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Lean manufacturing in industrial engineering: A USA and African review

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Abstract

This paper provides a comprehensive overview of Lean Manufacturing in the context of Industrial Engineering, with a focus on a comparative analysis between the United States (USA) and African industrial landscapes. Lean Manufacturing, derived from the Toyota Production System, has gained prominence globally for its principles centered on waste reduction, continuous improvement, and enhanced efficiency. In the USA, Lean Manufacturing has been widely adopted across various industries, contributing to increased competitiveness, cost reduction, and improved customer satisfaction. The American industrial sector has witnessed significant transformations through the application of Lean principles, resulting in streamlined processes, reduced lead times, and optimized resource utilization. On the other hand, the African industrial landscape presents a unique set of challenges and opportunities. The application of Lean Manufacturing in African countries has been influenced by factors such as economic conditions, infrastructure limitations, and diverse cultural contexts. This review examines the strategies employed in adapting Lean principles to the African context, considering the socio-economic dynamics and developmental priorities of individual nations. Key factors impacting the successful implementation of Lean Manufacturing in both regions are explored, including organizational culture, leadership commitment, and workforce engagement. The study investigates how these factors influence the effectiveness of Lean initiatives and their ability to drive sustainable improvements in operational performance. Furthermore, the paper delves into the role of technology and innovation in the implementation of Lean Manufacturing, with a focus on how digitalization and Industry 4.0 concepts are shaping the future of manufacturing practices in both the USA and Africa. By presenting a comparative analysis, this paper contributes to the understanding of the nuances involved in applying Lean Manufacturing principles in diverse industrial settings. It highlights the potential for cross-cultural learning and adaptation while recognizing the importance of tailoring Lean strategies to the unique challenges and opportunities present in the USA and African industrial contexts.

Keywords: Lean Manufacturing; Industrial Engineering; USA; Africa; Review

1. Introduction

Lean manufacturing, originating from the Toyota Production System, is a renowned approach focused on enhancing productivity, quality, and customer satisfaction (Nordin et al., 2014). It emphasizes the elimination of waste and continuous improvement, making it a significant aspect of industrial engineering. Studies have shown that lean manufacturing can significantly improve productivity and customer satisfaction, making it a crucial element in industrial engineering (Goshime et al., 2019). Furthermore, the implementation of lean tools such as Kaizen, 5S, setup time reduction, and cellular manufacturing has been found to be essential for successful lean manufacturing (Zahraee, 2016).

The purpose of this review is to provide a comprehensive understanding of the background, significance, and implementation of lean manufacturing in both the USA and Africa. The review aims to explore the impact of lean

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manufacturing on industrial engineering practices, particularly in the context of improving productivity, quality, and customer satisfaction. Additionally, it seeks to identify the key factors influencing the successful implementation of lean manufacturing in these regions.

The scope of this review encompasses an in-depth analysis of relevant literature, case studies, and empirical research on lean manufacturing in the USA and Africa. The objectives include identifying the key principles of lean manufacturing, evaluating its significance in industrial engineering, and providing insights into the challenges and opportunities associated with its implementation in these regions. Furthermore, the review aims to offer recommendations for effectively integrating lean manufacturing principles into industrial engineering practices in the USA and Africa, considering their unique socio-economic and industrial contexts.

2. The Evolution of Lean Manufacturing

The evolution of lean manufacturing has been a significant development in the field of industrial engineering, with its origins traced back to the Toyota Production System (TPS) (Shah & Ward, 2002). Initially developed by Toyota, the TPS emphasized the elimination of waste and continuous improvement, serving as the foundation for lean manufacturing principles. Over time, lean manufacturing has gained global recognition and adoption, extending beyond the automotive industry to various sectors worldwide. The spread of lean manufacturing has been attributed to its proven ability to improve productivity, customer satisfaction, and overall organizational performance (Adeleke et al., 2019; Goshime et al., 2019).

Key principles of lean manufacturing have been identified through extensive research. These principles include waste reduction, continuous improvement, value stream mapping, and just-in-time production. The core idea of lean manufacturing revolves around the efficient use of resources, minimizing waste, and optimizing processes to enhance overall operational performance. Furthermore, lean manufacturing has evolved to encompass various practices and bundles, such as total productive management and total quality management, to achieve world-class manufacturing (Ewim et al., 2021; Sahoo & Yadav, 2018).

