

THE IMPACT OF ARTIFICIAL INTELLIGENCE (AI) ON THE MANUFACTURING SECTOR IN UGANDA

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ABSTRACT

This study investigated the impact of artificial intelligence (AI) on the manufacturing sector in Uganda, examining how AI technologies are transforming production processes, improving efficiency, and driving economic growth. Through a combination of literature review, qualitative interviews, and case studies, the research identifies key areas where AI has been implemented, evaluates its effectiveness, and discusses the challenges and opportunities associated with AI adoption. The findings indicate that AI has the potential to significantly enhance productivity and innovation in Ugandan manufacturing, but barriers such as limited technical expertise and infrastructure need to be addressed. Recommendations for policy-makers and industry stakeholders are provided, along with suggestions for further research. This news highlights the key opportunities and challenges facing Uganda's manufacturing industry by analyzing the current situation, analyzing the international situation, and drawing insights from the achievements of other African countries and intellectual achievements around the world. The recommendations shall guide policymakers, business and industry stakeholders on the use of artificial intelligence to promote sustainable development and competitiveness in manufacturing.

Keywords: Artificial Intelligence; Manufacturing; Sector; Technologies; Production Processes.

I. INTRODUCTION

The work was productive. Uganda's industrial sector has shown continuous growth in recent years, with an average annual growth rate of 6%, according to a report published by the Uganda Manufacturers Association (UMA). To meet the growing demand for efficiency and effectiveness, manufacturing companies in Uganda are increasingly turning to artificial intelligence (AI) and business intelligence (ERP) systems to increase their productivity and competitiveness. To meet the needs of the business and help companies meet their needs, ebizframe Uganda has developed a smart ERP system. Although African countries are productive and productive, their production capacity is decreasing over the years.

This has limited economic reforms and economic development that create good jobs that could reduce the impact of expansion into the continent. Signe and Johnson (2018) argue that the transformation of manufacturing into the country of wealth in the world in countries such as the United States, England, France, Japan, Germany and recently China is the result of the first economy. Revolution. These have helped these businesses experience change and economic growth. The world's negative cycle is caused by slow economic growth of the population, which aims to increase to half of the world's population by 2050 (Cilliers, 2021; Borat, Rooney & Steenkamp, 2019). The economic development of African countries has improved, but they are still not competitive enough compared to developed countries in the global economic environment (ACET, 2018). The reason for the success of industrialized countries is not far from their ability to adapt to new technologies and innovations. Developing countries are approaching the fifth industrial revolution by investing heavily in new technologies and innovations supported by the use of artificial intelligence (AI) and machine learning algorithms in production activities. Application of artificial intelligence in manufacturing can benefit production, marketing and business. Increase customer satisfaction. AI can help brands increase customer satisfaction by analyzing customer data and behavior. By understanding customer needs and preferences, companies can develop marketing strategies and improve customer experience. This helps increase customer loyalty and retention, which is vital for the long-term success of manufacturing in Uganda using a purpose-built ERP system. (Ikumapayi et al., 2022; Luo, Li, & Yu, 2020; Huang, Wang, & Liang, 2019;). Although their findings and opinions differ, they all agree that intelligence is beneficial to productivity. It was created by Ferencz,

Javier, and Garcia (2022) to examine the feasibility of artificial intelligence to achieve economies of scale, reduce costs, increase jobs, increase profits, and ensure trade pressure on businesses. Meltzer, (2018); Goldfar and Treffler (2018); common recognition that AI increases the economic efficiency of the economy and that countries whose manufacturing companies switch to AI have a comparative advantage and better overall business expansion. Strengthening the use of artificial intelligence in the pursuit of economic development in the production of goods where economic development is weak and there is economic decline. Luo, Li, and Yu (2021) pointed out the transition from traditional production to modern production by integrating information technology and management methods. Businesses use artificial intelligence and machine learning to solve many problems. The economy, which plays an important role in the economic development of the country, has grown rapidly compared to Africa, which, despite having rich resources, is still behind in terms of technology use. Adesina (2017) attributes the underdevelopment and lack of competitiveness of the African economy to low technology, poor research, poor infrastructure and poor environment. As Huang, Wang, and Steven (2019) point out, the success of developed countries is based on large investments in technological development and continuous improvement through business.

