
Original Article

The Impact of Artificial Intelligence on Sustainability Accounting Practices in Nigeria's Manufacturing Sector: A stakeholder perspective.

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Abstract: Sustainability accounting has grown in importance and influence, helping corporations tackle germane operational issues relating to the environmental and social impacts of their productive activities. The execution of sustainability accounting as a performance management system can be complicated, thus cutting-edge methods like artificial intelligence (AI) are being explored to improve its ease of use. While AI is being used in more financial reporting workloads in reporting entities, its impact on sustainability accounting has not been properly investigated, especially in developing countries like Nigeria. This study addresses this gap by examining the impact of AI in Nigerian manufacturing companies, analysing stakeholders' views on AI's impact on sustainability accounting. A cross-sectional study was conducted on ninety-one (91) finance professionals (managers and individual contributors). The study's hypothesis was: the proportion of stakeholders that perceive that AI improves sustainability accounting practices is less than or equal to 50% ($\alpha = 0.05$). A one-sample z-test of proportions was conducted to validate the study's hypothesis and data analysis ($p < 0.05$) revealed that a significant proportion of respondents agree that sustainability accounting can be improved by artificial intelligence in Nigeria. The study also revealed that the primary workloads for which AI was utilized in sustainability accounting in Nigeria were: advanced analytics and natural language processing. However, the study acknowledges certain limitations, notable of which is the small sample size and its focus on manufacturing industries. The study concludes that AI is very effective in sustainability accounting, hence its adoption in Nigerian reporting entities is encouraged. This study is the first attempt by any study to assess the mechanisms through which AI impacts sustainability accounting in Nigeria, and its findings have implications for both academics and practitioners, highlighting the potential benefits of adopting AI in sustainability accounting practices to enhance the accuracy and efficiency of reporting.

Keywords: Artificial intelligence, sustainability accounting, machine learning, deep learning, natural language processing, analytics

1. Introduction

Sustainability has become a stark reality that organizations have had to factor into their strategic planning and execution in order to remain competitive. While very early studies like Robbins (1935) identified the finiteness of factors of production and posited that one of management's cardinal roles is to ensure that scarce resources are utilized in a way that ensures that maximises the value created by the organization, the reality of the finiteness of factors of production has never been more

pronounced as it is in this dispensation, and this has prompted various responses from sustainability-promoter organizations. The United Nations (UN), for instance, has adopted a multidisciplinary and multifaceted approach to tackling the sustainability challenge with programmes like Sustainable Development Goals (SDGs), the Conference of Parties (COP) organized under the United Nations Framework Convention on Climate Change (UNFCCC), and similar agencies (Jones et al, 2017; Hickmann et al, 2021).

Sustainability accounting is a holistic approach to financial accounting that integrates environmental, social, and governance (ESG) factors into the traditional financial reporting process. This approach ensures that organizational stakeholders possess comprehensive information about the organization's true state of affairs, including the externalities (either positive or negative) created by its operations and their effects on stakeholders (Oyewo et al, 2022; Ikpor et al, 2022).

Artificial intelligence (AI) has emerged as a transformative technology with the potential to enhance the efficiency and accuracy of various business functions, including sustainability accounting. The integration of AI in sustainability accounting can help organizations process vast amounts of data, automate routine tasks, and generate insights for decision-making (Solikin & Darmawan, 2023). However, the relationship between AI and sustainability accounting remains understudied, particularly in developing countries like Nigeria.

To address this gap, this study aims to evaluate the perceptions of stakeholders from the finance departments and management of manufacturing firms in Nigeria regarding the effectiveness of AI in improving sustainability accounting practices. By doing so, the study contributes to the growing body of knowledge on the role of AI in sustainability accounting, particularly in a developing country context. The findings have implications for both academics, sustainability accounting practitioners, reporting entities and creators of business software highlighting the potential benefits of adopting AI in sustainability accounting practices to enhance the accuracy and efficiency of reporting.

Background

With organizations producing increased volumes of data at an exponential rate, the accounting function must develop and creatively use the power of technology in the production of performance reports. In organizations that have digitalized their operations, most source documents required for audit trail are generated by these digital systems. It therefore follows that for efficiency, the systems that generate the organization's performance reports ought to be digitalized. The effects of this digital transformation touch all facets of the accounting function, including sustainability accounting (Adebola et al, 2023; Krishna et al, 2022; Mpofu, 2019; Nkwede & Aniuga, 2023; Ukpong, 2023). It is in the light of these, that this study seeks to evaluate the effect of AI on sustainability accounting in Nigeria, and whether or not the stakeholders agree that investment in AI capabilities can be a booster to value derived from the practice of sustainability accounting in reporting entities in Nigeria.