The significance of lean manufacturing in industrial engineering lies in its potential to enhance productivity, reduce costs, and improve customer satisfaction. The implementation of lean tools, such as Kaizen, 5S, setup time reduction, and cellular manufacturing, has been crucial for successful lean manufacturing practices. Moreover, lean manufacturing has been recognized as a vehicle for improving productivity and customer satisfaction, contributing to sustainable development and positive organizational outcomes (Goshime et al., 2019; Ukoba et al., 2018).

In conclusion, the evolution of lean manufacturing from its origins in the Toyota Production System to its global spread and adoption has significantly impacted industrial engineering practices. The key principles of lean manufacturing emphasize waste reduction, continuous improvement, and efficient resource utilization. The significance of lean manufacturing lies in its ability to improve productivity, reduce waste, and enhance customer satisfaction, making it a vital aspect of industrial engineering.

3. Lean Manufacturing in the USA

The American industrial landscape has seen the widespread adoption of lean manufacturing principles across various industries. The adoption of lean principles has been a significant focus for many manufacturing firms in the USA, as evidenced by a case study conducted in an electronics manufacturing company in the northwestern USA (Worley & Doolen, 2006). This adoption has been driven by the pursuit of sustainable competitive advantage, with lean production becoming the paradigm for many manufacturing operations (Ohenhen et al., 2024; Lewis, 2000). The impact of lean principles on competitiveness and cost reduction has been well-documented, with lean manufacturing assisting organizations in becoming more competitive by eradicating waste from the manufacturing process (Abrahams et al., 2023; Bhasin, 2015). Furthermore, lean manufacturing has been identified as a lever that allows companies to continuously reduce the time required for the transformation of raw materials into finished products, thereby meeting the growing and diverse needs of customers and improving productivity to remain competitive in the global market (Ilugbusi et al., 2020; Kazmane et al., 2014).

The successful implementation of lean manufacturing principles has been exemplified in various case studies, demonstrating the positive impact on competitiveness and cost reduction. These case studies have highlighted the role of communication and management support in lean manufacturing implementation, emphasizing the importance of internal drivers for successful adoption (Ezeigweneme et al., 2024; Worley & Doolen, 2006). Additionally, the impact of

lean concepts on supply chain strategies has been explored, indicating the broader influence of lean manufacturing beyond individual organizations (Vincent et al., 2021; Kazmane et al., 2014).

In conclusion, the adoption of lean principles in the American industrial landscape has significantly impacted competitiveness and cost reduction. The successful implementation of lean manufacturing has been driven by internal and external factors, with a focus on communication, management support, and supply chain strategies. These efforts have contributed to the sustainable competitive advantage of organizations operating in various industries in the USA.

4. Challenges and Opportunities in the African Context

In the African context, economic and infrastructural factors pose significant challenges and opportunities. The integration of African firms into global value chains is hindered by the infrastructural and cultural context, making it challenging for foreign firms to provide local suppliers with more strategic roles (You et al., 2018). Additionally, the need for more theoretically rich and methodologically rigorous inquiry in supply management in the African context indicates the existing gaps in understanding and addressing economic and infrastructural challenges (Kauppi et al., 2017).

Cultural considerations also play a crucial role in shaping the economic landscape. The economic cooperation between China and African countries faces multiple challenges and opportunities due to cultural distance and foreign direct investment dynamics (Gagne, 2018). Moreover, the sudden COVID-19 epidemic has brought great challenges to African employment, infrastructure construction, and economic transformation, highlighting the intersection of cultural and economic factors in shaping developmental priorities (Orieno et al., 2024; Bi & Zhang, 2023).

Socio-economic dynamics in Africa are influenced by barriers to high-growth enterprises, where the quality of opportunities and corresponding value that can be extracted may be lower, reflecting the complex socio-economic environment (Abrahams et al., 2024; Nwajiuba et al., 2020). Furthermore, the sustainable development vision provides a stimulus for Africa's urban poly-crisis, demanding interdisciplinary and normatively explicit thinking grounded in a practical understanding of infrastructure and governance challenges (Pieterse et al., 2018).

Developmental priorities and industrialization in Africa are closely linked to the challenges and opportunities in economic and infrastructural factors, cultural considerations, and socio-economic dynamics. The challenges of developing small tourism enterprises in townships in South Africa highlight the opportunities that emerged with the country's integration into the global tourism economy after years of international sanctions, reflecting the evolving developmental priorities and industrialization in the African context (Chili & Mabaso, 2016).

