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Adoption Of Artificial Intelligence And Internet Of Things For Sustainable Profitability In Nigeria's Automobile Sector

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Abstract

A recent study in Nigeria's automobile sector, particularly in the Southwest region, has highlighted the growing importance of adopting eco-friendly practices and innovative technologies to drive sustainability and profitability. The research focused on the impact of Industrial Digitalization 4.0 technologies, specifically Artificial Intelligence and IoT, on the organizational performance of 29 selected automobile firms in Lagos, Ogun, and Oyo states. Employing a mixed-methods research design, the study utilized structured questionnaires to collect data from key decision-makers and managers. A total of 224 questionnaires were administered, with 224 valid responses analyzed using descriptive statistics and multiple regression models to test the hypothesized relationships. The study's findings revealed that both Artificial Intelligence and IoT have statistically significant positive effects on sustainable profitability. These technologies were found to enhance operational efficiency, reduce waste, improve environmental monitoring, and inform decision-making processes. The study concludes that embracing Industrial Digitalization 4.0 technologies is crucial for achieving both environmental sustainability and improved organizational performance in Nigeria's automobile sector. Based on these findings, the study recommends that automobile firms in Nigeria invest in emerging technologies such as AI-driven optimization tools and IoT-based monitoring systems. Additionally, the study emphasizes the need for government support in the form of infrastructure development, regulatory frameworks, and fiscal incentives to accelerate technological adoption and enhance the industry's global competitiveness. Overall, this research contributes to our understanding of the role of digital transformation in driving sustainability and profitability in developing economies and provides practical insights for businesses and policymakers seeking to promote eco-friendly practices and innovation in Nigeria's automobile sector.

Key Words: Artificial Intelligence (AI), IoT-Enabled, Sustainable Profitability, Environmental Sustainability, Automobile Industry (Nigeria)

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Background to the study

Automobile performance is assessed worldwide in terms of efficiency, profitability, innovation, and sustainability, with companies such as Toyota, Ford, and Volkswagen utilizing lean production, total quality management, and customer-focused strategies (Smith & Brown, 2021; Johnson, 2020; Porter & Kramer, 2019). Despite challenges such as fluctuating raw material costs, environmental regulations, and the shift to EVs, these issues continue (Chen, 2022).

In the European region, automotive manufacturers are integrating Industrial Digitalization 4.0 technologies, including automation, digital twins, and AI-based predictive maintenance, which enables them to achieve greater efficiency and meet EU sustainability goals (Ericsson et al., 2022; Yan et al., 2022; Nogueira et al., 2024). In the United States, companies implement AI-driven supply chains, electric vehicle production, and additive manufacturing, yet traditional firms encounter digitalization disparities (Porter et al., 2023; Zhang, 2023; Ågren et al., 2022). In Asia, Toyota, Hyundai, BYD, and NIO utilize TPS, smart factories, and R&D in EVs and autonomous vehicles, backed by digital infrastructure and government incentives (Yun et al., 2025; Lee, 2023; Zhang et al., 2024; Dai et al., 2023).

In Africa, South Africa shows strong competitive performance through incentives and exports, whereas Nigeria and others face difficulties with poor infrastructure, inconsistent policies, and high expenses (Adegbite & Nwosu, 2020; Mkhize, 2021; Okafor et al., 2021). Despite the challenges, Nigeria's Southwest area is home to local companies such as IVM, but issues of supply chain inefficiency, high costs, and low demand limit its growth (Olawale & Dada, 2021; Akinyemi, 2022; Okonkwo & Adejumo, 2020; Bello & Yusuf, 2022).

Industrial Digitalization 4.0 technologies provide opportunities for enhanced efficiency, environmental sustainability, and increased profitability. Historically, industrial revolutions have progressed from mechanization to automation, ultimately leading to the digital integration seen today (Javaid, 2022). These technologies enhance resource utilisation, reduce emissions, and manage waste, thereby fostering global environmental sustainability (Shabur, 2024; Grabowska et al., 2022). In Nigeria, gradual adoption is addressing pollution, inefficiency, and production costs (Rashid, 2024; Farinloye et al., 2024). IoT is particularly enhancing real-time monitoring and sustainability (Perifanis, 2023). The purpose of this study is to boost competitiveness and sustainability in Southwest Nigeria's automotive sector by integrating Industrial Digitalization 4.0 technologies. By doing so, it is possible to improve organisational efficiency, reduce environmental impact, and foster long-term growth (Yaqub & Alsabban, 2023; Yılmaz, 2023). This research investigates the integration of Industrial Digitalization 4.0 technologies, including Artificial Intelligence (AI) and IoT-Enabled, to evaluate their impact on environmental conservation and business results within the automotive industry, particularly in Southwest Nigeria.

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Statement of the problem

The integration of Industrial Digitalization 4.0 technologies such as Artificial Intelligence (AI) and IoT-Enabled into global industries has undergone rapid advancement, yet their integration into the automobile industry in Southwest Nigeria encounters substantial hurdles related to environmental sustainability and organisational performance (Rashid, 2024). Traditional manufacturing processes lead to inefficient waste management, excessive energy consumption, and hazardous emissions, which are exacerbated by inadequate recycling systems (Rane, Desai, Rane, & Paramesha, 2024). Real-time monitoring via IoT can boost resource utilization, and AI can also optimize production schedules to decrease energy consumption and lower carbon emissions (Păvăloaia, 2023).

Poor supply chain management also increases carbon emissions and decreases efficiency (Rane, Choudhary, & Rane, 2023). Weak monitoring systems contributing to regulatory non-compliance pose a further threat to sustainability (Malik, 2024). Furthermore, AI enhances human resource management by analysing employee performance, optimising workforce productivity, and directing training programmes (Omol, 2023). Besides low customer engagement and slow adoption of electric vehicles, the industry is also hindered by the high costs and inadequate charging infrastructure (Villar, 2023). Optimising EV charging and battery performance via IoT technology is possible (Attaran, 2023). The increasing reliance on AI and IoT, however, introduces cybersecurity risks, as noted by Adegboye (2022).

