



INTEGRATION OF MANAGEMENT THEORY AND INDUSTRY 4.0 TECHNOLOGIES FOR ECONOMIC DEVELOPMENT IN AFRICA: A FRAMEWORK PROPOSAL

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ABSTRACT: *Purpose-* This study investigated the intersection of management theories, technology adoption enablers, and I4.0 technologies' collective impact on business growth and economic development in Africa. *Design/methodology-* The study used a systematic narrative and analytic literature review method to gather metadata on the relationship and interaction study variables. We used fuzzy interpretative structural modelling (Fuzzy-ISM) in the Python programming language to model metadata from 40 pieces of literature reporting the study theme interactions, aiming to understand the relationship and interaction between MT, technology adoption enablers, and I4.0 technologies. *Findings-* The findings indicate that integrating I4.0 technologies with conventional manufacturing techniques can revolutionise industrial processes, boost productivity, and stimulate entrepreneurial innovation. The findings further validate that factors such as digital transformation, innovation, and collaboration play essential roles in facilitating the adoption of I4.0 technology. *Nonetheless,* obstacles like technological disruption, skill gaps, and socioeconomic issues present considerable hurdles to the adoption of I4.0 technology among businesses in Africa. *Practical implication-* The study emphasises the importance of strategic alignment between MTs, enablers, and I4.0 technologies to accelerate business growth, Africa's industrialisation, and economic growth, although this requires substantial investments and localised adaptation. *Originality/value-* Overall, the study provides valuable insight into how African businesses can leverage I4.0 technologies to drive sustainable development while mitigating the risks associated with technological adoptions.

KEYWORDS: Industry 4.0, Management theory, Economic development, Business growth, Narrative and analytical approach, Fuzzy model.



INTRODUCTION

Management theory (MT) organises relevant managerial knowledge into a cohesive framework by integrating management concepts, principles, and practices. In numerous economic sectors, MTs can influence policies and management practices (Inyang, 2007; Filatotchev et al., 2022; Guo et al., 2024). Global economic progress relies on human activities and management (Bernstein, 2017; Morgan et al., 2019) therefore, management theories will help organise organisations, enhance decision-making, promote harmony, and improve corporate operational performance (George et al., 2016; Taylor, 2023). Consequently, African organisations, as vital parts of the global society, have developed unique approaches to addressing economic issues (Omodan et al., 2020), by adopting and adapting strategies, and management methods to address its challenges. MTs can help organisations achieve efficiency despite challenges associated with MT indigenisation and adaptation (Zoogah et al., 2015; Bush, 2020). MTs enable a systematic method through which African managers can make well-informed business decisions. Management theories help political and corporate leaders comprehend the economy, business dynamics, and human needs (Nachum et al., 2023).

Industry 4.0 (I4.0) is a digital transformation framework that uses cyber-physical systems, automation, and data exchange to boost corporate productivity and national economic growth (Chhabra & Singh, 2022; Yaqub & Alsabban, 2023; Atieh et al., 2023; Javaid et al., 2024; Caiado et al., 2024). Khan et al. (2023) noted that Industry 4.0 boosts productivity, efficiency, and competitiveness across sectors, promoting economic growth. This shows that I4.0 technologies offer African economies seeking sustainable development both opportunities and challenges. However, Rajput and Singh (2021), and Mhlanga and Dzingirai, (2023) argued that I4.0 can use MT frameworks to boost innovation, corporate growth, and strategic decision-making. This is important for African economic growth (Lateef & Keikhosrokiani, 2023; Kaggwa et al., 2024; Onyeme & Liyanage, 2024). Samuel-Okon and Abejide (2024) and Udo et al. (2024) voiced worries about technological disruption, skill gaps, and digital divides that could increase socioeconomic inequality in Africa and hinder I4.0 adoption. Yu et al. (2021), Khan et al. (2023), Kumi-Yeboah et al. (2023), and Caiado et al. (2024) all suggest the adoption of I4.0 technologies necessitates a framework that systematically aligns these technologies with organisational practices.

Due to sociocultural appropriateness and economic conditions in various African nations, the implementation of I4.0 technologies for industrialisation in Africa may be limited due to their Western orientation (Nyagadza et al., 2022; Alabi & Mutula, 2022; Adetunla & Madonsela, 2022; Ndlovu-Gatsheni, 2023; Costa et al., 2023; Peter et al., 2023; Gartoumi & Tekouabou, 2024). As shown in Western countries, I4.0 technologies aim to improve industrialisation and economic growth (Dewa et al., 2018; Hallioui, 2022). Integration of management theory knowledge and concepts with I4.0 technologies can improve management practices and boost economic growth (Omoyele, 2019; Tilley, 2019). I4.0 with MTs could transform company processes and boost these nations' economies (Bongomin et al., 2020). While I4.0 offers numerous advantages, its successful adoption, integration, and implementation within the African context for economic growth face significant challenges (Peter et al., 2023; Mohammadian & Langari, 2023; Qiu et al., 2023; Ngepah et al., 2024). MT adaption and practices in African economic organisations are effective (Morgan et al., 2019; Odonkor et al., 2024), suggesting that MTs may drive I4.0 adaptation and implementation.



Thus, a comprehensive framework that incorporates I4.0 and MT is needed to accelerate African organisations' acceptance, adaptation, and deployment of I4.0 technologies for economic growth (Dewa et al., 2018; Omoyele, 2019; Bongomin, 2020; Nayernia, 2021; Adetunla & Madonsela, 2022; Antony et al., 2023; Peter et al., 2023; Chorused et al., 2023; Onyeme & Liyanage, 2024). This study sets out to address this gap, emphasising a framework integrating MT practices with I4.0. This framework would help African organisations integrate I4.0 technology, boosting economic growth. The study will examine how neoclassical, classical, and general system theories and practices can facilitate the adoption of I4.0 technologies. Specific goals are:

1. To investigate the role of scientific management theory on Africa's economic development in I4.0.
2. To determine the role of human relations theory practices on African economic development in I4.0.
3. To examine the role of bureaucratic theory on African economic development in I4.0.
4. To assess the role of system theory on Africa's economic development in I4.0.