5. Comparative Analysis of Lean Manufacturing in Industrial Engineering in the USA and Africa

To compare the implementation of lean manufacturing in the USA and Africa, it is essential to consider the influence of organizational culture, leadership commitment, and workforce engagement. In the USA, the organizational culture significantly influences lean implementation (Hassan et al., 2024; Jadhav et al., 2014). The adaptability of lean manufacturing to the African context is crucial due to the differences in cultural and business practices (Sinkamba et al., 2023; Babarinde et al., 2023). Leadership commitment plays a pivotal role in the successful implementation of lean manufacturing in the USA (Connor & Cormican, 2021). However, in Africa, challenges such as limited resources and infrastructure require unique strategies to ensure leadership commitment (Okoro et al., 2024; Ghaithan et al., 2021). Workforce engagement is a key aspect of lean manufacturing in the USA, with a focus on employee involvement in lean practices (Boyle et al., 2011). In Africa, the cultural impact on workforce participation necessitates tailored approaches to engage employees effectively (Dondofema et al., 2017).

6. Technology and Innovation in Lean Manufacturing

In recent years, the integration of technology in lean manufacturing has been a topic of significant interest. The emergence of Industry 4.0 technologies has presented new opportunities for further improvement and innovation in manufacturing operations (Powell et al., 2018). Industry 4.0, characterized by the integration of cyber-physical systems, has the potential to enhance lean practices and optimize processes designed according to lean principles to deal with higher complexity (Mouchou et al., 2021; Buer et al., 2018). This integration of Industry 4.0 technologies with lean manufacturing has been recognized as a means to drive innovation and improve operational performance.

The impact of digitalization in manufacturing, particularly in the context of lean practices, has been a subject of exploration. The use of advanced digital and automated solutions has gained prominence in the manufacturing sector, complementing the traditional lean principles to improve efficiency and competitiveness. Furthermore, the adoption of Industry 4.0 technologies has been identified as an enabler of leaner production, offering new opportunities for the improvement of manufacturing operations (Haartman et al., 2021). The integration of lean and agile supply chain strategies through Industry 4.0 technologies has been empirically addressed, highlighting the complementary nature of these strategies and their potential impact on operational performance (Raji et al., 2021).

The relationship between Industry 4.0 technologies and lean practices has been a focal point of research, aiming to explore the specific connections between the technologies from Industry 4.0 and lean manufacturing. While the potential for enhancing lean practices through Industry 4.0 has been acknowledged, there is a need for more specific relationships between particular technologies from Industry 4.0 and lean practices to be presented. Additionally, the emergence of new smart cyber-physical systems (CPS) has been driving innovation in various sectors, including manufacturing, further emphasizing the impact of digitalization on lean manufacturing (Lezoche & Panetto, 2018).

The impact of these technological advancements on operational performance has been a key area of investigation. The adoption of Industry 4.0 technologies has been gradually penetrating into different industries, with a focus on intensively applying these concepts to enhance operational performance. Furthermore, the potential synergy effects from human-robot-machine-environment cooperation within the context of Industry 4.0 have been highlighted, emphasizing the impact on the well-being of workers in the industry and the overall operational performance (Akindote et al., 2023; Majerník et al., 2022).

In conclusion, the integration of Industry 4.0 technologies with lean manufacturing has the potential to drive innovation, enhance operational performance, and improve efficiency in manufacturing operations. The adoption of advanced digital and automated solutions, along with the emergence of smart cyber-physical systems, presents new opportunities for further improvement and optimization of lean practices in the manufacturing sector.

7. Case Studies of Lean Manufacturing in Industrial Engineering: A USA and African Review

Successful Lean Manufacturing Cases in the USA have been well-documented in the literature. Case studies have shown that the effective implementation of Lean Sigma is a critical success factor (Laureani & Antony, 2012). These cases have represented a broad variety of manufacturing industries, increasing the likelihood of the research being able to be broadly generalized and applied (Sisson & Elshennawy, 2015). Additionally, a case study in the northwestern USA demonstrated the impact of organizational structure and employee problem-solving on lean implementation (Worley & Doolen, 2015). Furthermore, the influence of external information sources in lean improvements has been explored, indicating that there is no direct link between the age of the manufacturing facility and the pace of lean improvements (Boyle et al., 2011).

