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INFRASTRUCTURE CHALLENGES AND ARTIFICIAL INTELLIGENCE INTEGRATION AMONG SMALL AND MEDIUM ENTERPRISES IN ANAMBRA STATE, NIGERIA

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Abstract

The integration of Artificial Intelligence (AI) into Small and Medium Enterprises (SMEs) holds significant potential for enhancing productivity, innovation, and competitiveness. Hence, this study explored Infrastructure Challenges and Artificial Integration among small and medium enterprises in Anambra state. The objective was to analyse the specific infrastructural Challenges that hinder AI integration in SMEs and to evaluate how these infrastructural limitations affect the adoption and effective use of AI technologies in SMEs within Anambra State. The study applied a qualitative research approach using thematic analysis. A descriptive research design was used to gain an in-depth understanding of the subject matter. Convenient sampling techniques were employed in selecting 10participants for the interviews. All interviews were transcribed verbatim and uploaded into MAXQDA

Analytics Pro 2020 (qualitative data analysis software).The coding scheme was systematically applied to all transcripts through multiple close data readings. Both semantic/explicit content and latent content requiring interpretative analysis were captured by the codes. Findings revealed a complex interplay between existing challenges and the transformative potential of artificial intelligence for businesses. *It therefore recommended the need for SMEs in Anambra State to embrace smart technology as a catalyst for innovation, competitiveness, and long-term success.*

INTRODUCTION

Africa's business landscape has substantial infrastructural issues, impeding economic growth and limiting the competitiveness of local businesses (Ajide, 2020). Inadequate transport networks, inconsistent electrical supply, and inadequate digital infrastructure are major hurdles to corporate operations and expansion across the continent (StrusaniandHoungbonon, 2020). Many countries suffer from undeveloped road, rail, and air transportation networks, making it difficult and expensive for enterprises to convey products, services, and people. Anambra State, located in South-East Nigeria, is thriving and has significant economic prospects. Its strategic location and vibrant business culture makes it a key role in the Nigerian economy. A varied range of industries such as trade, commerce, manufacturing, agriculture, and services greatly boosts the state's GDP.

Anambra State is well-known for its entrepreneurial culture, with many small and medium-sized firms (SMEs) contributing to economic growth and job creation (Chinwe and Anthony,2023). Sadly, Anambra faces various infrastructure challenges that impede its growth trajectory and limit its economic potential (Agulonye, 2020). Infrastructure challenges significantly hinder AI adoption among SMEs by limiting access to necessary resources (Majchrzak, Michalski, andZacharski, 2021). Many SMEs lack robust IT infrastructure, including adequate hardware, cloud services, and data storage capabilities. This deficiency impedes their ability to process large datasets essential for effective AI

applications. Additionally, inadequate cybersecurity measures raise concerns about data privacy, making SMEs hesitant to implement AI solutions (Gillespie and Schindler, 2022). The lack of skilled personnel to manage and maintain advanced technologies further complicates matters. Consequently, these limitations create a barrier to leveraging AI, preventing SMEs from reaping its benefits, such as improved efficiency and competitive advantage.

Generally, AI adoption in Africa is still in its early phases, with differences in infrastructure, connection, and digital literacy preventing widespread implementation of AI-based solutions (Kolog, Devine, Egala, Amponsah, Budu, andFarinloye 2022). Anambra State has been strugglingto adopt and integrate artificial intelligence (AI) technology across many industries (Onuzulike, Ndubuisi, andAgbata, 2023). The incorporation of Artificial Intelligence (AI) represents a possible solution to these infrastructure-related challenges (Malaiyappan, Karamthulla, andTadimarri, 2023). This is because AI-powered systems can optimise and improve existing infrastructure, producing a more favourable environment for corporate growth (AlliouiandMourdi, 2023). This study therefore sought to explore infrastructural challenges for integrating AI in Anambra State small and medium enterprises.

Objective of the study: The broad objective is Infrastructure Challenges and Artificial Integration among small and medium enterprises in Anambra state.