Solikin & Darmawan (2023) posit that the implementation of AI in sustainability accounting can facilitate organizations' progress in managing and analyzing large quantities of data, automating routine operations, and producing insights for decision-making, however, the link between AI & sustainability accounting is under-researched, particularly in developing nations like Nigeria.

One of this study's main objectives is to fill the gap in literature on the role of AI in sustainability accounting, especially in the case of developing countries like Nigeria. While some studies, for example Oyewo et al (2022), have analysed the effect of technologies on sustainability reporting in the Nigerian context, this study creates new knowledge by narrowing the focus to the use of AI-capable tools in sustainability accounting in Nigeria. The results of this study are significant for both academics and practitioners, showing its users the various patterns of AI implementation in sustainability accounting practices.

Research objectives and research questions

This research aims to assess the effect of AI on the practice of sustainability accounting in Nigeria. The objectives of this research are to contribute to existing knowledge in the following areas:

- a) Provide an assessment of the effect of AI use and estimation of the prevalence of AI techniques in the Nigerian sustainability accounting context
- b) Provide guidance to intending users of AI in sustainability accounting, showing the various techniques used in the daily workflow of sustainability accounting, and the minimum viable AI workload to be contained in any technical products or applications to be acquired for sustainability accounting in Nigeria.

The research questions for this study are:

- a) Does AI usage have any effect on sustainability accounting practices in Nigeria?
- b) What are the most prominent AI workloads that are needed in products or applications that are used for daily sustainability accounting workflow in Nigeria?

In addressing these research questions, this study seeks to advance existing knowledge of AI in sustainability accounting in developing nations. The results will reveal consequences of employing AI in sustainability accounting and areas where further scholarly endeavours are required.

2. Literature

Artificial Intelligence (AI) and Sustainability Accounting

AI, as a terminology, has been used to define a group of techniques and tools that utilize statistics, mathematics, and modern computing to perform tasks that relate to forecasting, analytics, and pattern identification. Due to its effectiveness, AI is able to parse both structured and unstructured data, which is encountered in daily accounting workloads like document analysis and transaction processing (Association of Chartered Certified Accountants, 2017; Solikin & Darmawan, 2023; Kapoor et al, 2022).

Two prominent techniques exist in AI: machine learning and deep learning. Machine learning is normally used to describe the use of tools like statistics, math, and operational research in processing data, captured in tabular form. Machine learning techniques like regression, clustering, and classification are used to generate insights from data which originally was captured in tabular form. In deep learning, artificial neural networks are utilized to process vast volumes of data, whether structured in tabular form, or unstructured. In today's accounting, some workloads that have benefitted from deep learning include: using computer vision to scan invoices and other source documents, using natural language processing for classification of transactions, using deep neural networks for forecasting and budgeting (Association of Chartered Certified Accountants, 2017; Shimamoto, 2018).

AI impacts accounting by reducing errors and eliminating the use of man-hours for mundane transactions processing tasks. Because of the increase in computing power, AI is able to process far larger volumes of transactions than humans can, thereby giving organizations a boost in productivity. It appears that sustainability accounting, being a subset of accounting, can benefit from the versatility that AI brings (Shimamoto, 2018; Liaras & Nerantzidis, 2023; Peng et al, 2023).

Several studies have examined the impact of technology on accounting and sustainability reporting. One of such prominent studies is Oyewo et al. (2022), which investigated the impact of the use of technology in sustainability reporting in Nigeria, and posits that for sustainability accounting to be a fruitful endeavour in any reporting entity, significant investment in technology is inevitable. The deployment of these advanced technologies brings efficiency and helps accountants free up time to attend to more value-adding work that enhances the benefits (pecuniary and non-pecuniary) to the organization's stakeholders.

Chi & Chu (2021) opine that because of AI's advanced algorithms, it is possible to use AI in sustainability accounting for the purpose of predicting a firm's economic sustainability, and its capacity to continue creating value for stakeholders in the nearest future as a going-concern. Drawing their study's sample from the annual reports of companies listed in the Taiwan Stock Exchange Corporation (TWSE) and the Taipei Exchange (TPEX) between 2004 and 2019, the researchers utilised advanced AI algorithms like Long-Short Term Memory (LSTM) and Gated Recurrent Units (GRU) to perform advanced sustainability analysis of the firms and predicted their going concern status with up to 94% accuracy using each algorithm.