LITERATURE REVIEW

Theoretical framework: Knowledge-Based View (KBV)

Grant's 1996 knowledge-based perspective evolved from the resource-based view theory to include knowledge-based organisational resources. Here, knowledge is a vital organisational asset that may be shared, pooled, and appropriated (Pereira & Bamel, 2021). Thus, an organisation's competitive advantage depends on its transferable knowledge's accessibility and efficacy (Grant, 1996; Pereira & Bamel, 2021). In a knowledge-driven economy, an organisation's performance is driven by its intangible assets, expertise and abilities, and intangible management concepts underpin the company's human capital (Hafsi & Farashahi, 2005; Miroshnychenko, 2020). Grant's KBV theory shows how national organisations and private sector entities use scientific management, human relations, bureaucratic, and systems theories to manage their operations and grow economically.

Additionally, KBV principles emphasise African employees' technical, industry, managerial, and technological experience as human capital that leverages additional resources to boost production. African policymakers can use their manufacturing technological knowledge to adapt and integrate I4.0 technology (Tortorella et al., 2022; Skare & Blažević Burić, 2022; Peter et al., 2023; Kassa & Wube, 2023; Onyeme & Liyanage, 2024). KBV theory blends the integration of MT and I4.0 technology to enhance knowledge synergy and economic growth in nations and businesses. Therefore, derivative knowledge of management theories, concepts, and tenets can enhance African organisations' adoption of I4.0 (Sahibzada et al., 2020; Pereira & Bamel, 2021; Enaifobe, 2021; Marlapudi & Lenka, 2024; Ul-Durar et al., 2024).



Management theory concept

The academic literature has thoroughly explained the concept of management theory. Thus, it is unnecessary to overextend explications. Alvesson (2019) concisely summarises these explanations, stating that MT represents "a compilation of assertions indicating connections among parameters to furnish insights into a phenomenon." MT elucidates the causal relationships between variables within each organisational phenomenon (Piccarozzi et al., 2018; Cornelissen, 2023). Fundamentally, managers base their decisions on theories, even if they don't explicitly articulate them in written form (Uzo et al., 2018). According to Hamilton (2017) MTs consolidate existing knowledge, clarify occurrences or associations, and forecast impending development. MTs act as the mechanism that facilitates the creation of slots into which we categorise our understanding of the natural and social world (Hamilton, 2017; Akpor- Roaro & Omoyele, 2019). This permits us to identify, classify, and interpret social occurrences in particular environments and contexts systematically and effectively to solve business problems. MT encompasses any theory that aims to clarify the causal relationships between variables in organisational contexts. Franco-Santos and David (2018) thus posit that MT tailors itself to illuminate phenomena within organisations. Academic literature has extensively covered the benefits of management theory. Inyang (2008) summarises these benefits, emphasising that MT assists managers in overcoming organisational obstacles by providing instructions that enhance management effectiveness. It is safe to say that MTs enhance the achievement of goals by analysing tasks, allocating resources, and facilitating training where needed, thus crystallising the essence of management. (Emmanuel, 2021; Alfawaire & Atan, 2021).

Scientific Management Theory and I4.0 in Africa

This management approach, developed by Frederick Winslow Taylor in the late 19th and early 20th centuries, uses scientific methods to boost productivity, reduce inefficiencies, standardise processes, establish hierarchies, and implement incentive systems (Taylor, 2023). I4.0 improves operational efficiency and productivity through automation, digitisation, data analytics, machine learning, and predictive modelling (Davenport & Ronanki, 2018). SMT's emphasis on standardisation and specialisation matches I4.0, which requires standard protocols and automated specialist jobs in interconnected systems (Sisinni et al., 2018). SMT emphasises hierarchical organisations and clear job instructions. In I4.0, accurate digital directives guide automated operations and integrated cyber-physical systems (Lasi et al., 2014). SMT and I4.0 use digital performance-based algorithms, targeted training, and skill upgrading to excite employees and drive workplace innovation (Feshina et al., 2019). SMT also emphasises resource efficiency and cost savings (Masuku et al., 2019). I4.0 uses IoT and other technologies to improve resource management and reduce waste (Maqbool, 2023). SMT wants to increase output and efficiency, and I4.0's automation and data-informed decision-making enable economies of scale and improved operation efficiency (Bongomin et al., 2020). I4.0 uses rapid prototyping, iterative design, and real-time production and operational process changes to help SMT focus on innovation and improvement (Wagner et al., 2017). I4.0 technologies use data-driven insights to optimise resource distribution and collaboration (Cimini et al., 2022), akin to SMT's focus on process improvement and coordination (Ekpe & Ekpe, 2014). SMT practices have increased organisational productivity and output, boosting economic efficiency and growth (Ferdous, 2017). It also improves operational efficiency, waste reduction, and resource use, lowering costs and improving economic outcomes (Sisinni et al., 2018). Processes standardisation in SMT helps organisations



achieve economies of scale, increase production capabilities, and improve market position (Makadok et al., 2018; Masuku et al., 2019).