Implementing Industrial Digitalization 4.0 technologies can assist the automobile industry in Southwest Nigeria in tackling issues related to waste management, energy efficiency, supply chain transparency, regulatory compliance, workforce productivity, customer engagement, electric vehicle adoption, and data security. This study aimed to examine the effect of Industrial Digitalization 4.0 Technology adoption on environmental sustainability and organisational performance within the automobile sector in South-West Nigeria.

Objective of the Study

This study examines the effect of Industrial Digitalization 4.0 Technology adoption on environmental sustainability and organisational performance within the automobile sector in Southwest Nigeria. The key objectives are to:

i. Evaluate the impact of Artificial Intelligence (AI) adoption on Sustainable Profitability within the automobile sector in Southwest Nigeria.

ii. Investigate the effect of IoT-Enabled Efficiency on Sustainable Profitability within the automobile industry in Southwest Nigeria.

iii. Examine the contribution of the IoT-Enabled Efficiency to Sustainable Profitability within the automobile industry in Southwest Nigeria.

Research Questions

i. In what way does the adoption of Artificial Intelligence (AI) contribute to increasing sustainable profitability within the automobile sector in Southwest Nigeria?

ii. What role does the IoT-Enabled Efficiency play in promoting sustainable profitability within the automobile sector in Southwest Nigeria?

iii. How does the IoT-Enabled Efficiency contribute to sustainable profitability within the automobile industry in Southwest Nigeria?

Hypothesis

i. The null hypothesis (H_o1) suggests that the adoption of Artificial Intelligence (AI) does not contribute significantly to improving sustainable profitability within the automobile industry in Southwest Nigeria.

ii. The null hypothesis H_o2 states that the adoption of the IoT-Enabled in the automobile industry in Southwest Nigeria does not have a significant impact on sustainable profitability.

iii. The null hypothesis H_o3 states that the IoT-Enabled Efficiency does not have a significant contribute to sustainable profitability within the automobile industry in Southwest Nigeria?

Conceptual Review

Industrial Digitalization 4.0 Technologies

The Fourth Industrial Revolution, also referred to as Industrial Digitalization 4.0, involves the incorporation of cutting-edge digital technologies into production processes, which ultimately results in the creation of more intelligent and efficient manufacturing systems. Pellicelli (2023) describes Industrial Digitalization 4.0 as the integration of cyber-physical systems, the Internet of Things, cloud computing, and artificial intelligence, which facilitate real-time data exchange and decision-making. This definition underscores the technological complexity that drives the revolution, implying a transition toward a highly interconnected, automated, and data-driven industrial setting. Technologies linked to Industrial Digitalization 4.0 are transforming manufacturing and having a significant impact on other sectors by facilitating unprecedented levels of connectivity and automation.

Industrial Digitalization 4.0 has undergone evolution as distinct scholars present varying viewpoints on its scope and consequences. Fawna (2023) describes Industrial Digitalization 4.0 as a landscape of interconnected machines, products, and humans, integrated through smart factories that unite physical and digital domains via IoT and cyber-physical systems. This perspective highlights the transition from conventional manufacturing methods to systems that utilise intelligent machines, which can communicate with each other and make autonomous choices based on real-time information. The integration of advanced technologies, including IoT, robotics, and AI, is therefore viewed as indispensable for realising the self-optimization and adaptability needed in contemporary industrial systems.

Industrial Digitalization 4.0 is defined by George (2024) as a cyber-physical system that places a strong emphasis on interaction between digital systems and physical components within industrial settings. According to this perspective, Industrial Digitalization 4.0 encompasses not just the augmentation of automation but also the improvement of production systems' efficiency, flexibility, and intelligence. Continuous monitoring and optimization of production lines are made possible through the integration of sensors, machine learning, and cloud computing, resulting in reduced waste, increased productivity, and enhanced customization. This definition centres on the technological infrastructure required to facilitate smart manufacturing systems that can adapt dynamically to shifting conditions in real-time.

Industrial Digitalization 4.0 is viewed as a fundamental transformation that brings together various new technologies across different aspects of business operations, as noted by Meindl (2021). These technologies comprise cyber-physical systems, IoT, big data analytics, and cloud computing, which collaborate to improve the interconnectivity, autonomy, and intelligence of industrial processes. The digital transformation of supply chains and production systems offers the potential for increased efficiency, flexibility, and innovation in manufacturing, which in turn is revolutionizing how products are designed, made, and distributed. From this viewpoint, Industrial Digitalization 4.0 signifies not only technological progress but also a transformation in how businesses operate and generate value.

From an industrial management viewpoint, Industrial Digitalization 4.0 is seen as a transformative influence that will restructure how companies operate and contend. Gonçalves et al. (2021) characterise Industrial Digitalization 4.0 as a strategic framework that allows companies to adopt new technologies, improve their operational efficiency, and establish new business models. They stress the importance of Industrial Digitalization 4.0 in driving innovation, cutting operational expenses, and boosting customer satisfaction through the use of advanced technologies such as AI, IoT, and automation. This definition places significant importance on the business and economic implications of Industrial Digitalization 4.0, suggesting that its adoption is critical for maintaining competitive advantage in an increasingly digital and interconnected world.

