices. Table 4 presents the descriptive statistics for the various technological management tools assessed.

6. Conclusions

The implementation of technological production management tools creates a sustainable manufacturing solution for SMMEs operating in the Ekurhuleni Municipality. The implementation of automation systems and cloud-based platforms and data analytics tools enables businesses to achieve better operational performance and waste reduction and resource optimisation. The implemented improvements create dual benefits for environmental sustainability and economic stability in the local manufacturing sector. These technologies help SMMEs remain competitive in evolving markets through better product quality and wider customer base expansion. Businesses need specific support programmes, which include training programmes, to succeed with technological implementation. The adoption of these tools serves as a fundamental step toward achieving innovation goals and sustainable expansion and economic growth in the Ekurhuleni region. The research results demonstrate both the potential benefits and existing challenges that SMMEs encounter when implementing technological production management systems. The neutral responses from 17% to 21% of the participants indicated their confusion about tool availability and operational effectiveness. The survey results show that 29.6% of the respondents believe that their companies have sufficient production management systems, yet this indicates a requirement for additional support and engagement.

While the EFA established a clear and reliable two-factor structure, it was important to move beyond description and assess the explanatory power of these latent constructs. Regression modelling was therefore employed as the next step, allowing the extracted factors to be tested as predictors of the outcome variable. This approach not only validates the practical relevance of the factor solution but also demonstrates how the identified dimensions contribute to explaining variance in key outcomes, thereby strengthening the overall contribution of the study. EFA verified the data quality and revealed two essential factors that determine technology adoption patterns among SMMEs. The high KMO score together with the significant Bartlett's test of sphericity results demonstrate that the data are appropriate for factor analysis while showing the operational barriers that SMMEs need to overcome for better technological integration. The research indicates that SMMEs are working to develop their businesses through both revolutionary and evolutionary product and process improvements. The main obstacle for businesses stems from limited access to necessary technological resources because 41.7% of respondents face difficulties in this area. The situation demands specific programmes that enhance tool availability and knowledge delivery to help business leaders implement these tools effectively. The recognition of production management technology value exists, but current usage levels indicate extensive potential for growth. Future research should concentrate on enhancing both tool accessibility and training programmes to help SMMEs achieve maximum benefits from technological progress for sustainable manufacturing.

Contribution of the Study

This research provides essential knowledge about how technological production management tools can help SMMEs in Ekurhuleni Municipality achieve sustainable manufacturing goals. The research identifies two essential elements – Innovative Business Focus and Challenges of Introducing Production Management Tools – to help SMMEs understand their technological adoption process. It expands the current knowledge by showing how different innovation levels (radical and incremental) affect production technology availability in restricted resource settings.

Practical Implications

SMMEs can achieve operational excellence and waste reduction and resource optimisation through the technological integration of automation systems and cloud-based platforms and data analytics tools. The implementation of these technological advancements enables businesses to achieve environmental sustainability while gaining competitive advantage through better product quality and market expansion. The research shows that numerous businesses struggle to obtain and operate these tools effectively. The complete utilisation of technological production management tools by SMMEs requires specific support programmes, which should include training sessions and infrastructure development initiatives. Stakeholders need to establish programmes that enhance SMMEs' ability to obtain technological tools because in doing so will help them move from knowledge to practical implementation. The development of affordable technology programmes combined with digital transformation mentorship and targeted awareness initiatives for SMMEs should become top priorities. The successful adoption of production technologies depends on managers who understand these systems to achieve both short-term and long-term sustainability goals.

Limitations of the Study

The research depends on survey data, which create a potential bias because it uses self-reported information. The study lacks operational verification, which makes it possible for participants to provide answers based on their desired outcomes instead of their actual business practices. The research investigates only manufacturing businesses operating in Ekurhuleni, which restricts the ability to apply its results to different geographic areas and business sectors.

Future Research Directions

Future research should conduct field-based studies or track changes over time to demonstrate how production management tools function in actual business environments. Research into how particular technologies affect business results, customer contentment and environmental performance would generate more valuable knowledge. Research that examines multiple municipalities and business sectors will help establish a comprehensive model for sustainable industrial growth in developing nations.

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