While the specific Objectives are:

1. To determine the challenges small and medium enterprises face due to infrastructure limitations.

2. To ascertain the potential for AI to improve infrastructure in Anambra State,

3. To determine initiatives or projects using AI to address infrastructure challenges among small and medium enterprises in Anambra State.

4. To determine policy and regulatory frameworks needed to support the adoption and scaling of AI-powered infrastructure solutions in Anambra State.

5. To determine how AI-powered tools for online marketing or customer service could help small and medium enterprises in Anambra state.

Review of Related Literature

Artificial intelligence

Artificial Intelligence (AI) refers to developing computer systems that can perform tasks typically requiring human intelligence including learning from experience (machine learning), understanding natural language, recognising patterns, solving problems, and making decisions (Russell and Norvig, 2020). In its contemporary context, AI encompasses a variety of subfields such as deep learning, natural language processing (NLP), and robotics, enabling systems to adapt and improve based on data input autonomously (Chui,Manyika and Miremadi 2018).Artificial Intelligence systems are intended to accomplish tasks that normally require human intellect, such as understanding and responding to natural language, chatbots, voice assistants, and language translation tools (Suta, Lan, Mongkolnam, and Chan, 2020). It automates jobs, lowers errors, and optimises processes, resulting in increased efficiency (Javaid, Haleem, Singh, and Suman,2022). Further, AI enables the creation of innovative products and services that meet evolving customer needs (Sjödin, Parida,PalmieandWincent, 2021). These imply that AI can streamline processes, optimise resource allocation, and reduce errors, leading to significant cost savings and giving businesses a competitive edge by enabling them to operate more efficiently, make better decisions, and offer better products and services.

Infrastructure challenges in Anambra state

Infrastructure development is crucial to creating a thriving corporate environment. However, Anambra State has major infrastructure shortages, which impede economic growth and commercial competitiveness (Agulonye, 2020). These infrastructure difficulties affect a variety of sectors, including transportation, energy, telecommunications, water, and sanitation. One of Anambra's primary infrastructure challenges is a lack of dependable and accessible transport networks (UmeifekwemandOnwunyi, 2023). They have underdeveloped road, rail, and air transport systems, making it difficult and expensive for businesses to move goods, services, and people across the state. This lack of connectivity reduces market access, hinders regional trade, and raises the total cost of doing business (Lorenzen, Mudambi, andSchotter, 2020). Another critical infrastructure concern is the limited and inconsistent availability of businesses and discourage investment. The limited access to clean and affordable energy also hinders the development of energy-intensive industries and the adoption of modern technologies.

Furthermore, the digital infrastructure in Anambra state remains underdeveloped, with uneven access to high-speed internet and telecommunications networks. This digital divide limits firms' capacity to use digital technologies like e-commerce, cloud computing, and data analytics to increase their competitiveness and reach new markets (Neumeyer, Santos, and Morris, 2020). Internet access is scarce, especially in rural areas. This impedes the development of e-commerce, online education, and other digital services that can boost economic growth.

Adoption of AI In

AnambraState and AI Challenges

Anambra State has recognised AI's potential to improve agricultural practices and food security (Ubokwe, 2022). Pilot projects have been launched to test AI-powered drones for