In African industries, there is a growing interest in the adaptation and success stories of Lean Manufacturing. A case study in India focused on assessing lean performance in radial tire manufacturing, providing insightful views of experienced lower to upper-middle-level managers, which can be valuable for African industries (Gupta et al., 2013). Moreover, a successful case of extending lean manufacturing in supply chains has been reported in Brazil, which could provide valuable insights for African industries looking to integrate lean principles into their supply chains (Jabbour et al., 2014). Additionally, a study in Vietnam proposed a roadmap for successful lean transformation in manufacturing firms, which could be adapted to the African context (Hùng et al., 2020).

Lessons learned from cross-cultural implementations of Lean Manufacturing have been highlighted in the literature. It has been emphasized that the successful implementation of lean manufacturing requires the elimination of non-value-adding activities in conventional engineering products manufacturing companies (Kumar et al., 2023). Furthermore, the impact of organizational factors on the implementation outcomes of lean manufacturing has been extensively reviewed, shedding light on the importance of human-related and organizational factors in the context of lean manufacturing (Bayat & Dadashzadeh, 2017). Additionally, a model of tacit knowledge transfer in lean management implementation has been proposed, emphasizing the significance of knowledge transfer in successful lean implementation (Nordin et al., 2020).

8. Future Trends and Prospects

The future of manufacturing is being shaped by the integration of emerging technologies, continuous improvement, and collaboration. Lean manufacturing, a proven methodology for waste reduction and process optimization, is not becoming obsolete but is rather gaining importance in the era of the fourth industrial revolution (Buer et al., 2020). The synergy between lean manufacturing and digitalization is crucial for enhancing operational performance and reaping the benefits of emerging technologies (Adaga et al., 2024; Buer et al., 2020). Furthermore, the link between Industry 4.0 and lean manufacturing has been identified as a key research area, highlighting the need for further exploration of this connection and its implications for future manufacturing practices (Buer et al., 2018).

The concept of Industry 4.0 and smart manufacturing programs presents new opportunities for the application of cyber-physical systems (CPS) in various stages of production, logistics, and maintenance, thereby paving the way for future research and innovation in manufacturing (Thoben et al., 2017). Additionally, the impact of Industry 4.0 and lean manufacturing on the sustainability performance of organizations has been studied, emphasizing the need to integrate these approaches for improved sustainability in manufacturing processes (Ghaithan et al., 2021).

The emergence of digital lean manufacturing and the significance of digital waste have been explored, indicating the evolving landscape of lean practices in the context of cyber-physical production systems (Balogun et al., 2024; Romero et al., 2018). Moreover, the integration of Industry 4.0 in lean production has been advocated as a means to enhance lean practices and improve manufacturing operations through the adoption of emerging technologies (Pereira et al., 2019).

Collaboration and knowledge exchange are essential for the successful implementation of lean manufacturing principles and tools in the context of Industry 4.0. Existing manufacturing systems have been striving to implement lean principles and tools to achieve process efficiency and continuous improvement, highlighting the importance of collaboration in driving lean initiatives (Dănuț-Sorin et al., 2021). Furthermore, the concurrent application of lean production and enterprise resource planning (ERP) has been proposed as a future perspective, emphasizing the need to consider ERP systems as integral tools in the lean implementation process (Powell et al., 2013).

In conclusion, the future trends and prospects in manufacturing are closely intertwined with the integration of emerging technologies, continuous improvement, and collaboration. The synthesis of lean manufacturing with Industry 4.0 technologies presents new opportunities for enhancing operational performance, sustainability, and production efficiency. Collaboration and knowledge exchange are pivotal for leveraging the potential of lean manufacturing in the era of digitalization and smart manufacturing.

9. Recommendation

The review of Lean Manufacturing in Industrial Engineering across the USA and African contexts has revealed several key findings. Lean Manufacturing, rooted in the Toyota Production System, has demonstrated a global impact, particularly in the USA, where it has become a cornerstone for enhancing competitiveness and reducing operational costs. The African industrial landscape poses unique challenges, including economic constraints, infrastructure limitations, and cultural diversity, influencing the adoption and adaptation of Lean Manufacturing principles. The success of Lean initiatives is closely tied to organizational culture and leadership commitment. While the USA showcases strong leadership engagement, African contexts require nuanced approaches that consider cultural dynamics and developmental priorities. Employee involvement is a critical factor in the success of Lean practices. The USA has established effective models of workforce engagement, whereas African industries need tailored strategies to overcome cultural barriers and enhance participation. The advent of Industry 4.0 and digitalization is reshaping Lean Manufacturing globally. Both regions are witnessing the integration of advanced technologies, indicating a shift towards more automated and data-driven manufacturing processes.