Human Relation Theory and I4.0 in Africa

In 1933, Elton Mayo developed the human relations management philosophy. HRT emphasises social variables (Muldoon et al., 2020) and workplace interactions to understand employees' psychological and social demands (Sabokro et al., 2021). HRT emphasises teamwork, communication, and employee satisfaction (Omodan et al., 2020; Arimie & Oronsaye, 2020). Improved workplace relationships boost employee satisfaction and morale, and improve communication and collaboration for better performance (Knight & Parker, 2019). HRT promotes staff management and social connections, which boosts motivation, productivity, well-being, and job satisfaction (Nwankwo et al., 2019; Le et al., 2023), according to Aurelio and María, (2020), Emmanuel (2021), Addae and Boso, (2021), this leads to reduced turnover and absenteeism. HRT practice is highlighted by Industry 4.0's use of digital technologies, payroll automation, data analysis, and application tracking systems in recruitment and selection, along with various HR management systems to support employee satisfaction and performance (Vahdat, 2022). HRT's focus on strong workplace connections and effective communication aligns with I4.0's collaborative standards for HR process automation (Alshurideh et al., 2022). With the growing organisations digitising trends, employee well-being and happiness must be prioritised (Neumann et al., 2021; Rana & Sharma, 2019). Alabi and Mutula (2022) suggested that HRT's community-focused concepts may help integrate I4.0 technologies into HR management. HRT principles help organisations manage employee well-being, collaboration, and morale in a digital world (Tirabeni et al., 2019).

Bureaucratic Theory and I4.0 in Africa

Weber's 1922 bureaucratic model offered fundamental concepts for addressing Industry 4.0's challenges and potential. Igbokwe-Ibeto & Osakede (2023) describe this paradigm as hierarchical, with clear power structures, division of labour, formal norms and procedures, impersonality, merit-based selection and promotion, specialisation, and detailed documentation. These concepts can help African organisations undertake digital transformation more efficiently and effectively within I4.0 (Edwin & Anuoluwapo, 2020; Ding & Riccucci, 2021; Temitope & Qwabe, 2023; Onjewu et al., 2023). BT emphasises the importance of clear organisational command and reporting systems (Asaju & Ayeni, 2021), focusing on formal rules and procedures to improve work process standardisation (Tortorella et al., 2023) creating systematic processes to support I4.0 advanced technology integration (Cornell et al., 2020). BT formalisation gives a systematic method for technology modifications in response to rapid technological progress (Alshwayat, 2023). According to I4.0 requirements, BT's knowledge may help African industries navigate economic development uncertainties and hurdles (Rajput & Singh, 2021; Santos et al., 2024). The BT framework supports digital transformation, which requires specialised knowledge to use AI, IoT, and data analytics (Bongomin et al., 2020; Valle-Cruz & Garcia-Contreras, 2023). Furthermore, BT's emphasis on transparency and documentation could enhance the integration of I4.0 given the technology's systematic algorithms (Gatell & Avella, 2024). Digital technologies could generate large amounts of data when documented, analysed, and interpreted can enhance decision-making (Price, 2021; Peter et al. (2023; Gaiado et al., 2024).



General System Theory and I4.0 in Africa

Ludwig von Bertalanffy's 1928 General System Theory of Management views companies as complex, linked systems. It promotes understanding of component interdependencies because changes in one might affect others and overall functionality (Ahn et al., 2022). GST provides feedback, adaptability, and flexibility for resilient and effective responses to internal and external threats (Lephallala, 2018). GST fosters stakeholder cooperation (Sulich et al., 2021). I4.0's framework connects components, processes, communication, and collaboration in real-time (Rudrapati, 2022). The GST aims to boost productivity, cut costs, and improve decision-making in African companies (Marrucci et al., 2023; Ali & Johl, 2023; Caiado, 2024). This underscores the fundamental need for integrating digital technology, automation, data sharing, and smart systems across industries (Ren et al., 2023; Rana & Rathrope, 2023). Therefore, leveraging the knowledge of GST could enhance understanding of I4.0 capabilities in areas like IoT, advanced robotics, and AI to boost business productivity and performance (Liu et al., 2023; Narkhede et al., 2024). GST can help identify leverage points and intervention areas for sustainable growth in African economic development (Sulich et al., 2021; Adamu, 2023). Hence, requiring comprehensive strategies that consider agriculture, manufacturing, infrastructure, finance, and human capital development (Nwokolo et al., 2023; Okolo et al., 2024). System theory emphasises stakeholder engagement corresponding with I4.0's drive for inter-industry collaboration (Midgley & Lindhult, 2021; Pereira et al., 2023). Integrating I4.0 technologies can improve governments, industries, academic institutions, and communities' collaboration in innovation, optimise resource sharing, and address unsustainable economic issues (Götz, 2019; Chiyemura et al., 2021; Torres de Oliveira et al., 2023; Khan et al., 2023; Ocelík et al., 2023). GST's focus on feedback and adaptation matches Industry 4.0 principles in areas like smart manufacturing where real-time sensor and device data provide production feedback (Singh et al., 2022; Horigue et al., 2023; Wang, 2023; Soori, 2023; Zhang, 2024). GST and I4.0 technology systems-driven data will provide fast modifications, operational optimisation, and efficiency improvement (Filatotchev et al., 2022; Kassa & Wybe, 2023; Adeniyi & Adeeko, 2024; Idrisi & Koumetio Tekouabou, 2024; Abayomi et al., 2024; Ikevuje et al., 2024; Katuk, 2024; Nwosu, 2024) which can lead to improved manufacturing and quickly adapt to changing market demands.