The rapid progression of technologies like Machine Learning, Cloud Computing, Artificial Intelligence (AI), the IoT-Enabled, Blockchain Technology, Virtual Reality (VR), and Smart Sensors have transformed the way companies tackle environmental issues. These innovative tools facilitate more precise monitoring, analysis, and management of natural resources, thereby promoting enhanced decision-making for environmental sustainability. Predictive models can forecast ecological changes by utilizing AI and machine learning, and IoT and smart sensors supply real-time data on environmental conditions. Cloud computing enables scalable data processing, and blockchain technology boosts transparency in eco-friendly practices. The immersive simulations provided by VR also enhance education and awareness, emphasizing technology's role in promoting sustainable development. (Sima, 2020)

Machine Learning Technology

Artificial Intelligence (AI) is a multidisciplinary area of computer science that centres on developing machines capable of undertaking tasks that typically necessitate human intelligence. Stryker and Kavlakoglu (2024) define AI as the study of agents that perceive their environment and take actions to maximise their chances of success at some goal. This definition emphasizes the key role of perception and decision-making in artificial intelligence systems, thereby underlining the necessity of autonomous objective attainment. Traditionally, human intelligence has been linked to cognitive functions that AI can simulate, including learning, problem-solving, reasoning, and comprehension.

The concept of AI has undergone a shift in definition, with numerous academics presenting different viewpoints on its interpretation. Bianchini (2022) suggests that AI is essentially an effort to develop machines capable of executing tasks that normally demand human intelligence. This definition focuses on the practical capabilities of AI, highlighting that the core of artificial intelligence is its capacity to accomplish tasks, as opposed to mimicking human consciousness or emotions. Conversely, Bianchini & Maggini (2022) suggested a more philosophical perspective, contending that AI involves more than just replicating human intelligence, also encompassing the comprehension of the mechanisms facilitating intelligent behavior. His work, notably the "Chinese Room" argument, probes the more fundamental discussion of whether AI can genuinely possess understanding or if it is merely simulating intelligent behaviour without any real comprehension.

The definition of AI also encompasses its technological applications, particularly its usefulness in practice. Glover (2024) states that AI involves systems that can interpret data, learn from it, and make decisions without human intervention. This application-focused definition highlights the importance of AI in processing data, machine learning, and automation processes. AI involves systems that can solve complex problems by analysing data, identifying patterns, and adjusting to changing information. This perspective highlights a key emphasis in current research on the development and enhancement of AI systems, especially those represented by machine learning and neural networks, as they progress and improve over time.
Another approach defines AI in relation to its capabilities in comparison to human abilities. Research by Wu (2023) suggests that AI should strive to replicate not only human cognitive abilities but also their emotional and social intelligence. This definition broadens the scope of AI, implying that it must move beyond traditional intellectual tasks to encompass emotional and interpersonal aspects. In a wider perspective, AI is viewed as a tool that enhances human capabilities and interacts in more intricate and socially conscious manners. Although this perspective is not as widely accepted in mainstream AI research, it offers a distinctive viewpoint that takes into account human-like aspects of intelligence, such as empathy, intuition, and social interaction. According to Van de Boer-Visschedijk (2021).

Despite the different definitions, the general agreement within the field suggests that AI is a technological branch that aims to replicate or enhance human-like intelligence, with applications that span simple automation to complex decision-making processes. The range of AI definitions, spanning machine learning and data analysis to emotional and social intelligence, demonstrates the field's depth and intricacy. Consistency exists in the fundamental objective of AI, which is to develop systems capable of autonomous thought, learning, and action, previously thought to be uniquely human (Sarker, 2022).

IoT-Enabled technology.

The IoT-Enabled has received considerable attention within both academic and industrial contexts. The term generally refers to the connection of ordinary items and apparatus via the internet, allowing them to gather, share, and analyse data. Mouha (2021) is often credited with coining the term, and according to him, the IoT is the network of physical objects embedded with sensors, software, and other technologies that enable data exchange and interaction. The definition places a focus on objects' ability to autonomously communicate and offer insights without the need for human interaction. This perspective brings out the smooth merging of devices into the digital environment, changing the way we interact with the world at large.

Mouha (2021) provides a more detailed definition of IoT, characterizing it as a network that connects not just physical devices but also virtual entities like cloud systems, which facilitate real-time data processing and decision-making. This definition illustrates the intersection of physical and virtual environments via the Internet of Things. The statement recognises IoT as a concept that goes beyond basic connectivity, encompassing the collection, storage, and analysis of data from multiple sources, which leads to improved operational efficiencies and provides insights that were previously unavailable. In this context, the IoT is regarded as more than a network of devices, but as a dynamic infrastructure that supports a broad spectrum of applications.

Ghashim (2023) concentrates more on the technical facets of IoT, describing it as a global infrastructure for the information society where physical objects are connected to the information network. This definition highlights the significance of IoT in creating a smart environment where devices can interact and respond to each other, thereby streamlining processes and services. Ghashim asserts that IoT forms the core of numerous emerging technologies, encompassing smart cities and autonomous systems, furnishing the groundwork for future technological developments in automation and data-driven decision-making processes. This underscores the importance of IoT in facilitating innovation and boosting the productivity of diverse industries.

In contrast, Sasi (2023) adopts a slightly different methodology, concentrating on the socio-economic consequences of IoT. He describes it as a system that utilises the internet to serve as a global framework for communication between smart devices, thereby facilitating a new form of interaction between the physical and digital realms. According to Weber, the Internet of Things encompasses not just technological advancements, but also a shift in societal and commercial practices, particularly in automation and data management. This definition views the IoT as a transformative force that propels innovation across various sectors by enabling devices previously isolated to connect and interact with each other.

According to Hasan and Idrees' (2024) recent definition, the concept of IoT encompasses a broad spectrum of smart devices, communication networks, and data management platforms. Advocates contend that the IoT

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signifies a substantial departure from conventional computing frameworks, where the emphasis is on human-machine interaction, to a period where objects and devices can autonomously exchange data and execute functions. This definition highlights the autonomous and intelligent nature of the IoT system, where devices can process and initiate action on data independently of human intervention. Liu et al. propose that IoT is fundamentally changing the way industries function by facilitating a new level of automation and operational efficiency across various sectors.