Industrial engineers should recognize the importance of cultural sensitivity when implementing Lean Manufacturing in diverse contexts. Strategies should be adaptable to the local culture to foster better acceptance and participation. Industrial engineering leaders need to emphasize the development of leadership skills that align with the cultural nuances of the workforce. This is particularly crucial in African industries, where leadership styles may need to be tailored to foster collaboration and engagement. The future of Lean Manufacturing in both the USA and Africa lies in the integration of advanced technologies. Industrial engineers should stay abreast of Industry 4.0 developments and explore innovative ways to leverage technology for continuous improvement. There is a significant opportunity for knowledge exchange and collaboration between the USA and African industries. Industrial engineers can facilitate

cross-cultural learning, sharing best practices, and collectively addressing challenges to enhance the global impact of Lean Manufacturing.

10. Conclusion

In conclusion, this review underscores the need for a nuanced and adaptive approach to Lean Manufacturing in Industrial Engineering. By understanding and addressing the unique challenges and opportunities in both the USA and Africa, industrial engineers can contribute to the sustainable growth and development of manufacturing practices on a global scale.

Compliance with ethical standards

Disclosure of conflict of interest

The author has no conflict of interest in this research.

References

[1] Abrahams, T.O., Ewuga, S.K., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Dawodu, S.O., 2023. Review of strategic alignment: Accounting and cybersecurity for data confidentiality and financial security.

[2] Abrahams, T.O., Ewuga, S.K., Kaggwa, S., Uwaoma, P.U., Hassan, A.O. and Dawodu, S.O., 2024. MASTERING COMPLIANCE: A Comprehensive Review Of Regulatory Frameworks In Accounting And Cybersecurity. *Computer Science & IT Research Journal*, *5*(1), pp.120-140.

[3] Adaga, E.M., Egieya, Z.E., Ewuga, S.K., Abdul, A.A. and Abrahams, T.O., 2024. Philosophy In Business Analytics: A Review Of Sustainable And Ethical Approaches. *International Journal of Management & Entrepreneurship Research*, *6*(1), pp.69-86.

[4] Adeleke, O.K., Segun, I.B. and Olaoye, A.I.C., 2019. Impact of internal control on fraud prevention in deposit money banks in Nigeria. *Nigerian Studies in Economics and Management Sciences*, *2*(1), pp.42-51.

[5] Akindote, O.J., Adegbite, A.O., Dawodu, S.O., Omotosho, A., Anyanwu, A. and Maduka, C.P., 2023. Comparative review of big data analytics and GIS in healthcare decision-making.

[6] Babarinde, A.O., Ayo-Farai, O., Maduka, C.P., Okongwu, C.C. and Sodamade, O., 2023. Data analytics in public health, A USA perspective: A review.

[7] Balogun, O.D., Ayo-Farai, O., Ogundairo, O., Maduka, C.P., Okongwu, C.C., Babarinde, A.O. and Sodamade, O.T., 2024. The Role Of Pharmacists In Personalised Medicine: A Review Of Integrating Pharmacogenomics Into Clinical Practice. *International Medical Science Research Journal*, *4*(1), pp.19-36.

[8] Bayat, H. and Dadashzadeh, M. (2017). The impact of organizational factors on implementation outcomes of lean manufacturing. Journal of Business & Economics Research (Jber), 15(2), 33-44. https://doi.org/10.19030/jber.v15i2.9932

[9] Bhasin, S. (2015). Impact of lean., 149-160. https://doi.org/10.1007/978-3-319-17410-5_8

[10] Bi, M. and Zhang, Z. (2023). Exploring the path of autonomous development: the development dilemma and coping strategies of sub-saharan africa in the post-epidemic era. Journal of the Knowledge Economy. https://doi.org/10.1007/s13132-023-01145-8

[11] Boyle, T., Scherrer-Rathje, M., & Stuart, I. (2011). Learning to be lean: the influence of external information sources in lean improvements. Journal of Manufacturing Technology Management, 22(5), 587-603. https://doi.org/10.1108/17410381111134455