Cihan (2023) avers that using AI, firms are able to produce more complete reports that aid monitoring and evaluation of a reporting entity's economic and social activities in line with the Sustainable Development Goals (SDGs). By performing a systematic review of existing literature, Cihan (2023) identifies AI as a key contributing factor for the attainment of all SDGs.

Musleh Al-Sartawi et al (2022), in their study, reveal that one of the most important contributions to AI in sustainability is that organizations can use AI to facilitate the process of ensuring that those charged with corporate governance have enough information to utilize a holistic approach to economic and social governance within their corporations. When this is done, the corporations are set on the path to achieve their SDG targets in an easier manner than in the absence of AI.

Hillebrand et al (2023) in their product evaluation study assess the impact of context-aware, recommender systems powered by natural language processing AI algorithms on sustainability accounting. Their study reveals that when such algorithms are used, the process of providing audit and assurance reviews for sustainability accounts becomes more efficient, thereby enhancing the quality and usability of the sustainability accounts provided to stakeholders.

There is, however, a dearth of research on the use of AI in sustainability accounting in the Nigerian context. This study aims to address this gap by evaluating the perceived usefulness and ease of use of AI in the practice of sustainability accounting in Nigeria, using the Technological Adoption Framework (TAM) and the Stakeholder Theory (Denning, 2013) as its theoretical compass.

Theoretical Framework for AI use in Sustainability Accounting

This study draws on the Technological Adoption Model (TAM) posited by Venkatesh & Bala (2008). The central idea of TAM is that the decision to adopt a technology is influenced by two cardinal factors: perceived usefulness of the technology, and its perceived ease of use. Perceived usefulness refers to the extent to which a user believes that utilizing the technology will enhance their job performance, while perceived ease of use refers to the extent to which a user believes that using the technology will be free of effort (Venkatesh & Bala, 2008). In the context of this study, the TAM is used as a basic framework to elicit first-hand information from the users of AI-capable tools in sustainability accounting in Nigeria, about their perception of value created by AI and the mechanisms through which such value is created. The aim is to find out from the respondents, whether the use of AI in their sustainability reporting workflow is perceived by them to be useful and without any cumbersome side-effects.

Another theory that provides a framework for this study is the Stakeholder theory. As opined in Hühn (2023), there are two contrasting ideologies that predominate in management research as pertains to an organization's corporate responsibilities:

- a) The shareholder value theory; and
- b) The stakeholder value theory

The shareholder value school of thought draws its defining framework from the work of Milton Friedman. In Friedman's now infamous New York Times article, titled "*A Friedman doctrine-- the social responsibility of business is to increase its profits*", Friedman (1970) opines that the only obligation a business owes its community is to make profit ethically.

A number of management researchers have disagreed with Friedman's doctrine, and one of the most prominent of these was R. Edward Freeman, who negated Friedman's postulations, and eventually introduced an alternate management theory known as the Stakeholder Value theory.

Freeman discussed the concept of stakeholder value creation as an alternative management theory that counters the deleterious effects introduced into management practice by Friedman's doctrine. Freeman asserts that all firms' economic activities affect a wide range of people and not only its owners or contributors of capital. To ensure fairness, equity and accountability, it behoves on those charged with the corporate governance of firms to declare the effects of their firms' operations on all stakeholders whose livelihood are affected in one way or another by the economic activities of the firm. This proactive declaration of the firms' effects on the lives of all its stakeholders ought to be a moral responsibility of the firm. As postulated by Friedman, a firm's performance or its impact should not be measured in its economic sustainability alone, but by how well it balances its duties to all its stakeholders. This postulation is one of the major groundworks for sustainability accounting as it is known today. Freeman's theory demands that a firm's interventions, like AI are viewed through a multi-stakeholder perspective, which necessitates that this study involve at least two set of stakeholders: finance departmental employees and executives of the reporting entities considered (Freeman, 1984).

3. Materials and Methods

Research design

This study adopted a quantitative research design, utilizing a cross-sectional survey of a sample of employees (of finance or related departments) and executive management of public companies in Nigeria that have adopted sustainability accounting. A stratified random sampling strategy was employed to ensure a representative sample of respondents across various industries and company sizes. This research design was chosen primarily due to time and resource constraints, and based on the researcher's experience, this methodology is desirable for studies like this.