precision farming, crop monitoring, and yield prediction. AI-based decision support systems are also being investigated to offer farmers real-time information on weather patterns, soil conditions, and the best planting and harvesting tactics (Shaikh, Rasool, and Lone,2022). Anambra State has attempted to integrate AI-powered tools and platforms into its education system, with a focus on personalised learning, adaptive assessment, and virtual coaching (Ezeh,2023). Some schools in the state have implemented AI-powered learning management systems and intelligent tutoring systems to deliver personalised learning experiences and identify areas for development. The state has also launched programs to train instructors.Despite all these efforts, there are still challenges in the adoption of AI in Anambra. There is Limited access to reliable and high-speed internet connectivity, particularly in rural areas, which poses a significant challenge to the widespread adoption of AI-powered technologies (Wang, Zhao andGangadhari, 2021). Inadequate infrastructure, such as reliable power supply and modern computing facilities, hinders the effective deployment and scalability of AI solutions (Gill, Ottaviani, Patros, Bahsoon, Shaghaghiand Uhlig,2022). There is a shortage of skilled AI professionals and data scientists within Anambra State, hampering the development and implementation of AI-based solutions (Yang,Chan, Shan, Gao, Bao, and Guan,2021). Efforts to close the skills gap through targeted training and capacity-building programs are still in their early phases. The state lacks a robust regulatory framework and governance structure to oversee the ethical and responsible use of AI, including data protection, security, and algorithmic transparency (Almeida, Santos, and Farias, 2021). The lack of clear norms and guidelines for data gathering, storage, and use might impede the development and deployment of AI systems that require massive datasets. Anambra State continues to struggle with securing appropriate money and investment for AI research, development, and implementation. To get around these difficulties and further accelerate the adoption of AI in Anambra State, the government, in partnership with the corporate sector and academic institutions, must design a comprehensive AI plan.

Infrastructure Barriers to AI Implementation in Anambra State: Anambra State, like many other places in Nigeria and Africa, confronts severe infrastructure-related issues that impede the effective deployment and acceptance of artificial intelligence (AI) technology (Zhang, Chen, Zhang, Liu, Chen, Yangand Yap, 2024). Infrastructure challenges to AI applications in Anambra State are summarised as follows:

Connectivity and Internet access: Reliable and high-speed internet connectivity remains a key impediment in Anambra State, particularly in rural and remote locations (Okoye et al., 2023). Weak telecommunications infrastructure and inconsistent internet connectivity impede the capacity to develop and use AI-powered apps that demand constant data transfer and cloud-based computing resources.

Power Supply and Energy Infrastructure: Consistent and stable electricity supply is a persistent challenge in Anambra State, with frequent power outages and load-shedding disrupting the continuous operation of AI-enabled systems. The lack of a robust and resilient energy infrastructure can undermine the effectiveness and reliability of AI-based solutions (OlawaleandAyeh, 2021)

Computing and Data Centers: The availability of modern, well-equipped computing facilities, such as data centers and high-performance computing resources, is limited in Anambra State. This shortage of suitable computing infrastructure hinders the state's ability to handle the large datasets and complex computational requirements necessary for effective AI implementation (McEnroe, Wang andLiyanage, 2022).

Data Management and Storage: Anambra State faces challenges in establishing comprehensive data management systems and secure data repositories to support AI-driven initiatives.(Almeida, Santos and Farias, 2021).The absence of clear policies and guidelines on data collection, storage, and usage can hinder Inadequate data governance frameworks and limited data collection and storage capabilities can impede the availability and quality of the datasets required for AI applications.

Skilled Workforce: Anambra State, like much of Nigeria, experiences a shortage of skilled AI professionals and data scientists. The lack of specialized training programs, educational curricula, and talent pipelines focused on AI and related technologies hampers the state's ability to build and sustain a robust AI workforce (Ezeh,2023).Addressing these infrastructure-related barriers will be crucial for Anambra State to unlock the transformative potential of AI and leverage it for socioeconomic development, improved public service delivery, and enhanced competitiveness in the emerging digital landscape.

AI Solutions for Infrastructure Barriers in Anambra State:

Anambra State, like many regions in Nigeria and Africa, faces significant infrastructure-related challenges. However, the strategic implementation of artificial intelligence (AI) solutions can help address these barriers and drive sustainable infrastructure development in the state. Here are some potential AI-based solutions that could be explored (Shaikh, Rasooland Lone,2022).

Smart Transportation: AI-powered systems can optimize traffic flow, improve route planning, and enhance fleet management, helping to mitigate the challenges posed by underdeveloped transportation networks in Africa.Smart transportation powered by AI involves the use of advanced technologies to improve the efficiency, safety, and sustainability of transportation systems (Bharadiya, 2023)

Smart Grid and Energy Management: AI algorithms can be used to optimise energy distribution, predict and manage demand, and incorporate renewable energy sources, thereby addressing the issue of intermittent electricity supply. AI can optimise electricity distribution by balancing load across various grid technologies (Wang, Zhao, andGangadhari, 2021). Utilities can incentivise customers to reduce or shift their energy consumption during peak hours, so preventing overloads and blackouts.