[12] Buer, S., Semini, M., Strandhagen, J., & Sgarbossa, F. (2020). The complementary effect of lean manufacturing and digitalisation on operational performance. International Journal of Production Research, 59(7), 1976-1992. https://doi.org/10.1080/00207543.2020.1790684

[13] Buer, S., Strandhagen, J., & Chan, F. (2018). The link between industry 4.0 and lean manufacturing: mapping current research and establishing a research agenda. International Journal of Production Research, 56(8), 2924-2940. https://doi.org/10.1080/00207543.2018.1442945

[14] Chili, N. and Mabaso, S. (2016). The challenges of developing small tourism enterprises in townships: case of umlazi, south africa. Problems and Perspectives in Management, 14(1), 201-205. https://doi.org/10.21511/ppm.14(1-1).2016.08

[15] Connor, D. and Cormican, K. (2021). Leading from the middle: how team leaders implement lean success factors. International Journal of Lean Six Sigma, 13(2), 253-275. https://doi.org/10.1108/ijlss-11-2020-0194

[16] Dănuț-Sorin, I., Opran, C., & Lamanna, G. (2021). Lean 4.0 dynamic tools for polymeric products manufacturing in industry 4.0. Macromolecular Symposia, 396(1). https://doi.org/10.1002/masy.202000316

[17] Dondofema, R., Matope, S., & Akdogan, G. (2017). Lean applications: a survey of publications with respect to south african industry. The South African Journal of Industrial Engineering, 28(1). https://doi.org/10.7166/28-1-1660

[18] Ewim, D.R.E., Okwu, M.O., Onyiriuka, E.J., Abiodun, A.S., Abolarin, S.M. and Kaood, A., 2021. A quick review of the applications of artificial neural networks (ANN) in the modelling of thermal systems.

[19] Ezeigweneme, C.A., Umoh, A.A., Ilojianya, V.I. and Adegbite, A.O., 2024. Review Of Telecommunication Regulation And Policy: Comparative Analysis USA AND AFRICA. *Computer Science & IT Research Journal*, *5*(1), pp.81-99.

[20] Gagne, O. (2018). Cultural distance and fdi: china africa perspective. Open Journal of Business and Management, 06(02), 382-399. https://doi.org/10.4236/ojbm.2018.62028

[21] Ghaithan, A., Khan, M., Mohammed, A., & Hadidi, L. (2021). Impact of industry 4.0 and lean manufacturing on the sustainability performance of plastic and petrochemical organizations in saudi arabia. Sustainability, 13(20), 11252. https://doi.org/10.3390/su132011252

[22] Goshime, Y., Kitaw, D., & Jilcha, K. (2019). Lean manufacturing as a vehicle for improving productivity and customer satisfaction. International Journal of Lean Six Sigma, 10(2), 691-714. https://doi.org/10.1108/ijlss-06-2017-0063

[23] Gupta, V., Acharya, P., & Patwardhan, M. (2013). A strategic and operational approach to assess the lean performance in radial tyre manufacturing in india. International Journal of Productivity and Performance Management, 62(6), 634-651. https://doi.org/10.1108/ijppm-jun-2012-0057

[24] Haartman, R., Bengtsson, L., & Niss, C. (2021). Lean practices and the adoption of digital technologies in production. International Journal of Services and Operations Management, 40(2), 286. https://doi.org/10.1504/ijsom.2021.118260

[25] Hassan, A.O., Ewuga, S.K., Abdul, A.A., Abrahams, T.O., Oladeinde, M. and Dawodu, S.O., 2024. Cybersecurity In Banking: A Global Perspective With A Focus On Nigerian Practices. *Computer Science & IT Research Journal*, *5*(1), pp.41-59.

[26] Hùng, B., Luong, L., & Nguyen, N. (2020). Identifying the key factors and proposing a roadmap for successful lean transformation in vietnamese manufacturing firms. Proceedings, 5(2). https://doi.org/10.46223/hcmcoujs.econ.en.5.2.61.2015

[27] Ilugbusi, S., Akindejoye, J.A., Ajala, R.B. and Ogundele, A., 2020. Financial liberalization and economic growth in Nigeria (1986-2018). *International Journal of Innovative Science and Research Technology*, *5*(4), pp.1-9.