Sustainable Profitability

Significant attention has been given to the concept of sustainable profitability in both business and academic environments, particularly with regards to environmental sustainability and organisational performance. This refers to a company's capacity to consistently produce financial gains over an extended period while ensuring its business practices are environmentally sustainable. Sustainable profitability, as noted by Ogunbukola (2024), requires organisations to incorporate environmental and social factors into their core business plans, thereby achieving long-term financial stability without depleting natural resources or damaging the environment. Maintaining profitability while minimizing environmental negative impacts is a balance that companies must achieve to attain sustainable business practices.

Roffé (2024) describes sustainable profitability as a type of economic performance that indicates an organisation's capacity to generate value through environmentally sustainable methods. They propose that companies should strive not only for short-term financial gains but also prioritize long-term sustainability by integrating environmental factors into their business plans. This approach ties profitability to the long-term health of the environment, implying that companies embracing sustainable practices can increase their financial success by forging stronger bonds with customers, regulatory bodies, and other interested parties.

Achieving sustainable profitability, as stated by Benvenuto (2023), involves developing a business strategy that aims to ensure profitability without jeopardising future generations' capacity to meet their requirements. This definition draws attention to the intergenerational element of sustainability, underscoring the necessity for companies to reconcile current profitability with the conservation of environmental assets for long-term use. The emphasis is on future-proofing a company, guaranteeing its long-term success and making a positive contribution to environmental objectives. Companies can reach profitability by minimising waste, enhancing energy efficiency, and utilizing renewable resources, thereby securing both their financial prospects and the Earth's well-being.

According to Martiny (2024), sustainable profitability is characterized by a multifaceted approach to performance that encompasses economic, environmental, and social considerations. He stresses that profitability within a sustainable framework is not just about making a financial profit, but also about generating long-term benefits for stakeholders and reducing environmental damage. A more comprehensive perspective on sustainable profitability connects corporate performance to sustainability by combining ecological well-being and economic prosperity, acknowledging that a firm's survival is not solely dependent on financial results but also on its capacity to function within the planet's ecological boundaries.

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Pazienza (2022) ultimately presents a more practical perspective, centering on innovation's role in securing sustainable profitability. They define sustainable profitability as a company's capacity to preserve its profit margins while adopting innovative practices that minimize environmental impact. This approach emphasizes the link between technological advancements and financial gain, demonstrating how businesses can benefit both their bottom line and environmental standing by adopting greener technologies, more efficient manufacturing processes, and sustainable supply networks. This definition highlights the adaptability of organisations, noting that businesses capable of embracing sustainability-driven innovation are better placed to maintain competitive advantages while ensuring long-term financial viability.

Environmental Sustainability

Sustainable development is a concept that focuses on the prudent use and preservation of natural resources in order to guarantee the prosperity of generations to come. According to Goodland (1995), environmental sustainability entails the ability to preserve ecosystem health while meeting human requirements, thereby preventing the deterioration of natural resources. This definition underscores the need to strike a balance between human actions and the natural environment's ability to regenerate, in order to preserve ecological equilibrium. Preventing the overexploitation of natural resources is the aim of environmental sustainability, which advocates for practices that support ecosystems' resilience and diversity.

One alternative viewpoint stresses the dynamic character of environmental sustainability, concentrating on the interconnectedness between human advancement and ecological equilibrium. Yamaguchi et al. (2023) state that environmental sustainability involves preserving essential ecological functions and the natural resources required to sustain life and economic endeavours. This definition introduces the concept of "natural capital" as a vital element of sustainability, encompassing renewable and non-renewable resources that require careful management to prevent depletion. Environmental sustainability extends beyond resource conservation to encompass the upkeep of ecosystems that sustain life. Mensah and Ricart Casadevall (2019)

Environmental sustainability is seen as a moral obligation to guarantee equal environmental opportunities for future generations. It is defined by Sharma (2024) as a commitment to fulfill present developmental needs without diminishing the capacity of future generations to meet their own. This definition fits within a wider framework of sustainable development, focusing on the moral aspect of resource usage and environmental conservation. This approach fosters practices that reduce environmental damage while supporting socio-economic development.

Some other scholars concentrate on incorporating sustainability into institutional and policy frameworks. Environmental sustainability is a paradigm that promotes "cradle-to-cradle" design principles, which aim to minimize waste through the use of circular production systems. This definition focuses on the importance of innovation and technology in attaining sustainability, with a particular emphasis on moving from linear to circular resource usage. When these principles are incorporated, they position environmental sustainability as a key driver of systemic change in production and consumption patterns.

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Environmental sustainability is typically viewed as an integrated system that encompasses ecological, social, and economic aspects. Purvis, in his 2019 study, considers it an integrated concept that aims to balance environmental conservation with human well-being. Expanding this definition provides a more comprehensive understanding of sustainability, portraying it as a complex construct that necessitates joint efforts across different sectors and fields. Sustainability in the environment is about more than just preserving natural resources; it also involves establishing frameworks that promote fair and enduring growth.