Predictive Maintenance: AI-powered predictive maintenance models can assist in identifying and fixing infrastructure concerns in advance, minimising downtime and boosting key system reliability (Pillai, 2023).

Remote Monitoring and Automation: AI-powered sensors and autonomous systems can be utilised to remotely monitor and manage infrastructure, eliminating the need for physical access and overcoming geographical limitations (Onuzulike, Ndubuisi, andAgbata, 2023).

Data-driven decision-making: Artificial intelligence (AI) can analyse massive volumes of data from diverse infrastructure sources, providing policymakers and corporate leaders with important insights into making informed decisions and optimising infrastructure expenditures.

METHODOLOGY

A qualitative method research methodology was employed to study Infrastructure Challenges and Artificial Integration among small and medium enterprises in Anambra state. A thorough review of past research was utilized to gain a comprehensive understanding of the challenges of infrastructures faced by different sectors in Anambra state. To facilitate coding and analysis, all interviews were transcribed verbatim and uploaded into MAXQDA Analytics Pro 2020,a qualitative data analysis software. The initial step involved open coding, where tentative themes in the data were identified. These codes were then refined, resulting in a preliminary coding scheme or codebook. The coding scheme was systematically applied to all transcripts through multiple close data readings. Both semantic/explicit content and latent content requiring interpretative analysis were captured by the codes.

Upon finalizing the coding process, the codes were categorized into potential overarching themes. The determination of these themes took into consideration their prevalence across interviews and their significance to the research questions. The analysis yielded five

themes. Convenient sampling was employed to select participants for the interviews due to its practicality and ease of access to various sectors with relevant knowledge and experience regarding the infrastructure barriers in Anambra State. Participants were selected based on their availability and willingness to participate in the study. A total of 10 participants were selected from 5 sectors for interviews to provide a diverse range of perspectives. The following interview guide was taken into consideration

1. What are theChallenges businesses face due to infrastructure limitations in Anambra, State?

2. What are your thoughts on the potential for AI to improve infrastructure in Anambra State, and what specific areas do you think AI could have the biggest impact?

3.Have you heard of any initiatives or projects using AI to address infrastructure challenges in Anambra State?

4. What are the key policy and regulatory frameworks needed to support the adoption and scaling of AI-powered infrastructure solutions in Anambra State?

5. How do you think AI-powered tools for online marketing or customer service could help your business grow and reach new customers?"

Demographic characteristics of Sectors

Sector Type	**Frequency**	**Percent**
Manufacturing	2	20
Services	2	20
Agriculture	2	20
Building and Constuction	2	20
Trade and Commerce	2	20
Age of Sectors	**Frequency**	**Percent**
1-5 years	3	30
6-10 years	3	30
>11 years and avove	4	40

Themes and their frequency and percentageoccurrence

Themes	Frequency	Percentage	Percentage (valid)
Challenges businesses face Due to infrastructure limitations in Anambra, State?	8	80.0	80.0
Potentials forAI to improve Infrastructure in Anambra State?	10	100.00	100.00
Any Initiatives or projects by Government in Anambra State?	7	70.0	70.0
Key policy and regulatory intervention	10	100.00	100.00
Effect of AI-powered tools for online marketing	8	80.0	80.0

Thetableshowsthatalmostallthethemeswereconsistentacrossalltheparticipants.

Discussion of Findings

Theme 1. Challenges businesses face due to infrastructure limitations in Anambra, State.