The initial sample size was estimated using the Cochran formula (Cochran, 1977) for sample size determination:

$$n = (Z^2 * P * (1-P)) / e^2$$

where:

n is the sample size,

Z is the Z-score corresponding to a 95% confidence level (1.96),

P is the estimated proportion of the population that perceives AI improves sustainability accounting practices (0.5), and

e is the margin of error (0.05).

Based on Cochran's formula, the minimum sample size required was approximately three hundred and eighty-four (384). To this end, five hundred (500) survey instruments were sent to the respondents in this survey. Out of the 500 survey questionnaires distributed, only 91 respondents completed and returned the questionnaire, resulting in a response rate of 18.2%. While this response rate is relatively low, it is still within the range of commonly observed response rates for social science survey research (Baruch & Holtom, 2008). Due to time and resource constraints, the study proceeded to analyse the data collected from the 91 respondents. This position is bolstered by the study's Cohen's h score, used to determine the effect size for proportions. The Cohen's h score is calculated using the formula below:

$$h = 2 \times \arcsin(\sqrt{p1}) - 2 \times \arcsin(\sqrt{p2}),$$

Where:

- p_1 is the proportion of the study's sample
- p_2 is the proportion under the null hypothesis (50%)

The survey instrument was pre-tested with a small sample of respondents to ensure clarity and validity of the questions. Among other questions related to demographics and experience with sustainability accounting, The survey instrument had two major questions pertinent to the attainment of this study's objectives:

- a) On a scale of 1 to 5, how much has artificial intelligence improved your organization's sustainability accounting practice?
- b) Which of the following AI workloads do you use primarily in your sustainability reporting system:
 - Natural Language Processing
 - Advanced Analytics (e.g. Forecasting)
 - Image Processing
 - Image Generation

To ensure the Likert-scaled responses yielded plausible results, only respondents that selected scores from 3 to 5 were marked as providing confirmation that AI significantly improved their sustainability accounting practice. Respondents with scores below 3 were marked as not providing evidence that AI made any significant improvements to their sustainability accounting practice.

Research Hypothesis

In order to attain the objectives of this study, the research hypothesis was formulated thus:

H_0 = The proportion of stakeholders that perceive that AI improves sustainability accounting practices is less than or equal to 50%

H_1 = The proportion of stakeholders that perceive that AI improves sustainability accounting practices is greater than 50%

To test the hypothesis above, Minitab (version 18) was used to perform one-sample z-test of proportions at a significance level of 0.05. By using a hypothesized proportion of 50%, this study deemed a simple majority satisfactory to assess whether or not there was evidence against the null hypothesis.

4. Results

Table 1 below shows the respondents' characteristics and job titles. In this table, the finance personnel's job titles are categorised by organisational hierarchy and proportion.

Table 1 – Profile of respondents and company characteristics

Descriptor	Category	Frequency	Percentage
Job Title	Chief Financial Officer/ VP Finance/Head of Finance/Financial Controller	15	16.4%
	Finance/Accounts Officer/Accountant	76	83.6%
	Total	91	100%

As seen in Table 1 above, finance executives (Chief Financial Officer/ VP Finance/Head of Finance/Financial Controller) were 15 persons, making up 16.4% of the respondents, while individual contributors in the accounting or finance department (Finance/Accounts Officer/Accountant) were 76 persons and accounted for 83.6% of respondents.

Table 2 below shows a breakdown of the responses to research question one based on respondents' profiles:

Table 2 – Distribution of responses based on perception of the impact of AI on sustainability accounting

Descriptor	Category	Frequency (Yes)	Frequency (No)	Total
Job Title	Chief Financial Officer/VP Finance/Head of Finance/Financial Controller	13	2	15
	Finance/Accounts Officer/Accountant	62	14	76
		75	16	91

As seen in Table 2 above, seventy-five (75) respondents opine that artificial intelligence has significantly impacted their sustainability accounting practice, while (sixteen (16) respondents) think artificial intelligence has not significantly impacted their firm’s sustainability accounting practice. Figure 1 below shows the percentages of respondents that responded in the affirmative (82.42% of respondents) against those that stated that AI did not yield any benefits in their sustainability accounting practice (17.58% of respondents).