The advent of artificial intelligence (AI) has revolutionized various industries globally, including the manufacturing sector. In developing countries like Uganda, AI presents a unique opportunity to enhance industrial capabilities, streamline production processes, and boost economic development. This study aims to explore the impact of AI on the manufacturing sector in Uganda, identifying the benefits, challenges, and future prospects of AI implementation.

Problem Statement

Despite the potential advantages of AI, its adoption in Uganda's manufacturing sector remains limited. The sector faces numerous challenges, including a lack of awareness, insufficient infrastructure, and a shortage of skilled personnel. This study seeks to understand how AI can be effectively integrated into the manufacturing processes in Uganda and the extent of its impact on the sector's growth and productivity.

Main Objective

The main objective of this research was to assess the impact of AI on the manufacturing sector in Uganda.

II. LITERATURE REVIEW

AI in manufacturing has been extensively studied, with numerous reports highlighting its transformative potential. According to Kagermann et al. (2013), AI technologies such as machine learning, robotics, and predictive analytics can optimize production processes, reduce downtime, and enhance product quality. In the context of developing countries, AI can bridge the gap between resource constraints and competitive industrial performance (World Economic Forum, 2020). However, literature also points to significant barriers, including technological, economic, and educational challenges (Chui et al., 2018).

Artificial Intelligence.

According to Buchmeister, Palcic, and Ojstersek (2019), artificial intelligence refers to any computer that can perform tasks that generally require human intelligence. Machine learning is a type of artificial intelligence that uses data and algorithms to make accurate decisions and solve problems that are difficult for humans to solve effectively. Artificial intelligence (AI) will be the main driver of technological change in business, and it is important to prepare people for future AI-controlled activities (Byrum, 2018). Production monitoring, which will have a significant impact on production with artificial intelligence, offers companies solutions to prevent damage to machines.

These AI solutions for manufacturing companies can predict equipment failures before they break down. Similarly, AI in manufacturing can help companies bring the best products to market on time. Thus, knowledge in production affects the quality of products and ensures good results (Jha, 2021). The best AI systems will be built around the concept of augmented intelligence. Artificial intelligence will change the process of business operations, ultimately making it almost impossible for human employees to make decisions about actions. (Kana, 2018). The use of artificial intelligence and machine learning in the production process will lead to smart manufacturing.

Wang, et al, (2018) stated that smart manufacturing meets three levels of digital production (first generation production), digital networked production (second generation production) and smart production (new design). The impact of intelligent design on products, digital twins, virtual reality, automation, product quality and personal care is the smartest thing to happen to the manufacturing process (Jha, 2021). Many major economies, including the United States, China, and EU countries, see smart manufacturing as a key factor for successful production (Ikumapayi et al., 2022; Bogle, 2017). Therefore, smart manufacturing reduces production costs.

Ugandan Situation.

According to the World Bank (World Bank, 2020), Uganda ranks near the bottom in Africa in terms of per capita productivity. The contribution of trade to the country's GDP is less than 10%, well below the average for Sub-Saharan Africa. However, the transfer of intellectual property will bring the following benefits to Uganda's manufacturing industry. Cost reduction means the most efficient use of all resources with the least expenditure of personnel and resources. The lowest price allows companies to produce quantities large enough to meet the needs of the market. Therefore, reducing costs leads to big business, high business, best results and high business for businesses and enterprises. Economic advantage is the comparative cost advantage of a business or industry over another business or industry. Most developing countries have better economies than weak economies or growing economies due to technological change.

AI technologies, such as machine learning, computer vision, and robotics, have enabled Ugandan manufacturers to reduce downtime, improve product quality, and streamline operations. Predictive maintenance systems, for instance, utilize AI algorithms to forecast equipment failures before they occur, allowing for timely interventions and minimizing production disruptions. This proactive approach not only extends the lifespan of machinery but also significantly reduces maintenance costs (Kagaba, 2022).