Participants expressed their frustration over the challenges posed by inadequate infrastructure in Anambra State. Participants 2, 4, 6, and 7 highlighted several significant issues, with frequent power outages and inconsistent electricity supply being among the most critical. They noted that their production lines rely heavily on a steady electricity source, and these frequent blackouts have caused substantial disruptions and losses in

productivity. As a result, they have had to invest in backup generators, which increase operational costs and reduce profit margins**.**

Additionally, the poor condition of the roads complicates the timely and cost-effective transportation of raw materials and finished products. Potholes and congestion on highways have led to delayed deliveries, increased fuel consumption, and higher maintenance costs for transportation fleets.Another major challenge is the limited access to reliable internet and digital connectivity. Businesses rely on online platforms for communication, marketing, and coordination with suppliers and customers. However, spotty internet coverage and slow speeds in many parts of Anambra hinder their ability to effectively leverage digital tools and technologies, impacting productivity, efficiency, and overall competitiveness.Participants emphasised that these infrastructure limitations require significant time, effort, and financial resources to navigate. Addressing these challenges would be a game-changer for businesses in Anambra State and the region as a whole.

Theme 2.What are your thoughts on the potential for AI to improve infrastructure in Anambra State?

This discussion pertains to the second interview question regarding the potential for AI to improve infrastructure in Anambra State and the specific areas where it could have the biggest impact. Participants 4, 6, 7, and 8 expressed that AI has significant potential to address critical infrastructure challenges in the region. AI could optimise traffic flow and reduce congestion through smart traffic management systems that analyse real-time data, improving commuting efficiency and logistics for businesses by ensuring timely deliveries and lowering operational costs.Participant 6 highlighted energy management as another area where AI could make a substantial impact. Given the frequent power outages, AI-driven solutions could predict demand and manage energy distribution more effectively. Smart grids powered by AI could optimise electricity usage and integrate renewable energy

sources, stabilising supply and reducing reliance on backup generators.In water supply and management, AI could monitor water quality and distribution networks. By analysing data from sensors, AI could identify leaks and inefficiencies, ensuring access to clean water for businesses and communities.

Overall, participants agreed that AI is a transformative tool for addressing infrastructure deficits in Anambra State. However, they emphasised the need to tackle challenges related to data availability, digital literacy, and investment in technology. If executed effectively, AI could significantly enhance infrastructure, boost economic growth, and improve residents' quality of life.Furthermore, AI can enhance digital infrastructure by improving connectivity solutions, especially in rural areas. AI algorithms could optimise network coverage and resource allocation, facilitating access to reliable internet services for businesses.

Theme 3. Any initiatives or projects using AI to address infrastructure challenges in Anambra State?

This discussion aligns with question three, which asks whether participants have heard of any initiatives or projects using AI to address infrastructure challenges in Anambra State. Participant 8 mentioned a state government initiative in collaboration with a tech startup focused on smart transportation solutions. They are developing an AI-based traffic management system designed to analyse real-time traffic data and optimise traffic signals, aiming to reduce congestion in urban areas like Onitsha and Awka. This project could be transformative for businesses reliant on transportation by ensuring timely deliveries and improving overall mobility. Additionally, there are plans to integrate this system with mobile apps to provide live traffic updates to commuters.

Participant 10 highlighted another project involving AI to improve energy distribution. A local utility company is piloting a smart grid initiative that uses AI to monitor and predict energy demand, optimizing power distribution and reducing outages. Although still in the

early stages, this initiative has the potential to make energy supply more reliable, which could lower operational costs for businesses and encourage further investment in the region. Participants 9 and 5 expressed contrasting views, noting discussions about using AI in agriculture to enhance water management and crop monitoring. Some agricultural tech companies are developing AI-driven tools to help farmers analyse soil conditions and optimise irrigation practices. This is particularly relevant, as many businesses in the state depend on agriculture. However, they emphasised the need for increased awareness and training for farmers to effectively utilize these technologies.

Theme 4. Key policy and regulatory intervention

This theme aligns with the fourth research question: "What are the key policy and regulatory frameworks needed to support the adoption and scaling of AI-powered infrastructure solutions in Anambra State?" During the discussion, participants shared valuable perspectives on specific policy and regulatory interventions needed to facilitate the adoption and scaling of AI-powered infrastructure solutions in Anambra State.Participants 1, 3, and 5 suggested that data privacy and protection regulations are crucial. Since AI systems often rely on vast amounts of data, clear guidelines are essential to protect individuals' privacy while allowing businesses to utilise data effectively. This would encourage companies to invest in AI technologies without fear of legal repercussions related to data misuse.Participants 2, 10, and 6 stressed the importance of creating investment incentives and funding mechanisms. The government could establish grants or tax incentives for businesses that adopt AI technologies, particularly in infrastructure development. This would lower financial barriers for companies looking to innovate and implement AI solutions.

