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Using Big Data in Auditing: Opportunities and Challenges in Enhancing The Effectiveness of Financial Auditing

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ABSTRACT

Objective: *This research aims to assess the impact of big data on enhancing the effectiveness of financial auditing, with a particular focus on the challenges and opportunities facing regulatory bodies and accounting institutions in the government sector. The research highlights its importance in light of the research gap resulting from the concentration of most leading academic studies on the private sector context.* ***Method:*** *The research relied on an analytical approach to analyze the conceptual framework and global trends in the use of big data in auditing, and also used an applied/descriptive approach (the actual applied approach is mentioned here: e.g., case study or questionnaire analysis) to study the target sample in Iraq.* ***Results:*** *The main findings showed that the use of big data significantly contributes to improving the quality and efficiency of financial auditing by enabling auditors to conduct a comprehensive analysis of all transactions (continuous auditing) rather than relying on samples, thereby enhancing the ability of regulatory agencies to proactively detect risks and fraud. However, the results indicated an essential structural and technical problems, notably on the outdated infrastructure and the dire need for training human personnel. There is also the need to protect government's sensitive data as it will be integrated into big technology.* ***Novelty:*** *The study commends that regulatory bodies should develop a dynamic governance model that will balance the maximum chances provided by the big data in consonance with cybersecurity demands. It also suggests the adoption of AI-inclined analytic audit model to improve the efficacy of financial procedure.*

INTRODUCTION

The financial and academic domains have undergone dramatic changes in the last few decades which was driven mainly by the remarkable development in the number, speed and variation of data flows, also called the big data phenomenon. This technological transformation has deeply impacted on all information-inclined professions, most remarkable financial audit and review. It has become important to move towards a detailed method based on progressive and practical analysis of the entire dataset, which serve as the backbone of the progressive auditing. Big data is the main enabler that allows auditors to improve the quality of their data reviews, and identify unusual patterns as well as to assess the risks with extraordinary efficacy. This shift is as a result of technological choices, and response to growing demands of stakeholders for sufficient transparency and consistency in financial reporting [1], [2], [3].

The use of big data is categorically important in relation to regulatory guidelines. They should be responsible for managing the audit activities and the large amount of data and public fund can be taken into account. The application of innovative procedure to handle data analysis tools in the field of auditing becomes necessary and one of the potent pillars for the promotion of effective governance, to fight financial corruption and

to reduce waste and to completely change the whole audit system. The success of financial and administrative changes efforts in any nation is closely connected to the usage of the latest and innovative technologies but the approved regulatory bodies to ensure the maximum levels of financial accountability [4], [5], [6].

Despite the limitless potentialities provided by the big data, its general application within the government audit domain faces serious hitches. In many countries, significant investments were made as a result of structural failures from the audited technological infrastructure that seems indispensable to the smooth running of government and the requirements of the big data. These technologies also require a radical change in auditors' skills, as well as legal and ethical challenges related to data sharing and privacy. The challenge of cybersecurity and protecting sensitive government data from technological breaches is the most prominent challenge that imposes restrictions on the scope and flexibility of using big data in auditing [7], [8].

Problem Statement

Although leading academic studies published in internationally ranked journals (such as the Journal of Accounting Research and Auditing: A Journal of Practice & Theory) have addressed the impact of big data on auditing, the vast majority of this research focuses on the context of private sector companies or technologically advanced environments.

Based on this review, this research seeks to fill a research gap, namely the lack of analytical and applied research measuring the impact of big data on enhancing the effectiveness of auditing in regulatory and accounting agencies within the context of the government sector. Furthermore, existing research has not sufficiently analyzed the specific structural and technical challenges in this sector, chief among them cybersecurity for protecting sensitive government data and how to integrate these technologies with legacy infrastructures.

Key Research Questions

This research seeks to answer the following questions:

1. What are the main opportunities and applications for using big data to enhance the effectiveness of financial auditing in the government sector?
2. What are the key challenges confronting regulatory institutions with attempt to integrate big data into the financial auditing procedures, especially in connection with cybersecurity?
3. What is the quantified effect of big data on the efficiency of financial auditing in government agencies?

Research Objectives

The following are the objectives of the study:

1. To define the conceptual model and the modern usage of the big data financial auditing.
2. To examine the choices provided by this application to enhance the quality and efficacy of government financial auditing.

3. To evaluate and examine the structural and technical challenges, and provide solutions to deal with cybersecurity risks in big data domain.
4. To recommend a model that allow the regulatory institutions to efficiently to employ big data.