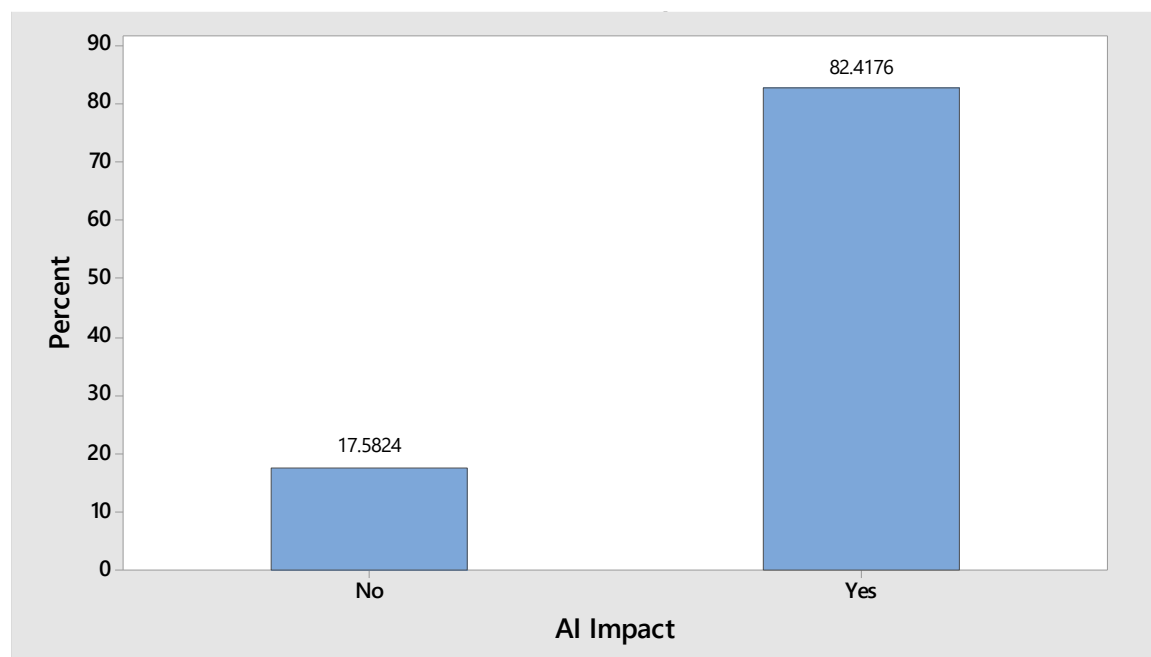


Figure 1 – Bar chart of responses grouped by opinion on AI impact in sustainability accounting.

As seen in Table 3 below, based on the data, the z-value for a one-sample test of proportion is 6.18, higher than the critical value of 1.645 for a one-tailed test with 95% confidence, while the p-value of 0.000 is below the study’s significance level (0.05). These indicate evidence against the null hypothesis.

Table 3 – Hypothesis test summaries from Minitab (version 18)

N	Event	Sample p	95% Lower Bound for p	Z-Value	P-Value
91	75	0.824176	0.758538	6.18	0.000

Also, based on Cohen's h formula stated above, the calculate h value is 0.71, which reveals a substantial effect size, suggesting that there is a significant difference between the observed proportion and the hypothesized value of 50%.

The data reveals that there are two main artificial intelligence techniques used in the preparation of sustainability reports in Nigeria: advanced analytics and natural language processing. Table 4 below shows the breakdown of the responses based on the primary AI workload the respondents use in their sustainability accounting practice:

Table 4 – Distribution of responses based on primary AI workload used by respondents in their sustainability accounting workflow

Descriptor	Category	Frequency (Advanced Analytics)	Frequency (Natural Language Processing)	Total
Job Title	Chief Financial Officer/ VP Finance/Head of Finance/Financial Controller	14	1	15
	Finance/Accounts Officer/Accountant	59	17	76
	Total	73	18	91

Figure 2 below shows the percentages of respondents that responded in the affirmative against those that stated that AI did not yield any benefits in their sustainability accounting practice.