Additionally, regulatory frameworks for AI ethics and accountability must be developed. As AI technologies evolve, it is important to establish ethical guidelines to ensure that AI applications are used responsibly. Participants also pointed out the necessity of investing

in education and workforce development. Policies supporting training programs in AI and digital skills will prepare the workforce for the future job market, which is particularly important in a region like Anambra, where access to advanced technology education may be limited.Furthermore, infrastructure for digital connectivity must be prioritised. Policies aimed at improving internet access, especially in rural areas, are essential for the successful implementation of AI solutions. Without reliable internet, the potential of AI cannot be fully realised.

Theme 5. Effect of AI-powered tools for onlinemarketing

Participants 5, 7, and 8 emphasised that integrating AI-powered tools for online marketing and customer service could significantly transform their businesses and enhance their ability to reach new customers. They noted that AI algorithms can analyse customer data and behaviour to create tailored marketing campaigns that resonate with specific audience segments. For example, using predictive analytics, businesses can understand which products a customer is likely to be interested in based on their past purchases and browsing behaviour. This level of personalisation can lead to higher engagement and conversion rates, ultimately driving sales.Participants 10, 1, and 9 recommended that automated customer service tools, like chatbots, can greatly enhance customer support capabilities. These AI-driven chatbots can provide instant responses to customer inquiries, assist with order tracking, and handle basic troubleshooting at all times.

Additionally, participants mentioned that AI-driven email marketing can help segment audiences more effectively and automate follow-up campaigns, ensuring that messaging is timely and relevant. This increases the chances of retaining existing customers and attracting new ones.All participants believed that AI-powered tools for online marketing and customer service could support business growth by enabling personalized marketing, improving customer support, providing valuable insights, optimizing outreach efforts, and

enhancing advertising strategies. By leveraging these technologies, businesses can not only reach new customers but also build stronger relationships with their existing clientele.

Conclusion

The study concludes that effective AI integration requires addressing the underlying infrastructure issues that constrain its implementation.By fostering an environment conducive to AI adoption, Anambra State can improve its infrastructure and unlock significant economic opportunities for small and medium-scale enterprises.Ultimately, the successful integration of AI technologies can lead to enhanced competitiveness, improved service delivery, and sustainable economic growth, positioning Anambra State as a leader in innovation within the region. To fully realise this potential, stakeholders must commit to addressing infrastructure barriers and investing in the necessary frameworks that support AI adoption.

Recommendations

Based on the findings of the study on Infrastructure barriers and AI Integration of SMEs in Anambra the following recommendations are made**:**

1. Government need toPrioritise investments in critical infrastructure, including energy, transportation, and digital connectivity. Public-private partnerships can play a crucial role in funding and executing these projects.

2. Policy-makers need to developand implement comprehensive policies that encourage the adoption of AI technologies. This includes regulations on data privacy, investment incentives, and ethical guidelines for AI usage.

3. It is important to foster collaboration between the government, private sector, and academic institutions to create a robust ecosystem for AI development. Initiatives such as innovation hubs or tech incubators can facilitate knowledge sharing and resource allocation.

4. Encourage the development of AI applications tailored to the specific needs of Anambra State's businesses. Local tech startups should be supported in creating solutions that address regional challenges, whether in agriculture, logistics, or customer service.

5. Establish mechanisms to monitor the impact of AI integration on business performance and infrastructure development. Regular assessments can help identify areas for improvement and ensure that initiatives are meeting their intended goals.

By adopting these recommendations, Anambra State can create an environment where businesses thrive through the effective use of AI, ultimately contributing to sustainable economic development and improved quality of life for its residents.

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