METHODOLOGY

The study was structured to integrate theoretical exposition with empirical analysis. The study concentrates on leveraging the knowledge and practice of neo-classical, classical, and general system theories to adopt and implement I4.0 technologies in African organisations. To achieve this, the research applied a systematic narrative and analytic literature review approach. A fuzzy interpretative structural modelling (Fuzzy-ISM) was used to analyse the interaction between MT and I4.0 technologies (Carlsson et al., 2012; Bakhtari et al., 2021; Núñez-Merino et al., 2022; Hasteer et al., 2023) for business growth (Marrucci et al., 2023) and African economic development. The narrative analysis systematically reviews and synthesises published literature to identify key themes and their variable relationships (Siddawa et al., 2019). The analytical process employed inductive reasoning to establish relationships and develop a conceptual framework that captures the hierarchical structure and interactive relationships between different MT and I4.0 technologies (Bhatt & Sarkar, 2020).



Metadata from scientific research discussing MT, or I4.0, was systematically collected and synthesised in three steps. In the first step, the research objective keywords (MT-Scientific, Bureaucratic, System, and Human Relations; I4.0 technologies) were optimised and entered into EBSCO, Scopus, and Google Scholar. Table 1 illustrates the data inclusion and exclusion procedure.

Table 1: Research database Search engine data identification

Sources	Identified research	Include MTs	Include I4.0	Between 2018-2024
EBSCO	106	64	29	16
Scopus	689	41	18	13
Google Scholar	1,491	433	274	35
Total	2,286	538	321	64

In the second step, we used content analysis to screen and validate 64 scientific papers that reported on the relationship among the study variables (MT: scientific, bureaucratic, system, and human relations; I4.0: automation, IoT, AI, big data analytics, cloud computing, and advanced robotics). The thematic content analysis process systematically reviewed the selected literature to establish content validity. We excluded articles and books that were not within the variable scope and published outside the timeframe of 2018–2024, resulting in the retention of 40 sources that met the inclusion criteria. This method allows for theory building without biases (Meredith, 1993; Akpor-Roaro & Omoyele, 2019; Felsberger & Reiner, 2020). This step was crucial for maintaining the credibility and relevance of the review (Bingham & Vanover, 2022; Nunez-Merino et al., 2022).

After conducting a thematic content analysis, we conducted a narrative analysis using an analytical inductive approach, which we present bibliographically in Table 2 (Bhat & Sarkar, 2020). This method facilitated a comprehensive analysis of the data, enabling the identification of themes, patterns, and causal inferences (Morgan, 1993; Elo & Kyngäs, 2008; Robinson, 2022; Marlapudi & Lenka, 2024) concerning the influence, impact, and interplay of management theories and I4.0 on business growth and African economic development.

In addition to the preliminary qualitative analysis, fuzzy interpretive structural modelling (fuzzy-ISM) was used to model the interactions between management theories and I4.0 technologies. Using the fuzzy-ISM method, you build a structural self-interaction matrix (SSIM) by judging thematic themes analytically and inductively (Matia et al., 2014; Singh & Lone, 2020; Spolaor et al., 2020; Bakhtari et al., 2021; and Hasteer et al., 2023). This matrix was used to identify and analyse the direct and indirect relationships among variables (Sharma et al., 2023). Also, a binary reachability matrix was derived from the SSIM to facilitate the analysis of these relationships (Bhatt & Sarkar 2020). The reachability matrix was then used to partition the variables into hierarchical levels, resulting in the development of a fuzzy interpretive structural model (ISM) presented in Figure 3. The fuzzy-ISM visually represents the hierarchical and interactive relationships among variables, providing a clear depiction of how management theories and I4.0 technologies interact (Zadeh, 1965; Carlsson et al., 2012; Dumay & Cai, 2015; Feng et al., 2023).



We conducted the qualitative analysis of the study using Python. We constructed the structural self-interaction matrix (SSIM), operationalized the fuzzy reachability matrix, and simulated the fuzzy-ISM model using the NumPy and Pandas libraries. Furthermore, we visualised the model using the NetworkX and Matplotlib libraries in Python (Spolaor et al., 2020; Singh & Lone, 2020). Combining the qualitative analysis of the ISM with the narrative analysis allows for a comprehensive evaluation of how MT integrates with I4.0 technologies to drive business growth and economic development in Africa. By adopting these robust approaches, the study provides an understanding of the theoretical and practical implications of the interactions between MT and I4.0 technologies in enhancing business growth and economic development in Africa.

RESULTS AND DISCUSSION

After conducting a systematic narrative and analytical induction review, Table 2's bibliographic presentation reveals that factors such as collaboration (CoL), digital transformation (DT), data science (DS), and innovation (InV) enable the use of MT to integrate I4.0 technologies. These findings prompted the inclusion of these variables as enablers in the study.

Table 2: Thematic Themes Bibliographic Table

Source	Key Theme	MTs	Enablers	14.0 Technologies	Relationship/Connection
Ahleroff et al., (2020)	Policy and System Implementation	GST	DtS	IoT, AI, BDA, Automation	MT develop mitigating policies for deploying I4.0 technologies
Akpor-Roaro & Omoyele (2019)	MT Organizing Knowledge	General (MT concept)	InV	-	MT organises knowledge to understand organisational phenomena.
Alfawaire & Atan (2021)	Role of MT in knowledge creation and transformation	General (MT concept)	InV	-	MT aids in leveraging organisational knowledge for innovation.
Alvesson (2019)	MT conceptualisation	General (MT concept)	-	-	MT explains relationships among variables.
Amos et al. (2018)	Efficiency, Productivity	SMT	DT, InV	IoT, AI	MTs improve operational efficiency, I4.0 boosts output
Atieh et al. (2023)	Automation in I4.0	-	InV	Automation IoT	I4.0 technologies enable process automation through digitalisation
Bongomin et al. (2020)	Economies of Scale, AI Adoption	SMT, GST	InV, DtS	AI, IoT, BDA	MT enables economies of scale, I4.0 boosts productivity