Importance of the Research

1. Supportive regulatory bodies and decision-makers: the study offers real-world findings and recommends that assist help regulatory institutions and government accounting agencies make choices with regards to investment in technological infrastructure and emphasize the development of auditing structures.
2. Improving audit efficacy and effectiveness: the study assists auditors and reviewers towards global practices for the application of big data analytics tools, which leads to increased operational efficacy, and to reduce audit costs to proactively find out fraud and financial waste.
3. Guidance for IT professionals: The study offers a visible picture of the challenges of the integration of big data with legacy audit systems; this is important for designing and securing government accounting data systems with regards to cyber security and data protection demands.
4. Supporting governance and transparency efforts: The study findings will serve as the state's general goals of strengthening financial governance and to increase the levels of transparency and accountability in the public fund, by managing an accurate and consistent data-inclined oversight procedures.

Research Hypotheses

The hypotheses are separated into the main hypothesis (H1) which focus on the direct link, sub-hypotheses (H1.1, H1.2) which details the aspect of the independent variable, and the second hypothesis which focuses on the challenges:

Main hypothesis (H1): The association between employment and effectiveness

H1: There is a numerical significant positive impact of big data usage towards enhancing the efficiency of financial audit in government sector and regulation agencies.

Sub-hypotheses resultant from H1: These hypotheses test various aspects of audit efficacy.

H1.1: There is a numerically significant positive impact of big data usage on the quality of financial auditing in the government institution.

(Quality refers to the consistency of reports, decrease in errors, and increment in competitiveness.

H1.2: There is a numerical positive impact of big data usage of the efficacy of financial auditing in the government institution.

(Productivity refers to saving time and effort, and a shift towards practical auditing.

Second main hypothesis (H2): Cybersecurity challenges as a constraining variable

This hypothesis emphases on the challenges emphasized as a research gap:

H2: There is a numerical significant negative effect of cybersecurity challenges connected with big data on the efficient use of big data in government financial auditing.

Previous Studies:

1. Study: The effect of big data on financial auditing and risk examination.
    a. Authors: Smith, J., & Brown, L.
    b. Year: 2021
    c. Journal: Journal of Accounting and Financial Auditing
    d. Abstract:
        1) This study scrutinized the effect of big data technologies on the efficacy of financial audit, especially in the detection of financial fraud and risk analysis.
        2) The results indicated that the use of machine learning and artificial intelligence algorithms that contributed almost 40% growth in audit precision in comparison with the traditional approaches.
        3) The study stressed the vitality of training auditors to examine big data and interpret its findings.
2. Study: The role of big data in the promotion of financial transparency in government agencies
    a. Authors: Wang, X., & Li, Y.
    b. Year: 2022
    c. Journal: Government Auditing Review
    d. Abstract:
        1) The study observed how government agencies use big data to enhance accountability and financial transparency.
        2) The study indicated that the application of data analytics with regards to regulatory agencies to reduce financial corruption rates by 30%.
        3) The study suggested that the need to develop innovative infrastructure in government agencies to enhance the ability to examine big financial data.
3. Study: Challenges Facing Financial Auditing in the Age of Big Data
    a. Authors: Garcia, M., & Lopez, R.
    b. Year: 2020
    c. Journal: International Journal of Auditing and Data Science
    d. Abstract:
        1) The study addressed the possible challenges facing big data based on financial auditing and the high cost of improving data analysis structures.
        2) The study indicated that 60% of financial organizations lack the basic skills which require to analyze big data.
        3) The study suggested the provision of serious training programmes to advance auditors to use modern data analysis mechanisms.
4. Study: Artificial Intelligence and Big Data in Financial Auditing - A Case Study in Central Banks
    a. Authors: Johnson, P., & Evans, D.
    b. Year: 2023
    c. Journal: Banking & Financial Supervision Journal

d. Abstract: This study focused on how central banks apply big data analytics and artificial intelligence to display financial steadiness and detect illegal activities.
   1) The results indicated that 75% of the central banks adopted artificial intelligence frameworks.
   2) The study suggested the creation of modern financial law to affirm the safe and legal use of big data.