In the realm of quality control, AI-powered vision systems have been employed to inspect products for defects with high precision and speed. These systems can detect inconsistencies and anomalies that human inspectors might overlook, ensuring that only high-quality products reach the market. Consequently, manufacturers in Uganda are able to enhance customer satisfaction and reduce waste (Nabukeera, 2023).

Moreover, AI has optimized supply chain management by providing real-time insights into inventory levels, demand forecasting, and logistics. This has enabled manufacturers to respond swiftly to market changes, manage resources more effectively, and reduce lead times. The integration of AI in supply chain processes has thus led to more resilient and agile manufacturing operations (Mukasa, 2022).

Despite these advancements, the adoption of AI in Uganda's manufacturing sector faces several challenges. High initial investment costs, lack of skilled personnel, and concerns about data privacy and security are significant barriers. Additionally, there is a need for supportive infrastructure and policies to facilitate the widespread implementation of AI technologies (Kyeyune, 2022).

The global viewpoint of artificial intelligence

The development of digitalization and artificial intelligence demonstrates the country's commitment to the use of technology to promote economic development, including manufacturing. Significant progress has been made in integrating intelligence into production to increase productivity, quality and competitiveness. For example, using technologies such as robotics, predictive maintenance and smart manufacturing, China has become a global leader in intelligence-based manufacturing. Likewise, Germany's economic strategy emphasizes the integration of intellectual skills, and by studying these examples, Uganda can provide good insights and best practices on the use of AI in business development. A study was conducted in 2017. It was revealed that more than forty-seven percent (47%) of US residents will use a computer in the next two years (20). These jobs include business, human services, service jobs, insurance management and more. Use AI in their services/processes. The author says most businesses are considering incorporating AI into their operations. Research has shown that intelligence can benefit people in the following areas: sports, emotional intelligence, diagnosis, facial recognition, courage, and predictive behavior (Unerman, 2017).

In the United States, 47% of jobs are now at risk from computer use. This means that 47% of workers will soon lose their jobs due to their skills (Cheiliah, 2017). The country announced its Artificial Intelligence Strategy for Mauritius, Digital Government Transformation Strategy 2018-2022 and Digital Mauritius 2030 Strategic Plan in December 2018 (GIS, 2018; Government of Mauritius, 2018). The government also announced that it will

establish the Mauritius Artificial Intelligence Commission (MAIC) (Sey, 2020). Another country on the African continent regarding artificial intelligence is Nigeria, which established the Nigerian Center for Artificial Intelligence and Robotics (CFAIR) in Abuja in November 2020 (FinIntell, 2020).

A task force was also created to manage the development of the national intelligence strategy. Kenya established a task force on business technology and skills deployment in February 2018 (Wall Street Kenya, 2018). In its final report, published in July 2019, the staff focused on the potential and perceived impact of AI on key developments such as healthcare, food security, manufacturing, housing and education. The report presents a broad argument for and against the government's intellectual property policy and offers general policy recommendations (Mpala, 2019).

III. METHODOLOGY

This study employed a mixed-methods approach, combining qualitative and quantitative research methods. Data collection involved Literature Review, Analyzing existing research and reports on AI in manufacturing. Semi-structured interviews were conducted with industry experts, policymakers, and manufacturing company representatives in Uganda. The study was descriptive in nature because the researchers needed to describe the situation as it is both locally and internationally to draw a valid conclusion and way forward.

IV. RESULTS AND DISCUSSION

The study on the impact of artificial intelligence (AI) on the manufacturing sector in Uganda reveals several key findings. These findings are based on a combination of literature review, interviews with industry experts, and case studies of specific manufacturing companies in Uganda.

1. Current State of AI Adoption

AI adoption in Uganda's manufacturing sector is still in its early stages. However, there is a growing awareness and interest in AI technologies among manufacturers. Some leading companies have begun to implement AI solutions, primarily in areas such as predictive maintenance, quality control, and supply chain management. This is in line with the research finding of (Kaggwa, 2021; Nsubuga & Nalukwago, 2022)

2. Predictive Maintenance

One of the significant impacts of AI in the manufacturing sector is its application in predictive maintenance. AI algorithms are being used to analyze data from manufacturing equipment to predict potential failures before they occur. This has led to:

Reduced Downtime: Companies have reported a significant reduction in equipment downtime, as maintenance can be performed proactively rather than reactively. Cost Savings: The ability to predict failures and perform maintenance only when necessary has reduced maintenance costs. For instance, a study by Nsubuga and Nalukwago (2022) highlights how AI-driven predictive maintenance in a leading Ugandan manufacturing firm resulted in a 20% reduction in unplanned downtime.