Caiado et al. (2024)	I4.0 Enhancing Economic Development	-	InV, DtS	IoT, AI, BDA, AR	I4.0 enhances efficiency and economic development
Chiyemura et al. (2022)	Systems Thinking, Innovation	GST, SMT	DtS, InV	IoT, AI, BDA	MT supports interconnected systems; I4.0 enhances innovation
Cimini et al. (2022)	Resource Optimisation	SMT	Dts	IoT, BDA	MT enables effective resource allocation, and I4.0 supports data-driven decisions.
Davenport & Ronanki (2018)	Automation, efficiency	SMT	DT, InV	IoT, AI, CC	MTs Standardise processes, I4.0 enables automation
Dewa et al. (2018)	I4.0 Enables African Industrialization	-	InV. DtS	IoT, AI, BDA	I4.0 has the potential to replicate economic growth in African nations
Emmanuel (2021)	Management theorisation and societal goals	General (MT concept)	-	-	MT contributes to social progress through effective management
Ferdous (2017)	Enhanced Productivity and Growth	SMT	DT	IoT, AI, AR	I4.0 technology drives productivity in line with SMT principles
Feshina et al. (2019)	Motivation, Incentive Systems	HRT, GST	InV, CoL	AI, IoT, AR, CC, CS	MT incentivises innovation, I4.0 boosts productivity
Franco-Santos & David (2018)	MT in organisational	General (MT concept)	-	-	MT explains causality in organisational operations
Piccarozzi et al., (2018)	MT increased understanding of I4.0 capabilities	General (MT concept)	-	IoT, AI	Theories clarify relationships among variables within the organisation
Hamilton (2017)	Theoretical understanding of MT	General (MT concept)	-	-	MT helps understand social occurrences in organisational
Inyang (2008)	MT helps overcome organisational challenges	General (MT concept)	-	-	MT provides managerial guidelines to enhance the effectiveness
Javaid et al. (2024)	Cyber-Physical Systems and Automation	-	DT	IoT, AI, Cyber-physical systems	I4.0 technology integrates CPS with digital tools to enhance productivity
Kaggwa et al. (2024)	Strategic Decision-making in I4.0	-	DtS	IoT, AI, AR	I4.0 supports strategic decisions through data analytics



Khan et al. (2023)	Productivity and Competitiveness	-	InV, CoL	IoT, AI, BDA	I4.0 fosters competitiveness and productivity in African industries
Lateef & Keikhosrokiani (2023)	I4.0 Driving Entrepreneurial Growth	-	InV	IoT, AI, CS, CC, AR	I4.0 fosters entrepreneurial growth through digital tools
Mabaso et al. (2021)	Sustainable Economic Growth	GST, HRT	InV, CoL	IoT, AI, BDA	MT and I4.0 promote sustainable economic growth
Makadok et al. (2018)	Economics of Scale, Efficiency	SMT	InV	IoT, CC, BDA	MT supports economies of scale, I4.0 enhances operational efficiency
Masuku et al. (2019)	Continuous Improvement, Resource Allocation	SMT	DtS	IoT, AI, BDA, CC	MT supports resource optimisation; I4.0 technologies enable continuous improvement
Mhlanga & Dziugirai (2023)	Entrepreneurial Growth through I4.0	General	InV	IoT, AI, AR	I4.0 boosts entrepreneurial activities and digital innovation
Morgan et al. (2019)	MT's Role in Knowledge organisational	General	DT	-	MT supports digital transformation through knowledge management
Nachum et al. (2023)	MT's Role in Decision-Making for Economic Growth	General	-	IoT, AI	MT enables strategic decisions for economic development
Ndlovu-Gatsheni (2023)	I4.0 Transforming Africa's Economy	General	DT, InV	IoT, AI, BDA	I4.0 technologies transform Africa's industrial sectors
Nwankwo et al. (2019)	Innovation, Adaptability	GST, HRT	InV, CoL	AI, BDA, AR	Enablers inspire innovation and adaptability
Omoyele et al. (2021)	Economic Growth through I4.0 in Africa	SMT, GST	DT., InV	IoT, AI, CS	I4.0 technologies enhance Africa's industrial sectors
Peter et al. (2023)	Transparency, Data-Driven Decision Making	BT	DtS	BDA, AI, CC	I4.0 enables data analysis for better decision-making
Rajput & Singh (2021)	I4.0 Enhancing MT Frameworks	BT	InV, Dts	IoT, AI, CS	I4.0 enhances MTs through innovation and data analytics
Rudrapti (2022)	Policy and System Implementation	GST	Dts, CoL	AI, IoT, BDA	Systems theory enables I4.0 implementation in African organisations



Santos et al. (2024)	Standardisation and Resistance to Technology	SMT, HRT	DT	IoT, AI, CS	MT aids adoption of I4.0
Sisinni et al. (2018)	Standardisation	SMT	DT, InV	IoT, AI, Cyber-physical systems	MT standardises processes, I4.0 enables automation and digitalisation
Tirabeni et al. (2019)	Collaboration Employee Satisfaction	HRT	CoL	-	MT supports collaboration, aligning with 14.0 principles
Uzo et al. (2018)	Role of MT in decision-making	General (MT concept)	-	-	MT informs decision-making within organisational
Yaqub & Alsabban (2023)	Data Exchange and Digital Transformation	-	DtS, DT	IoT, AI, CC, CS	I4.0 enhances data exchange and transformation for industry growth