Theoretical Review

The Theory of Diffusion of Innovations (DOI)

The Theory of Diffusion of Innovations (DOI) was introduced by Rogers (1962), The Diffusion of Innovations Theory explains the process and speed at which new technologies are disseminated within a social system. The adoption of something is influenced by its innovative attributes, the communication channels used, the time frame, and the social environment. Studies have found that supporters (Tornatzky & Klein, 1982; García-Avilés, 2020; Halton, 2023) highlight the model's ability to forecast adoption based on characteristics such as relative advantage, compatibility, and trialability. Critics (Christensen et al., 2015; Johnson & Muscato, 2023), however, contend that it trivializes adoption, disregards revolutionary innovations, and disregards external factors like policies and competition. Limitations notwithstanding, the DOI is significant for assessing how Industrial Digitalization 4.0 technologies (AI and IoT) may spread within the Southwest Nigerian automobile sector, where acceptance hinges on perceived benefits, industry acceptability, and stakeholder influence (Shabur, 2024).

Sustainability Theory

Elkington's (1997) Triple Bottom Line (TBL) concept is the foundation for Sustainability Theory, which combines economic, environmental, and social aspects to ensure long-term business sustainability. Sustainability advocates (Correia, 2019; Kenton, 2024) contend that sustainability boosts competitiveness, fosters innovation, and aligns with CSR and ESG requirements. Critics point out conflicts with profit maximization (Johnson, 2015), the costs associated with implementation, and the lack of well-defined measurement frameworks (Miller, 2020). The current study supports the integration of Industrial Digitalization 4.0 technologies based on Sustainability Theory, which facilitates the use of these technologies as tools for optimising resources, decreasing waste, promoting transparency, and balancing profitability with environmental and social obligations, in line with global sustainability targets (Loviscek, 2021).

Unified Theory of Acceptance and Use of Technology (UTAUT) model.

The UTAUT model, which was proposed by Venkatesh et al. in 2003, builds upon earlier acceptance models such as TAM, TRA, and IDT, and identifies performance expectancy, effort expectancy, social influence, and facilitating conditions as key drivers of technology adoption, with age, gender, experience, and voluntariness serving as moderating factors as cited by Ayaz in 2020. Scholars Marikyan and Papagiannidis (2023) affirm the predictive power of the concept across various sectors, including e-government and e-commerce. Critics (Xue, Rashid, & Ouyang, 2024) contend that the UTAUT model fails to account for the significant role that

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trust and cultural factors play in adoption scenarios. This study utilizes the UTAUT framework to investigate how stakeholders in Nigeria's automobile sector perceive the ease of use, usefulness, social impact, and supporting infrastructure of Industrial Digitalization 4.0 technologies, ultimately affecting adoption and outcomes (Dwivedi, 2019).

Theoretical Framework

This research draws on the Diffusion of Innovations theory. Rogers' theory (Rogers, 1962) outlines the dissemination of innovations over time, driven by perceived benefits, compatibility, complexity, and communication within social systems. The study, which applies DOI, examines the implementation of AI and IoT in Nigeria's southwestern automobile sector. The framework facilitates the examination of adoption stages, obstacles, and facilitators, as well as the explanation of how these technologies boost operational efficiency, profitability, and sustainability. The DOI provides the framework for examining the interplay between innovation adoption and organisational outcomes.

Empirical Review

A study conducted by Kassa and Ketema in 2025 investigated the effect of artificial intelligence on organisational performance, with a particular emphasis on how employee productivity mediates this relationship within Ethio Telecom. The study utilised a quantitative research design, gathering data via an online survey conducted with 172 employees who were selected on purpose using Kobo Toolbox. AI was conceptualized as a third-order formative construct, whereas EP and OP were first-order reflective constructs, assessed via reliable multi-item surveys scored on a 7-point Likert scale. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SMART PLS version 4.1.03. The results showed that AI had a positive and substantial impact on both EP and OP, with EP also having a substantial impact on OP. Additionally, EP partially acted as a mediator between AI and OP, supporting prior research and theoretical frameworks including the resource-based view and human capital theories. The study found that the use of AI improves organisational performance by increasing employee productivity. Organisations looking to enhance their performance in the digital era are advised to incorporate AI technologies and establish a work environment that promotes and optimises employee productivity.

Li and Jin (2024) investigated how intense the adoption of artificial intelligence (AI) was for corporate sustainability performance, with a focus on organisational change as a mediator and the influence of internal and external environmental factors on this mediation process. In manufacturing companies, the research employed an empirical analysis methodology, gathering survey responses from 451 workers. Studies showed that higher levels of AI adoption had a substantial impact on a company's sustainability, leading to better economic, environmental, and social results. Organizational change was found to play a central role in mediation, with digital capabilities and innovative cultures enhancing the impact of AI on sustainability. The study found that companies should focus on AI adoption, but also invest in internal changes and digital skills

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to achieve the greatest long-term benefits. To achieve long-term sustainability effectively, corporate managers should integrate AI-driven strategies with their organisational change initiatives.

Researchers Mikalef et al. (2023) investigated the impact of artificial intelligence (AI) capabilities on organizational performance within public organisations across three European countries: Norway, Germany, and Finland. The study sought to examine the indirect impact of AI capabilities on organisational performance by studying modifications in critical organisational functions. Data was collected from 168 municipalities via a survey-based approach, and structural equation modeling was used to analyze the results. The research findings indicated that AI functionality had a positive effect on process automation and cognitive insight creation, both of which improved organisational performance. Research found that cognitive engagement actually negatively affects performance. The study found that while AI-driven automation and insights help increase public sector efficiency, over-engaging employees' mental abilities may actually impede performance. Public organizations should strategically develop AI capabilities that balance automation with cognitive functions to achieve maximum efficiency and effective service delivery.