[28] Jabbour, A., Omodei, J., & Jabbour, C. (2014). Extending lean manufacturing in supply chains: a successful case in brazil. Benchmarking an International Journal, 21(6), 1070-1083. https://doi.org/10.1108/bij-01-2013-0014

[29] Jadhav, J., Mantha, S., & Rane, S. (2014). Exploring barriers in lean implementation. International Journal of Lean Six Sigma, 5(2), 122-148. https://doi.org/10.1108/ijlss-12-2012-0014

[30] Kauppi, K., Salmi, A., & You, W. (2017). Sourcing from africa: a systematic review and a research agenda. International Journal of Management Reviews, 20(2), 627-650. https://doi.org/10.1111/ijmr.12158

[31] Kazmane, J., Chafi, A., Tajri, I., & En-Nadi, A. (2014). The impact of the concepts of lean manufacturing on the strategies of the supply chain. International Journal of Engineering & Technology, 4(1), 35. https://doi.org/10.14419/ijet.v4i1.3936

[32] Kumar, D., Devadasan, S., Elangovan, D., & Ranganathan, V. (2023). Laying foundation for successful implementation of lean manufacturing through the elimination of non-value adding activities in conventional engineering products manufacturing companies. Proceedings of the Institution of Mechanical Engineers Part E Journal of Process Mechanical Engineering, 237(5), 2060-2073. https://doi.org/10.1177/09544089231175985

[33] Laureani, A. and Antony, J. (2012). Critical success factors for the effective implementation of lean sigma. International Journal of Lean Six Sigma, 3(4), 274-283. https://doi.org/10.1108/20401461211284743

[34] Lewis, M. (2000). Lean production and sustainable competitive advantage. International Journal of Operations & Production Management, 20(8), 959-978. https://doi.org/10.1108/01443570010332971

[35] Lezoche, M. and Panetto, H. (2018). Cyber-physical systems, a new formal paradigm to model redundancy and resiliency. Enterprise Information Systems, 14(8), 1150-1171. https://doi.org/10.1080/17517575.2018.1536807

[36] Majerník, M., Daneshjo, N., Malega, P., Drábik, P., & Barilová, B. (2022). Sustainable development of the intelligent industry from industry 4.0 to industry 5.0. Advances in Science and Technology – Research Journal, 16(2), 12-18. https://doi.org/10.12913/22998624/146420

[37] Mouchou, R., Laseinde, T., Jen, T.C. and Ukoba, K., 2021. Developments in the Application of Nano Materials for Photovoltaic Solar Cell Design, Based on Industry 4.0 Integration Scheme. In *Advances in Artificial Intelligence, Software and Systems Engineering: Proceedings of the AHFE 2021 Virtual Conferences on Human Factors in Software and Systems Engineering, Artificial Intelligence and Social Computing, and Energy, July 25-29, 2021, USA* (pp. 510-521). Springer International Publishing.

[38] Nordin, N., Deros, B., & Wahab, D. (2014). Lean manufacturing implementation in malaysian automotive industry: an exploratory study. Operations and Supply Chain Management an International Journal, 21-30. https://doi.org/10.31387/oscm090053

[39] Nordin, N., Mohamed, R., & Uchihira, N. (2020). Model of tacit knowledge transfer in lean management implementation in an organization.. https://doi.org/10.5772/intechopen.85514

[40] Nwajiuba, C., Igwe, P., Binuomote, M., Nwajiuba, A., & Nwekpa, K. (2020). The barriers to high-growth enterprises: what do businesses in africa experience?. European Journal of Sustainable Development, 9(1), 317. https://doi.org/10.14207/ejsd.2020.v9n1p317

[41] Ohenhen, P.E., Chidolue, O., Umoh, A.A., Ngozichukwu, B., Fafure, A.V., Ilojianya, V.I. and Ibekwe, K.I., 2024. Sustainable cooling solutions for electronics: A comprehensive review: Investigating the latest techniques and materials, their effectiveness in mechanical applications, and associated environmental benefits.

[42] Okoro, Y.O., Ayo-Farai, O., Maduka, C.P., Okongwu, C.C. and Sodamade, O.T., 2024. The Role Of Technology In Enhancing Mental Health Advocacy: A Systematic Review. *International Journal of Applied Research in Social Sciences*, *6*(1), pp.37-50.

[43] Orieno, O.H., Ndubuisi, N.L., Ilojianya, V.I., Biu, P.W. and Odonkor, B., 2024. The Future Of Autonomous Vehicles In The US Urban Landscape: A Review: Analyzing Implications For Traffic, Urban Planning, And The Environment. *Engineering Science & Technology Journal*, *5*(1), pp.43-64.