Figure 1: Themes count of MTs, Enablers and I4.0 technologies mentioned in

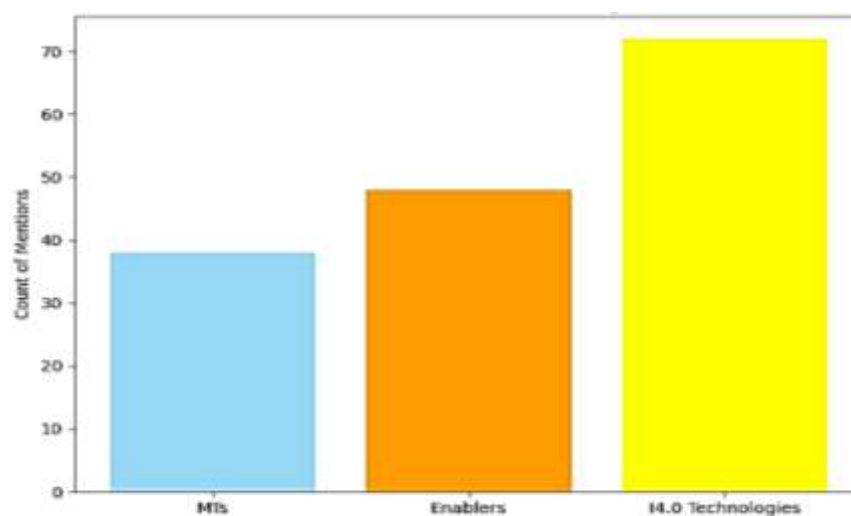
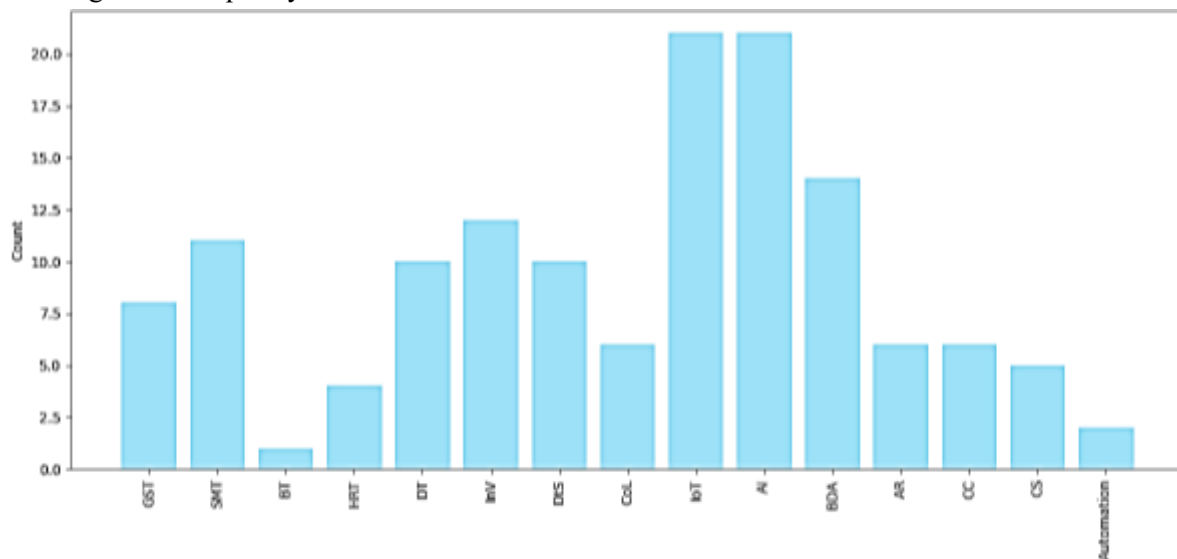


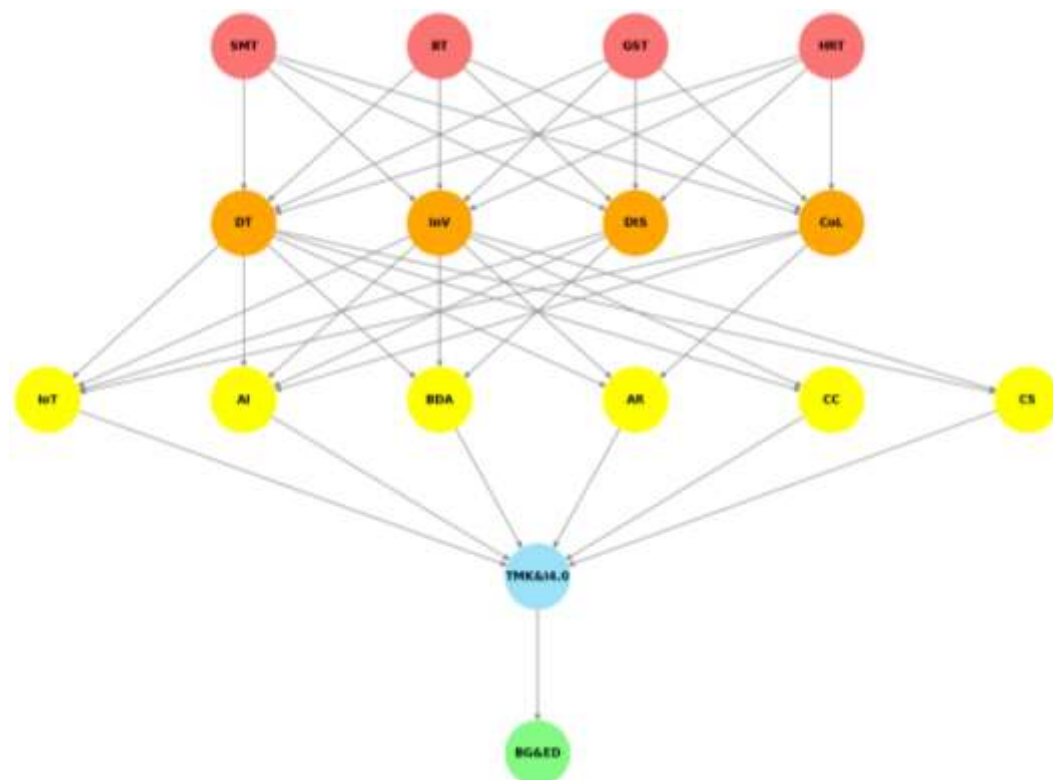
Figure 1 displays the grouped occurrence of themes from the reviewed literature. It shows that MTs were mentioned 39 times, enablers were referenced 49 times, and I4.0 technologies were mentioned over 60 times. The distribution in Figure 2 also indicates that GST and SMT were studied more frequently in the context of I4.0 technology adoption compared to BT and HRT. Additionally, the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data Analytics (BDA) emerged as the most researched I4.0 technologies, surpassing other technologies like Autonomous Robotics (AR), Automation, Cloud Computing (CC), and Cybersecurity (CS). This suggests that IoT, AI, and BDA are the most sought-after technologies in the I4.0 landscape.