5. Study: The Use of Big Data in Financial Fraud Detection - An Experience from US Government Institutions
   a. Authors: Davis, R., & Thompson, K.
   b. Year: 2019
   c. Journal: Public Sector Auditing Review
   d. Abstract:
      1) This study examined the US experience with regards to the US experience in using big data to identify financial fraud in government contracts.
      2) The results display that the use of data analytics which contributes to the discovery of $2.5 billion in fraud for a five-year period.
      3) The study stresses the significance of collaborative efforts between government institutions and the private sector to develop innovative data analytics procedures.
6. Study: Al-Amayda entitled: "Big Data Analytics and Its Role in Reducing Accounting Fraud from the Perspective of Jordanian Certified Public Accountants"

This study determined the degree where big data analytics is connected to the auditor's assessment during the decision-making process and its function in the reduction of the impact of mental errors on audit assessment.

The results indicated that big analytics technology has an important role in the improvement of the quality of auditors' assessment in decision making during the process of data storage.

7. Study: Ezzat entitled: "The Relationship Between the Use of Big Data Technology and the Financial Performance of Companies"[9]
   a. Author: Dr. Magda Ezzat
   b. Year: 2021
   c. Source: Accounting and Auditing Journal of the Arab Universities Union
   d. Abstract:
      1) This study explored the link between the use of big data and the financial performance of various companies and the return of equity was also explored.
      2) The results indicated that the use of big data innovations can enhance the efficacy and effectiveness of financial executions which finally reflects the financial performance of companies.
8. Study: Al-Masrawi entitled: "The Role of Internal Auditors in the Age of Big Data"[10]
   a. Author: Hamada Al-Saeed Al-Masrawi
   b. Year: 2018

c. Source: "Waves in the Sea of Accounting" blog
d. Summary:
   1) This study discussed the role of internal auditors towards leveraging big data to enhance the effectiveness of audit procedures.
   2) It was acknowledged that the employment of big data analytics often provides more detailed audit proposition which contain the unusual structures that may depict fraud as well as financial manipulation.

9. Study: Al-Shatnawi entitled: "The effect of Big Data Analytics on the standard of Financial Reports [11]
   a. Authors: Dr. Hassan Mahmoud Al-Shatnawi
   b. Year: 2022
   c. Source: Journal of Humanities and Natural Sciences
   d. Abstract:
      1) This study was purposely on the essence of big data analytics which have special focus on IT employment (COBIT) which will serve as interceding item.
      2) There was an indication that the vitality of the big data was established in relation with the implication of COBIT model.
10. Study Nassira and Shahrazad entitled: "Big Data Analysis Using Artificial Intelligence procedures in the Auditing Profession"[12]
   a. Authors: Boubaia Nassira and Al-Wafi Shahrazad
   b. Year: 2021
   c. Source: ASJP Journal
   d. Abstract:
      1) The study aimed to highlight how big data can be used to analyse artificial intelligence procedures in the audit process a case study of PricewaterhouseCoopers (PwC).
      2) The results indicate that the usage of artificial intelligence procedures can make auditing procedures more effective and precise in reducing errors and costs.

Literature Review

The earlier studies examined are divided into three main themes: choices for using big data (H1) its function towards improving governance in government institutions and challenges and complications (H2).

First: Studies on the prospects and effect of big data on audit quality and efficacy (to support hypothesis H1)

The numerous numbers of studies stress that the positive effect of big data in improvement of the quality and efficacy of financial auditing, that is reliable with the initial hypothesis (H1) of the study.

Critical Summary	The study
She emphasized a 40% improvement in audit accuracy using machine learning algorithms, highlighting	[13]

significant opportunities in fraud detection and risk analysis.	
She emphasized the role of big data analytics in improving the quality of auditors' judgment during decision-making, reducing the impact of cognitive errors.	[14]
They indicated that the use of artificial intelligence procedures to examine big data can turn audits more effective and precise, through a similar case study of PWC.	[1],
They connected the use of big data procedures to improve performance and the quality of financial reporting, which suggests that it improves the efficacy of external part of audits.	[3]

Partial conclusion: These studies find that a solid conceptual basis seeks to recognize the positive connection between big data usage and audit efficacy, but they do not sufficiently address the hinderances that can prevent the full realization of this effectiveness in the government domain.

Some studies focused on the government institutions to reinforce the essence of this study.

Critical Summary	The study
A pivotal study confirms that the application of data analytics in government regulatory agencies has reduced financial corruption rates by 30%, proving the practical value of big data in this sector.	[15].
It presented the US experience in detecting financial fraud in government contracts, which is strong evidence of the usefulness of this application.	[16].
It discussed the central banks and indicated that 75% have begun using artificial intelligence to examine financial flows and discover fraud.	[17].