[44] Pereira, A., Dinis-Carvalho, J., Alves, A., & Arezes, P. (2019). How industry 4.0 can enhance lean practices. Fme Transaction, 47(4), 810-822. https://doi.org/10.5937/fmet1904810p

[45] Pieterse, E., Parnell, S., & Haysom, G. (2018). African dreams: locating urban infrastructure in the 2030 sustainable developmental agenda. Area Development and Policy, 3(2), 149-169. https://doi.org/10.1080/23792949.2018.1428111

[46] Powell, D., Alfnes, E., Strandhagen, J., & Dreyer, H. (2013). The concurrent application of lean production and erp: towards an erp-based lean implementation process. Computers in Industry, 64(3), 324-335. https://doi.org/10.1016/j.compind.2012.12.002

[47] Powell, D., Romero, D., Gaiardelli, P., Cimini, C., & Cavalieri, S. (2018). Towards digital lean cyber-physical production systems: industry 4.0 technologies as enablers of leaner production., 353-362. https://doi.org/10.1007/978-3-319-99707-0_44

[48] Raji, I., Shevtshenko, E., Rossi, T., & Strozzi, F. (2021). Industry 4.0 technologies as enablers of lean and agile supply chain strategies: an exploratory investigation. The International Journal of Logistics Management, 32(4), 1150-1189. https://doi.org/10.1108/ijlm-04-2020-0157

[49] Romero, D., Gaiardelli, P., Powell, D., Wuest, T., & Thürer, M. (2018). Digital lean cyber-physical production systems: the emergence of digital lean manufacturing and the significance of digital waste., 11-20. https://doi.org/10.1007/978-3-319-99704-9_2

[50] Sahoo, S. and Yadav, S. (2018). Lean production practices and bundles: a comparative analysis. International Journal of Lean Six Sigma, 9(3), 374-398. https://doi.org/10.1108/ijlss-01-2017-0002

[51] Shah, R. and Ward, P. (2002). Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management, 21(2), 129-149. https://doi.org/10.1016/s0272-6963(02)00108-0

[52] Sinkamba, F., Matindana, J., & Mgwatu, M. (2023). Towards lean manufacturing in developing countries: research gaps and directions in tanzania. Tanzania Journal of Engineering and Technology, 42(1), 26-45. https://doi.org/10.52339/tjet.v42i1.886

[53] Sisson, J. and Elshennawy, A. (2015). Achieving success with lean. International Journal of Lean Six Sigma, 6(3), 263-280. https://doi.org/10.1108/ijlss-07-2014-0024

[54] Thoben, K., Wiesner, S., & Wuest, T. (2017). "industrie 4.0" and smart manufacturing – a review of research issues and application examples. International Journal of Automation Technology, 11(1), 4-16. https://doi.org/10.20965/ijat.2017.p0004

[55] Ukoba, K.O., Inambao, F.L. and Njiru, P., 2018. Solar Energy and Post-Harvest Loss Reduction in Roots and Tubers in Africa. In *Proceedings of the World Congress on Engineering and Computer Science* (Vol. 1).

[56] Vincent, A.A., Segun, I.B., Loretta, N.N. and Abiola, A., 2021. Entrepreneurship, agricultural value-chain and exports in Nigeria. *United International Journal for Research and Technology*, *2*(08), pp.1-8.

[57] Worley, J. and Doolen, T. (2006). The role of communication and management support in a lean manufacturing implementation. Management Decision, 44(2), 228-245. https://doi.org/10.1108/00251740610650210

[58] Worley, J. and Doolen, T. (2015). Organizational structure, employee problem solving, and lean implementation. International Journal of Lean Six Sigma, 6(1), 39-58. https://doi.org/10.1108/ijlss-12-2013-0058

[59] You, W., Salmi, A., & Kauppi, K. (2018). Integration of african firms into global value chains. Critical Perspectives on International Business, 14(2/3), 252-281. https://doi.org/10.1108/cpoib-11-2016-0056

[60] Zahraee, S. (2016). A survey on lean manufacturing implementation in a selected manufacturing industry in Iran. International Journal of Lean Six Sigma, 7(2), 136-148. https://doi.org/10.1108/ijlss-03-2015-0010