Figure 2: Frequency of themes occurrence



Using the thematic findings from Table 2, the fuzzy-ISM model was constructed to map the relationships and interconnectedness between MTs, enablers, and I4.0 technologies, showing how each component leads to the next in a hierarchical movement. The output of this model presented in Figure 4 is business growth and African economic development.

Figure 4: Fuzzy-ISM Model of MT leverage for I4.0





The fuzzy-ISM model analysis of classical management theories revealed that SMT serves as leverage to organisations' digital transformation, innovation, data science, and collaboration, enabling the adoption and integration of AR, BDA, AI, and IoT. This finding suggests that SMT, its enablers, and I4.0 technologies can significantly contribute to the knowledge and technological capabilities that drive business growth and economic development in Africa. This confirms the findings in the literature that SMT enhances productivity and output in organisations (Ferdous, 2017; Cimini et al., 2022), leading to increased economies of scale, efficiency, and growth (Makadok et al., 2018; Omoyele, 2019). SMT principles practised in I4.0 allow for innovation, streamline operations, reduce waste (Chivemura et al., 2022), and optimise resource utilisation (Dewa et al., 2018), resulting in cost savings and improved economic performance. It will promote consistent and standardised processes (Santos et al., 2018; Sisinni et al., 2018), enabling organisations to achieve economies of scale, increase production volume, optimise, and compete more effectively in the market (Amos et al., 2018; Bongomin et al., 2020; Okolocha & Anugwu, 2022). Interestingly, digital transformation, innovation, automation, and robotics enable the modern context of I4.0, where these fundamental principles remain relevant (Yaqub & Alsabban, 2023). Integrating I4.0 technologies with SMT principles enhances coordination, reduces errors, and ensures smooth workflow, increasing productivity and economic outcomes. Leveraging SMT to implement I4.0 technologies encourages higher levels of output, incentivises innovation, fosters a culture of continuous improvement (Ogunsiji et al., 2017; Masuku et al., 2019; Sibanda et al., 2021), contributes to overall economic growth, facilitates efficient resource allocation, strategic planning, and effective coordination of activities, and supports business growth and macroeconomic development. Just as I4.0 leverages innovative tools for enhanced efficiency, African economies can leverage I4.0 and SMT to drive economic advancement, foster innovation, and lay the foundation for sustained economic growth.

Similarly, the literature reveals that HRT improves workplace relationships, fostering higher employee satisfaction and morale and increasing employee motivation, organisational performance and productivity. Resonating with the findings of Mabaso et al. (2021), the study found that leveraging HRT to adapt and integrate I4.0 technologies can enhance organisation output and business growth and support sustainable economic development in Africa. The fuzzy-ISM reveals that enablers such as digital transformation, innovative policies, and thinking can effectively facilitate the adoption of I4.0 technologies like AI, big data analysis, and IoT. The collaborative enabler of I4.0 adoption echoes HRT's call for teamwork, while the digitised landscape heightens the significance of nurturing employee well-being with a focus on worker satisfaction. Nwankwo et al. (2019) also found HRT facilitates organisational inventiveness and I4.0 adaptability for economic growth in Africa. In African organisations, HRT harmonising with collaborative values aids the adaptation of IoT (Omodan et al., 2020; Alabi & Mutula, 2022). The study further shows that embracing HRT principles ensured holistic digital presence and effective human and machine collaboration to boost business growth and African economic development. This finding aligns with Santos et al. (2024) and Feshina et al. (2019), who found that HRT mitigates standardisation resistance caused by organisation technology adoption pressure and digital transformation. The analysis also highlights that positive social interactions, teamwork, and effective communication increase organisational and employee productivity, reduce turnover, and foster innovation (Nica & Orzan, 2015; Tirabeni et al., 2019; Dhanpat et al., 2020). By prioritising employee well-being and satisfaction through digital transformation, AI and IoT can create a skilled workforce capable of navigating technological advancement. Applying HRT principles can ultimately



enhance organisational reputation, attract investments, increase business productivity, and drive economic growth across African nations.

The applicability of BT and I4.0 for business growth and African economic development reveals significant findings. The BT principles align with digital transformation practices, allowing the integration of I4.0 technologies for business efficiency and productivity (Peter et al., 2023). In addition, BT's principles of scalar chain and transparency allow the adoption of I4.0 technologies like AI, big data analysis, and cloud computing, which rely on structural methodologies to arrive at feasible decisions. Mbugi and Lutego (2022) reported that the integration of digital technologies, like AI and automation processes, enhances decision-making and accountability in organisations. Furthermore, Igbokwe-Ibeto and Osakede (2023) advocate for the establishment of transparent chains of command and reporting lines within organisations to facilitate coordinated decision-making. According to Ding et al. (2021), adopting I4.0 technologies increases organisational cohesiveness, operational efficiency, and overall business and economic growth. The fuzzy analysis further reveals that BT guides the development of frameworks to standardise procedures pertinent to the use of AI, IoT, BDA, and innovation (Rajput & Singh, 2021). This coordination forms a catalytic synergy between man and technology (Sulich and Ferasso, 2021), offering a reliable mechanism to optimise resources for business growth and African economic growth.