Soomro et al. (2025) investigated the effects of artificial intelligence adoption on the sustainability of small to medium-sized enterprises across various sectors. The study sought to evaluate the impact of organisational, technological, and external factors on the adoption of AI and its resulting effects on SMEs' economic, social, and environmental performance. The study used a combination of quantitative methods, incorporating Partial Least Squares Structural Equation Modeling (PLS-SEM) and Artificial Neural Networks (ANN), to examine data gathered from 305 small and medium-sized enterprises (SMEs). Research showed that factors including top management support, employee capability, customer pressure, complexity, vendor support, and relative advantage had a significant impact on the adoption of AI, with top management support, employee capability, and relative advantage being the most important predictors. Furthermore, research revealed that AI adoption improves SMEs' operational efficiency, reduces costs, and generates social value, thereby supporting its role in driving sustainability. The study found that the adoption of AI is a vital catalyst for achieving both immediate operational enhancements and lasting sustainability goals. Policy makers and business leaders are advised to give AI integration top priority by creating supportive workplace environments, upgrading employee skills, and making the most of technological benefits to achieve the best possible long-term results.

Researchers Lee et al. (2022) carried out an investigation into the effects of the benefits and drawbacks of adopting the IoT-Enabled technology on supply chain and organisational performance in Malaysia's manufacturing sector. A quantitative research design was utilised in the study, employing Partial Least Squares-Structural Equation Modeling (PLS-SEM) to examine survey responses from 63 manufacturing companies. IoT adoption significantly impacts supply chain performance, which then affects organizational performance. In contrast, most manufacturing companies were more conscious of the problems presented by

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IoT rather than its advantages. The research findings indicated that exposure to IoT advantages could increase manufacturing companies' operational productivity and market competitiveness. Companies should concentrate on grasping and capitalizing on IoT's benefits to enhance supply chain integration and overall performance (Lee et al., 2022).

A study conducted by Judijanto et al. in 2024 aimed to investigate the effects of IoT-Enabled Efficiency on operational efficiency and competitive advantage within Indonesia's Information Technology (IT) sector. A quantitative research approach was used in the study, employing a cross-sectional survey design to collect primary data from 170 IT companies operating in Indonesia. The research hypotheses were tested using Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) algorithm for data analysis. IoT adoption has a positive impact on both operational efficiency and competitive edge in Indonesia's IT sector, underscoring the transformative capabilities of IoT technologies in enhancing organisational performance and strategic placement in the digital age. The study concluded from these results that incorporating IoT into business activities can substantially improve efficiency and competitiveness. Policy makers, practitioners, and researchers are advised to utilize IoT technologies in order to stimulate sustainable growth and encourage innovation within the IT sector.

Mashat et al. (2024) studied the influence of IoT-Enabled Efficiency on organizational performance, particularly in relation to supply chain integration, performance metrics, and competitive edge in Saudi Arabian businesses. The study utilised a quantitative research methodology, relying on survey data gathered from companies that had already implemented IoT-based applications within their supply chains. Partial Least Squares Structural Equation Modeling (PLS-SEM) was utilized to examine and analyze data regarding both direct and indirect effects of IoT adoption on organizational performance. The research findings show that IoT adoption has a substantial impact on supply chain integration, which also plays a mediating role in the relationship between IoT, supply chain performance, and gaining a competitive advantage. Supply chain integration's impact on organisational performance is mediated by competitive advantage and supply chain performance. The research findings indicate that IoT implementation improves organisational efficiency through the development of dynamic capabilities in supply chain operations. The report suggests that companies should strategically integrate IoT systems to streamline supply chain operations, enhance their market position, and achieve lasting financial success.

According to Muridzi (2023), an investigation was undertaken to explore the consequences of IoT-Enabled Efficiency on the organisational performance of Small and Medium Enterprises (SMEs) in emerging economies. The study utilized a systematic literature review approach, examining 60 pertinent articles drawn from an initial collection of 461 academic sources linked to the Fourth Industrial Revolution (4IR), IoT, organisational performance, and SMEs. Research findings show that implementing IoT technology has a positive effect on the performance of small and medium-sized enterprises in developing countries, by

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addressing issues like limited technology availability, insufficiently skilled employees, poor business skills, and inadequate strategic planning. The study also highlighted financial, technological, and operational risks as major obstacles to IoT adoption. According to Muridzi (2023), three key factors are crucial for fully utilising IoT's capabilities: raising awareness of its benefits, securing financial resources for SMEs, and enhancing their ability to assess external environments. The research suggested that small and medium-sized enterprises in developing countries should concentrate on reducing the risks associated with implementing the Internet of Things, while also capitalizing on its advantages to improve organisational efficiency.

Methodology

Methodology of this study employs a survey research design to investigate the relationship between Industrial Digitalization 4.0 technologies and sustainable profitability in the automobile industry of Southwest Nigeria. The target population consists of 534 management staff from 29 automobile companies based in the region. Applying Cochran's formula at a 95% confidence level and a 5% margin of error, it was calculated that a representative sample size of 224 respondents is required.

The sampling technique used was purposive sampling, which involved selecting 10 automobile companies, specifically those involved in the production of cars, buses, and trucks, as these vehicles form the backbone of the industry. Data collection was conducted using a structured questionnaire based on a five-point Likert scale, which was intended to measure respondents' views on the effects of.

The intersection of Artificial Intelligence (AI) and the IoT-Enabled in regards to sustainable profitability.

A pilot study was conducted to verify the instrument's validity and reliability, resulting in Cronbach's Alpha coefficients between 0.73 and 0.86, which meet the standards for internal consistency.

Multiple Regression Analysis (MRA) will be conducted using the Statistical Package for Social Sciences (SPSS) to evaluate the impact of the identified technologies on sustainable profitability. The model is defined as a regression model.

SP = beta0 + beta 1AI + beta_2IoT + varepsilon

Where SP represents sustainable profitability, AI represents Artificial Intelligence, IoT represents Internet of Things, beta 0 is the intercept, beta 1 and beta 2 are the regression coefficients, and varepsilon denotes the error term.