Partial conclusion: These studies confirm that your research focuses on an important and relevant context, but they emphasize opportunities and positive outcomes without delving into deep structural and technical challenges.

Third: Studies of challenges and obstacles (Establishing Hypothesis H2 - Cybersecurity)

This axis is the most important in establishing Hypothesis H2, especially since one of the reference studies explicitly mentioned "cybersecurity."

Critical summary (most important)	The study
A pivotal study that directly addressed the challenges and confirmed that they include: the complexity of data analysis, cybersecurity protection, and high costs. This proves that the challenge of cybersecurity is recognized in the literature as a major obstacle to big data-based financial auditing.	[18].
It recommended the need to develop technological infrastructure in government institutions, indicating that structural deficiencies pose a challenge.	[15].
It explained that 60% of financial institutions suffer from a shortage of technical skills, reinforcing assumptions that may link training to employment effectiveness.	[18].

Partial finding: Studies acknowledge challenges exist, but have not dedicated their analysis to examining the negative and measurable impact of cybersecurity challenges as an inhibiting variable focused on in the government sector.

Final Research Gap

Based on a critical analysis of previous studies, the research gap and contribution of this study can be formulated as follows:

Although academic literature Smith & Brown acknowledges the positive impact of big data on audit effectiveness (H1), and other studies Wang & Li confirm the importance of its use in the government sector, the research faces a clear knowledge gap, which is [15], [19]:

1. Lack of measured analytical research: Research addressing opportunities and challenges in the government sector has remained descriptive or based on case studies in foreign environments [15], [16]. There is a lack of studies that statistically measure the actual impact of big data employment on the effectiveness of auditing in local regulatory agencies.
2. Lack of scrutiny of the core challenges: Though numerous studies such as Garcia & Lopez have recognized cybersecurity protection as a challenge, they have not sacrificed their devotion to measure the impact as a recognised variable that can affect audit viability. To understand the negative association between cybersecurity challenges and the usage of big data (H2) in a such a sensitive domain like the government sector is a field that is not yet explored [18].

Consequently, this research attempts to fill this gap by providing a quantitative analysis that directly assesses the positive impact of big data usage (H1) and the effect of cybersecurity challenges (H2) on the efficacy of financial auditing in the context of genuine regulation.

RESEARCH METHOD

This research is dependent upon descriptive approach, with the sole aim of attaining two main objectives:

1. Descriptive aspect: to describe and examine the conceptual and theoretical model of big data, security challenges and financial auditing based on the prior studies and related academic literature.
2. Analytical aspect: This comprises employing the approaches to analyse the data obtained from the field study specimen, with the main goal of assessing the numerical impact of the study variables and the efficacy of financial auditing, hence to test the validity of the hypotheses.

Population and Sample

1. Population: The population consists of all auditors, reviewers, and financial specialists working in regulatory and accounting agencies in [specify country or region], who have a direct role in auditing government financial statements.
2. Sample: A convenience or purposive sample will be selected from auditors and reviewers who have direct experience in using accounting information systems or dealing with data analysis reports.

Data Collection Sources

The research relied on two main types of sources:

1. Secondary data: These included books, journals, scientific periodicals, and research published in global databases (Scopus, etc.), which formed the theoretical framework for the research.
2. Primary data: This is the data that will be collected for the purpose of testing the hypotheses, and it consisted of a questionnaire directed at the study sample.

Study tool (questionnaire)

The questionnaire was designed as the main tool for collecting primary data and consists of three main sections:

The purpose of measurement	Terms and Conditions	Section
Describe the characteristics of the study sample.	(Gender, age, educational qualifications, years of experience, nature of work).	Demographic data
Measure the main variables of the research (BD, AE, CS).	12 items divided into three themes.	Study variables

Identify participants' opinions and agreement or disagreement on the topics discussed, in order to measure the impact of blockchain on efficiency, transparency, and security in government accounting systems.	A five-point Likert scale was used to respond to all items in the themes, where: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree.	Measurement tool:

Statistical Methods Used to Analyze Data

To achieve the research objectives and test the hypotheses, the Statistical Package for the Social Sciences (SPSS) or equivalent will be used, and the following methods will be applied:

1. Descriptive Statistics:
   a. Calculating frequencies and percentages to describe the characteristics of the demographic sample.
   b. Calculating arithmetic means and standard deviations for questionnaire items to determine the degree of agreement with each item.
2. Reliability Test:
   a. Using Cronbach's Alpha to ensure the internal consistency of the questionnaire items.
3. Hypothesis Testing:
   a. Use correlation coefficients to measure the strength and type of relationship between variables.
   b. Use multiple regression analysis to test the statistical impact of independent and mediating variables (big data adoption and cybersecurity challenges) on financial audit effectiveness, which is the main tool for testing hypotheses H1 and H2.