The system theory of management increases operational synergy through innovative thinking, collaboration, and data science, allowing the implementation of I4.0 technologies like AI, IoT, and BDA and the digital transformation of businesses (Omoyele, 2019; Nqankwo et al., 2019; Rudrapati, 2022). This finding aligns with the findings of Nwankwo et al. (2019), and Mabaso et al. (2021) whose findings underscored those African businesses adopting I4.0 technology could establish interconnected business systems that foster collaboration, adaptability, and innovation. The fuzzy model in Figure 4 shows the interconnectedness of these technologies driven by collaboration, digital transformation, and system thinking. Interestingly, both the GST and I4.0 technologies, when integrated, could become pivotal in critical sectors such as agriculture (Chiyemura et al., 2021), manufacturing, infrastructure (Bongomin, 2020), and digital space to create mutually reinforcing cycles of progress (Halloui et al., 2022). Furthermore, I4.0 system thinking could further enhance the policy-making process, creating an Afro-connected policy web that aligns African countries' private and public sector economic policies for the common good (Asikhia, 2019; Mabaso et al., 2022; Sulich et al., 2021; Rudrapati, 2022; Ahn et al., 2022). Therefore, leveraging MT and I4.0 technologies presents a potential economic cause-effect for business growth and African economic development in the following areas.

1. **Increased efficiency and productivity:** Applying MTs can lead to improved operational efficiency, reduced waste, and increased productivity. This will contribute to cost savings, improved output, and enhanced competitiveness, potentially leading to economic growth and profitability.
2. **Enhanced innovation and adaptability:** I4.0 can enhance the innovativeness of industries, flexibility, and open innovation practices, and may inspire African organisations to create innovative goods, services, and processes to remain competitive in the dynamic global markets, attract investments, create new jobs, and stimulate economic growth.



3. **Improved market positioning and competitiveness:** MTs and I4.0 technologies can enhance the implementation of diversification, differentiation, competitive advantage strategies, and other market positioning frameworks, assisting African businesses in identifying their unique strengths, differentiating from European, Asian, and American competitors, and targeting specific market segments. This combination will allow African businesses to gain a competitive edge, expand their market share, and attract foreign direct investment to boost national economic development.
4. **Human capital development and skills enhancement:** MTs like HRT emphasize the need to invest in employee training, talent management, a supportive work environment, and employee engagement. These practices can increase human capital, and improve productivity, innovation, and economic growth.
5. **Efficient resource allocation:** MTs such as GST, SMT, and BT facilitate agile, lean, and leagile processes utilised in manufacturing automation, IoT, process innovation, and digital transformation of operations. These processes enhance collaboration, eliminate waste, and improve resource allocation and fiscal management efficiency. This robust process optimisation could improve organisational stability, reduce financial risks, and promote sustainable economic growth.

CONCLUSION AND RECOMMENDATION

This study concludes that management theories play a significant role in developing frameworks that guide policy development relevant to I4.0 technologies in African businesses. A key feature of this study is the proposed approach that recognises synergy between management theories and Industry 4.0 technologies, thereby debunking the notion of technology resistance among some African private and public organisations. The implications of the findings of this study are twofold: firstly, they highlight the imperative for stakeholders—governments, businesses, individuals, and management scholars—to collaborate in promoting the effective adoption and implementation of I4.0 technologies, utilising the embedded principles of management theories as a touchpoint within African organisations. Secondly, it underscores the necessity for indigenous management research and the development or realignment of management theories (MTs) with an African focus, which can easily adapt to the unique socioeconomic conditions of the continent, to maximise the benefits of I4.0 and the upcoming I5.0.

It is important to recognise this study's limitations. While management theories provide valuable guidance, their application may encounter contextual barriers within the African business landscape, including socio-cultural gradations, resource constraints, and institutional challenges. Moreover, the dynamic nature of Industry 4.0 necessitates the continuous adaptation and evolution of management practices, which may pose implementation challenges for organisations operating in resource-constrained environments. According to the knowledge-based view theory, African business owners should encourage staff to pursue training and development in management studies, digital technologies, and collaborative work to enhance their knowledge and capabilities of these concepts. Such motives will not only increase the knowledge base of human resources in Africa, but will increase organisational performance, productivity, and the scale of African economic development.



SUGGESTIONS FOR FUTURE RESEARCH

Future studies examining the interaction between I4.0 and MT and African economic development could adopt the Social Capital Theory (SCT) and the Resource-Based View (RBV) theory. These theoretical frameworks could offer valuable insights into the socio-economic dynamics and organisational capabilities essential for leveraging Industry 4.0 technologies in the African context. Also, researchers could investigate the role of SCT in facilitating the adoption and diffusion of Industry 4.0 practices within African enterprises. SCT emphasises the importance of social networks, trust, and norms, facilitating cooperation and knowledge sharing among individuals and organisations. Future studies could also explore how social capital networks enable African firms to access resources, expertise, and market opportunities critical for harnessing the potential of Industry 4.0. A comparative approach to examine the impact of Industry 4.0 adoption on economic development across various African countries and regions could benefit the literature. Future studies should also aim to identify the various programs for implementing Industry 4.0 in African countries.

Conflict of interest

The author has no conflict of interest to declare.

Data availability statement

Data sharing does not apply to this paper since no new data were created or analysed in the study.

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