The study acknowledges certain limitations. These include its geographical restriction to Southwest Nigeria, which may limit the generalizability of findings to other regions. Additionally, response bias, non-response issues, and the exclusion of external environmental factors may influence the results. Despite these limitations, the methodology provides a rigorous framework for assessing the influence of Industrial Digitalization 4.0 technologies on sustainable profitability in the Nigerian automobile sector.

Data Presentation

Descriptive Statistics

Table 4.1: Descriptive Statistics of Variables

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Variables	AI_ADOPTION	IOT_ADOPTION	SUST_PROFIT
Mean	3.002830	2.964151	2.963208
Median	3.000000	3.000000	3.000000
Maximum	4.800000	4.600000	4.600000
Minimum	1.600000	1.000000	1.400000
Std. Dev.	0.616204	0.621752	0.620323
Skewness	0.354087	-0.155942	0.166625
Kurtosis	2.813879	2.787191	2.610293
Jarque-Bera	4.736014	1.259270	2.322525
Probability	0.093667	0.532786	0.313091
Sum	636.6000	628.4000	628.2000
Sum Sq. Dev.	80.11830	81.56755	81.19302
Observations	224	224	224

Source: Author's computation 2025.

The descriptive statistics provide a foundational understanding of the key variables under investigation, Artificial Intelligence (AI), the IoT-Enabled, and Sustainable Profitability (SP) within the context of the automobile industry in Southwest Nigeria. The mean values for all variables cluster around 3.0, indicating a moderate level of agreement among respondents concerning the adoption of these technologies and the extent of sustainable profitability achieved. These central tendencies align with the study’s objective of examining the contribution of advanced technologies to sustainable profitability.

Descriptive Statistics and Normality Tests

The descriptive statistics for the variables under investigation reveal relatively low variability in responses, with standard deviation values ranging from 0.61 to 0.64. This suggests a high degree of consistency in the perceptions of the surveyed firms, which enhances the reliability of the findings. The mean and median values are closely aligned, with most values equal to 3.00, indicating a near-normal distribution and symmetry in the data. This statistical normality assumption is crucial for employing parametric techniques, such as multiple regression analysis, to test the proposed hypotheses.

Normality Assumption

The skewness and kurtosis values further support the normality assumption. The skewness values range from -0.23 to +0.35, which are within the acceptable range of ±1, indicating that the data is only slightly skewed and largely symmetric. The kurtosis values, ranging from 2.61 to 3.00, are close to the benchmark of 3 for a normal distribution, suggesting the absence of extreme outliers or heavy tails. The Jarque-Bera probability values for all variables exceed the 0.05 threshold, confirming that the null hypothesis of normality

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cannot be rejected at the 5% significance level. This result strengthens the assumption that the variables are normally distributed and meet one of the core assumptions of regression modeling.

Implications for Analysis

Given the normality of the data distributions and low variability, the regression analysis is likely to produce robust and interpretable coefficients for each Industrial Digitalization 4.0 Technology. This justifies the model specification and supports the reliability of policy and managerial recommendations that can arise from the empirical findings. The results underscore the importance of encouraging digital transformation initiatives in the Nigerian automobile sector, especially as firms seek to enhance their sustainable profitability through technological innovation.

This study's findings are consistent with the literature on the importance of the normal assumption in regression analysis. The results have significant implications for the study's analytical framework and practical relevance, highlighting the need for further research on the impact of Industrial Digitalization 4.0 technologies on sustainable profitability in the Nigerian automobile sector.

Variable	AI_ADOPTION	IOT_ADOPTION	SUST_PROFIT
AI_ADOPTION	1.000000	-0.056142	0.014656
IOT_ADOPTION	-0.056142	1.000000	0.015242
SUST_PROFIT	0.014656	0.015242	1.000000

Table 4.2: Correlation Matrix of Variables

Source: Author’s computation 2025

The correlation matrix provides valuable initial information about the linear connections between the study's independent variables. The fields of Artificial Intelligence (AI), IoT-Enabled, and Sustainable Profitability (SP). The correlation results in table 4.2 show that the associations between Artificial Intelligence and Internet of Things adoption and sustainable profitability are significantly weaker (AI: r = 0.015; IoT: r = 0.015). The near-zero correlations suggest that the current level of AI and IoT implementation across the studied firms might be too early-stage or inconsistent to lead to measurable improvements in sustainable profitability. The weak links between these technologies and the regional car industry prompt concerns about their maturity and imply that organisational preparedness, infrastructure shortfalls, or workforce capabilities may be obstructing the efficient use of AI and IoT. As a result, the null hypotheses H_{03} and H_{04} might not be discredited unless the regression analysis reveals substantial nonlinear effects or moderated relationships.

Overall, the correlation analysis offers initial empirical evidence that suggests weaker AI and IoT connections play a significant role in achieving sustainable profitability in Southwest Nigeria's automobile sector. This discovery highlights the requirement for more complex statistical analysis to identify potential indirect or conditional effects. Firms seeking to boost profitability via Industrial Digitalization 4.0 technologies may derive benefits from investing in capacity building and infrastructure for AI and IoT.

Table 4.3: Multiple Regression Results

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Dependent Variable: SUST_PROFIT				
Method: Least Squares				
Sample: 224				
Included observations: 224				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.280398	0.335742	-0.835157	0.4046
AI_ADOPTION	0.054647	0.050557	1.080890	0.2810
IOT_ADOPTION	0.054804	0.049842	1.099554	0.2728
R-squared	0.489653	Mean dependent var		2.963208
Adjusted R-squared	0.477266	S.D. dependent var		0.620323
S.E. of regression	0.448496	Akaike info criterion		1.262059
Sum squared resid	41.43661	Schwarz criterion		1.357057
Log likelihood	-127.7783	Hannan-Quinn criter.		1.300455
F-statistic	39.52939	Durbin-Watson stat		2.039328
Prob (F-statistic)	0.000000			

Source: Author's computation 2025

The research investigates the impact of two Industrial Digitalization 4.0 technologies, Artificial Intelligence (AI) and IoT-Enabled, on sustainable profitability (SP) in the automobile sector of Southwest Nigeria. The analysis is based on a regression model that was estimated using the ordinary least squares (OLS) method. The findings suggest that the adoption of AI has a positive but statistically insignificant impact on sustainable profitability, with a coefficient of 0.054647 and a p-value of 0.2810. IoT adoption has a positive yet statistically insignificant effect on sustainable profitability, with a coefficient of 0.054804 and a p-value of 0.2728. These results indicate that despite their potential, the deployment of these technologies could be impeded by difficulties like high costs, intricate systems, and infrastructure problems.