3. Quality Control

AI technologies, particularly machine learning and computer vision, have been deployed to enhance quality control processes. Benefits observed include:

Improved Defect Detection: AI systems have improved the accuracy of defect detection in manufactured products, leading to higher quality outputs (Case Study: Company X, 2023). Consistency: AI-driven quality control ensures consistent inspection standards, reducing human error and variability.

4. Supply Chain Optimization

AI-driven analytics have been utilized to optimize supply chain operations. This includes better demand forecasting, inventory management, and logistics planning. The impacts are:

Enhanced Efficiency: Companies have achieved more efficient supply chain operations, reducing lead times and costs (Interview with procurement manager Behariz, 2024).

Better Inventory Management: AI has helped in maintaining optimal inventory levels, reducing overstock and stockouts.

5. Machine learning and computer vision technologies have improved the accuracy of defect detection, ensuring higher product quality and consistency. Kagondo (2020) noted that a Ugandan textile manufacturer

implementing AI for quality control experienced a 15% improvement in defect detection rates. Supply Chain Optimization AI technologies are aiding in supply chain optimization by improving demand forecasting, inventory management, and logistics planning. This has resulted in enhanced efficiency and reduced operational costs.

6. Challenges to AI Adoption

Despite the promising impacts, several challenges hinder the widespread adoption of AI in Uganda's manufacturing sector:

High Initial Costs: The initial investment required for AI implementation is high, which is a significant barrier for many manufacturers.

There is a lack of skilled personnel with expertise in AI and related technologies, limiting the effective deployment and maintenance of AI systems (Okello & Nabiryo, 2021).

Inadequate Infrastructure: The existing technological infrastructure in Uganda is often insufficient to support advanced AI applications, particularly in smaller firms (Kaggwa, 2021).

7. Opportunities and Recommendations

Training and Education: Developing specialized AI training programs to build expertise among the workforce Nsubuga & Nalukwago, (2022) Collaborative efforts between industry, academia, and government can help bridge the skills gap.

Government Support: Policy initiatives and financial incentives from the government can lower barriers to AI adoption. This includes subsidies for AI investments and support for infrastructure development (Kagondo, 2020).

Public-Private Partnerships: Encouraging partnerships between the public and private sectors can foster innovation and facilitate the sharing of resources and expertise. This supported by the research of Mugisha, (2021) which encourages collaborations between the public and private sectors to foster innovation and facilitate resource sharing

V. CONCLUSION

The impact of artificial intelligence is profound, leading to major changes in efficiency, productivity and innovation. Artificial intelligence technologies, including machine learning, robotics and data analysis, are accelerating the use of AI in manufacturing, enabling improvements in maintenance, quality control, supply chain quality and production lines. This change not only increases business efficiency, but also paves the way for better work, flexibility and efficiency. Integrating artificial intelligence into the production of products is crucial to increase flexibility, reduce downtime and improve product quality through monitoring and control time. Additionally, the move to smart factories that incorporate data from decision-making and unstructured work demonstrates the broad impact of AI on the manufacturing ecosystem, including personnel development and environmental safety. Although there are many benefits, there are also challenges and opportunities for further research. The study concludes that AI holds significant potential for transforming the manufacturing sector in Uganda by enhancing efficiency, reducing costs, and driving innovation. However, to fully realize these benefits, it is crucial to address the barriers to AI adoption through targeted investments in infrastructure, education, and policy support.

Areas of Further Research

Future research should focus on:

1. Developing AI training programs tailored to the needs of the manufacturing sector in Uganda.
2. Investigating the long-term economic impacts of AI adoption on Uganda's industrial growth.
3. Exploring the role of public-private partnerships in fostering AI innovation in manufacturing.

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