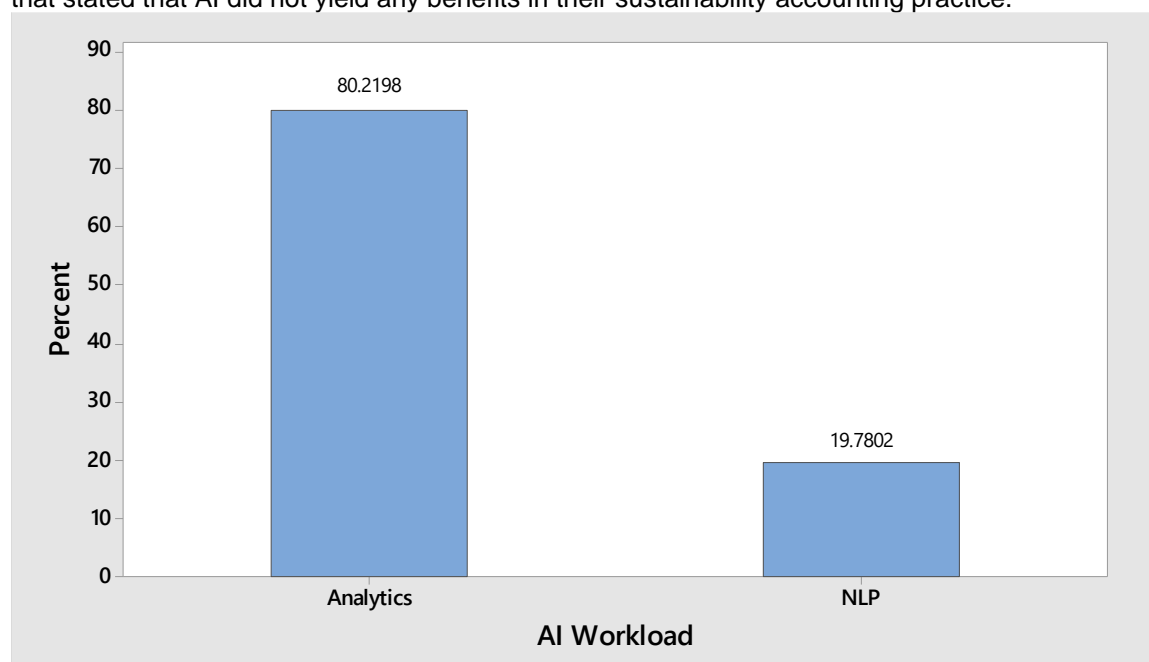


Figure 2 – Bar chart showing proportion of respondents based on AI techniques used in preparation of sustainability accounts

As seen in Figure 2 above, 80.2% (seventy-three (73) respondents) say that the major use of AI is in analytics, while 19.78% (eighteen (18) respondents) say their primary use of AI is natural language processing. None of the respondents indicated that they used artificial intelligence in any other workload like image processing or image generation.

5. Discussion

Sustainability accounting requires disclosure of a lot of non-monetary information in both structured and unstructured form, and in conformity with requirements that have been defined by sustainability accounting standards and regulatory frameworks (Peng et al, 2023). In addition to disclosure required by sustainability standards and frameworks, other stakeholders of reporting entities have disclosure requirements imposed on reporting entities either through moral suasion, pressure or some form of collective bargaining (Amran & Keat, 2014, Batra et al, 2022). While these requirements can make sustainability accounting an onerous task, the data suggests that artificial intelligence can help reporting entities comply with disclosure requirements and improve the efficiency of persons involved in the finance function in reporting entities.

The data suggests that much of the workload for which Nigerian entities use artificial intelligence solutions pertain to analytics and natural language processing. Due to the power of deep neural networks, reporting entities in Nigeria appear to mostly use artificial intelligence to perform complex analytical procedures like forecasting, analytical reviews, trend monitoring, pattern matching and similar tasks that appear too convoluted for manual accounting systems. Also, because most of sustainability reporting is largely about disclosure in explanatory notes, natural language processing with techniques like Retrieval Augmented Generation (RAG) can be used to accelerate the preparation of sustainability reports (De Villiers et al, 2024).

Limitations

While utmost care has been taken to ensure that the results of this study can be generalized easily, this study faces some noteworthy limitations:

- Geographical limitations: This study is limited to manufacturing companies in Nigeria. Particularly, respondents were picked from Lagos, Ogun and Abuja. Care should be taken when extending the results of this study beyond the aforementioned geographical locations.
- Methodological limitations: This study uses a cross-sectional survey design which captured the respondents' feedback at a point in time. While a longitudinal survey might yield clearer insights, especially by showing how respondents' views develop with the passage of time, financial and time constraints necessitated the use of a cross-sectional survey.
- Sample size: This study uses a survey of 91 respondents. While this sample appears to be small, an analysis of its Cohen's h reveals a significant difference between the sample and hypothesized proportion.

6. Conclusions

This study concludes that for Nigerian firms, artificial intelligence has the capacity to enhance the practice of sustainability accounting.

This study also concludes that most firms that deploy artificial intelligence techniques utilise them for advanced analytics and natural language processing.

Further study can reveal findings such as: challenges of deploying artificial intelligence in sustainability accounting in Nigeria, and whether a reporting entity's size affects its ability to use artificial intelligence in sustainability accounting..

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