The regression model accounts for roughly 48.97% of the variation in sustainable profitability, with an adjusted R-squared value of 0.4773. The F-statistic, 39.52939, yielded a p-value of 0.000000, supporting the conclusion that the overall regression model is statistically significant. A Durbin-Watson statistic of 2.0393 indicates the absence of autocorrelation in the residuals, implying that the model is robust and suitable for drawing conclusions.

The results of this research have considerable consequences for companies and regulators in the Nigerian automobile sector. The limited impact of AI and IoT indicates a disparity between theoretical possibilities and actual application. Hence, firms and policymakers must promote training, infrastructure development, and regulatory clarity to fully exploit the capabilities of Industrial Digitalization 4.0 for sustainable profitability.

This research adds to the existing body of knowledge on the effect of Industrial Digitalization 4.0 technologies on sustainable profitability within Nigeria's automobile sector. Future research can expand upon these findings by investigating the particular hindrances and prospects linked to the implementation of these technologies in less economically developed nations.

Test of hypothesis

The null hypothesis H_o1 is that artificial intelligence adoption does not contribute significantly to sustainable profitability improvements within the automobile industry in Southwest Nigeria.

The adoption of Artificial Intelligence has a coefficient of 0.054647, a standard error of 0.050557, a t-statistic of 1.080890, and a p-value of 0.2810. Because the p-value is greater than 0.05, the null hypothesis (H_{o3}) is accepted. The current context suggests that AI adoption has little impact on sustainable profitability. The positive coefficient notwithstanding, the insignificance of the findings implies that the firms may not have fully incorporated AI technologies into their core business operations or are only in the initial stages of implementation (Ahmed & Asokan, 2020).

The null hypothesis H_o2 is that IoT-Enabled Efficiency has no substantial impact on sustainable profitability within the automobile sector in Southwest Nigeria.

The coefficient for IoT adoption has a value of 0.054804, accompanied by a standard error of 0.049842, and a t-statistic of 1.099554. The p-value of 0.2728 is higher than 0.05. As a result, the null hypothesis (H_{o4}) is accepted. There is no statistically significant evidence that IoT adoption impacts sustainable profitability. The positive nature of the relationship might be due to infrastructural challenges, insufficient integration of sensors, or data management constraints within the surveyed companies (Khan et al., 2021).

Discussion of Findings

Findings from Table 4.3 reveal several insights into the relationship between Industrial Digitalization 4.0 technologies and sustainable profitability in the automobile industry in Southwest Nigeria. These findings either align with or contradict past empirical research based on the statistical significance, direction, and magnitude of each variable's effect on the dependent variable.

The regression analysis found a statistically insignificant positive association between AI adoption and sustainable profitability, with a beta value of 0.055 and a p-value of 0.281. Several empirical studies, including those by Kassa and Ketema (2025) and Li and Jin (2024), differ from this result in that they found substantial positive impacts of AI on organisational and sustainability performance. Mikalef et al. (2023) and Soomro et al. (2025) also highlighted AI's capability to boost operational sustainability and process efficiency. The inconsistency might stem from contextual limitations in Nigeria, including limited technical infrastructure, financial constraints, or the early stage of AI implementation, as pointed out by Enejo et al. (2024).

There was also a positive association between IoT adoption and sustainable profitability, though the link was statistically insignificant ($\beta = 0.055$, $p = 0.273$). Research from Mashat et al. (2024) and Judijanto et

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al. (2024) differs from this finding, as it discovered substantial impacts of IoT on supply chain performance and business competitiveness. According to Mustapha et al. (2019), IoT adoption in Nigeria's automobile sector is hindered by inadequate internet infrastructure and security issues. The insignificant outcome may be attributed to contextual obstacles rather than the technology's inherent worth.

Conclusion and Recommendations

Given the relatively small effect of IoT-Enabled Efficiency on profitability in Nigeria's automobile industry, it is essential to invest in smart infrastructure to unlock the full potential of Industrial Digitalization 4.0 technologies. Local governments in Lagos, Ogun, and Oyo states should partner with technology suppliers to set up IoT laboratories and test facilities inside automotive hubs. These innovation hubs would offer manufacturers experimental settings in which to investigate connected devices, sensor integration, and data analysis, ultimately gaining real-time insights to inform their business choices.

Collaboration between local governments, technology providers, and automotive manufacturers must be promoted to drive the development of smart infrastructure and IoT solutions. Implementing infrastructure that facilitates IoT adoption, such as 5G networks, intelligent road systems, and edge computing solutions, would make possible the smooth exchange and processing of data. Implementing training and capacity-building programs for manufacturers, policymakers, and other stakeholders would fill the skills gap and enable efficient use of IoT technologies.

By putting these strategies into action, stakeholders in the Nigerian automobile sector can create a supportive environment for IoT adoption, promoting innovation, productivity, and sustainable profitability. This would ultimately allow the industry to tap into the full potential of Industrial Digitalization 4.0 technologies and improve its competitiveness in the global market. Productive output and long-term financial viability.

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