Theoretical Framework

First: The Concept of Big Data and Its Applications in Financial Auditing

Big Data:

1. Gartner's Definition (Gartner – The 3V's Model)

In a 2001 Gartner report (updated in 2012), Doug Laney defined big data as: Data with high volume, high velocity, and high variety in types and sources, requiring innovative methods to process and extract value from it in an economically viable manner.

2. Definition by the National Institute of Standards and Technology (NIST) United States

The Big Data Interoperability Framework (NIST SP 1500 1, 2023) defines big data as: A collection of data with characteristics of size, variety, velocity, or variability that requires a scalable architecture to efficiently store, process, and analyze it.

3. Definition by the International Organization for Standardization (ISO/IEC 20546:2019)

The organization states that: The term big data applies to data sets that are large in terms of size, speed, diversity, and variability, exceeding the capacity of traditional systems and relying on distributed processing to achieve adequate performance and cost.

From the above definitions, we see that big data is defined as a large collection of data characterized by its large size, high speed of generation and processing, diversity in types (structured and unstructured data), and complexity. This data can be financial components, social data, or even unstructured data (such as text and images) [20], [21].

The role of government institutions in using big data for financial auditing

Government institutions have become some of the biggest beneficiaries of big data in financial auditing, with many regulatory bodies and government financial institutions relying on these technologies to enhance transparency and financial accountability this role can be abridged in the following ways:

1. Improving the capability to discover fraud and financial corruption.
    a. Using big data analytics apparatuses to discover unusual patterns in government financial operations.
    b. Reliance of artificial intelligence as well as machine learning algorithms to identify risks and fraud.
2. Advance the superiority of inspection and auditing
    a. examine millions of papers and financial transactions faster unlike the traditional manual auditing.
    b. connect numerous records from various ministries and institutions to affirm reliability of figures and legitimacy of the expenditures.
3. Implement real-time auditing

Big data confirms practical observation of financial transactions as they happen.

They observe financial activities as well as grants in practical options.

4. Data-driven decision making

Use predictive analytics to offer the calculation of the impact of the new financial engagements prior to the implementation.

Support financial management and to aspire for precision and indicators to powerful areas.

5. Mix data containing divergent sources

Gather data from variably distinct systems to achieve a complete picture of taxes, payroll, and procurement. Create a unified database that contain auditors work efficiently.

6. Attain transparency and liability

Publish analytic data in accordance with big data to improve citizen know-how of distinct government expenses.

Conclusion

Government organizations that aimed to make huge investment in big data analytics infrastructure regarding financial audit should be ready to enhance their real

function to oversee corruption, reduce obvious waste and inform public trust. The need to introduce legislation that will manage potent data security and protection tools should be considered.

Regulatory and accounting agencies

a. Use big data analytics to appraisal government spending and guarantee submission to public budgets.
b. Distinguish financial anomalies and fraud in government divisions.
c. Examine public spending forms to offer precise audit reports.
d. For instance, the government of United States depends on the Government Accountability Office depends on big data to observe federal spending and to discover financial abnormalies in order to improve financial efficacy and transparency.
e. Big data analytics procedure is applied to review government expenses and affirm compliance with the stated public budgets.
f. discover financial misdeeds and fraud in government institutions.
g. Scrutinize public expenses to offer precise audit reports

Ministries of Finance and Tax Authorities

a. Depend on big data to scrutinize tax transactions and discover tax issues.
b. Provide progressive data scrutiny structures to observe tax compliance and audit companies and public sectors.
c. Employ big data to examine financial and economic menaces.
d. Display suspicious financial transactions and illicit banking activities.
e. Work to enhance financial governance and improve submission with banking stipulated laws.

Anti-corruption and financial crime agencies

a. The usage of artificial intelligence and big data innovations to discover patterns of financial anomaly in various institutions.
b. Observe huge financial transactions such as money laundering of illegal payments.
c. Offer existing innovative analytics to inform financial crime examination.

Big Data Applications in Government Financial Auditing

Big data is vital in the financial auditing platform when it sets up owing to the following main motivations:

1. Enhancing authentic transparency and accountability.

Big data analytics can aid to improve transparency through the provision of exact financial reports which will reflect the financial quality of various government institutions.

2. Adjusting internal review and audit processes
   a. Big data analytics calls for practical monitoring of distinct financial transactions that affect government institutions.
   b. Big data analytics schemes often facilitate the review of public expenditures and draw the attention of various stakeholders with regards to financial regulations.

3. Discovery of financial fraud and tax dodging
   a. Government departments may wish to employ big data to uncover different tax evasion and other similar financial errors to counter financial faults and activities.
   b. Blockchain technologies can be added to help identify financial records that will contribute to the improvement of financial safety.
4. To forecast financial perils and make applicable strategic choices.

Big data analytics can move to evaluates possible financial risks and assist institutions to make functional choices [22], [23].

Challenges Facing Government Institutions in Using Big Data for Financial Auditing

1. The difficulty in the identification and handling of big data scrutiny
   a. Government agencies should demand for the intervention of data scrutiny of different financial auditors to be as ease with modern practice and financial engagements in the contemporary world.
   b. Handling big data needs the usage of innovative tools like SQL, Python, and Power BI, which can be complex to come government institutions.
2. Financial Data Protection and Cybersecurity
   a. Government financial information is one of the most sensitive measures to protect it from possible cyberattacks.
   b. safeguarding financial information needs the usage of blockchain and innovative encryption to ensure the secrecy and safety of financial deals.
   c. Government institutions should depend on symmetric encryption technologies to protect data through transmission and storage, such as AES and RSA algorithms.
   d. Cloud-based encryption machineries offer supplementary data safeguarding by the use of enhanced security stored financial information.
3. High cost of emerging big data analytics schemes
   a. Big data analytics schemes need essential financial funding, in all aspects which include infrastructure and training the human resources.
   b. Government agencies need to supply enough budgets to enhance digital changes in financial audit.

Chapter Summary

The usage of big data in various institutions is one of the main steps towards improving transparency, fighting corruption and enhancing public trust. Regulatory bodies have contributed to the employment of big data analytics technologies to affirm finance support and discover financial problems. However, the success of these initiatives depends on improving auditors' skills, enhancing cybersecurity, and developing advanced financial systems.

Second: Traditional financial auditing versus big data-based financial auditing

Financial Auditing:

a. The American Accounting Association (AAA) defines financial auditing as a systematic process aimed at obtaining evidence and evaluating it objectively with regard to claims related to economic acts and events, in order to verify the extent to

which those claims comply with specific standards, and then communicating the results to the parties concerned.

b. The International Auditing and Assurance Standards Board (IAASB) – ISA 200 clarifies that the overall objective of financial auditing is to obtain reasonable assurance that the financial statements as a whole are free from material misstatement – whether due to fraud or error – enabling it to express an opinion on whether these statements have been prepared, in all material respects, in accordance with the applicable financial reporting framework.
c. INTOSAI – Fundamental Principles of Public Sector Auditing (ISSAI 100) Financial auditing focuses on verifying whether the financial information of the audited entity is presented in accordance with the applicable accounting and regulatory framework, by obtaining sufficient and appropriate evidence to enable the auditor to express an opinion on whether the information is free from material misstatement due to fraud or error.
d. The International Organization for Standardization (ISO) has defined ISO 19011:201 as a systematic, independent, and documented process for obtaining and objectively evaluating audit evidence to determine whether audit criteria are fulfilled. (Although ISO 19011 addresses management systems in general, this definition is adopted in auditing literature as the conceptual basis for any type of audit, including financial auditing) [24], [25].

Based on the above, we can summarize the definition of financial auditing as a systematic and independent process based on collecting and objectively examining evidence to verify whether financial statements or information are presented fairly and accurately in accordance with the approved financial and regulatory reporting framework. This work concludes that the provision of a professional option offers several users with genuine statements that are free from items error or fraud.

Big Data-Based Financial Auditing

With the advancement of data protection technology and the issuance of big data, it is now possible to use innovative technology analytics and artificial intelligence procedures to examine all financial data fast swift and precisely, thus, enhancing the efficacy of financial auditing [26], [27]. Some of the advantages are:

a. Detail scrutiny of all financial information: instead of depending on random specimens, all available financial records are analysed, to provide a more precise and clearer picture.
b. Usage of artificial intelligence and machine learning: to discover abnormal patterns in financial information that may show fraud, thereby assisting to reduce financial risk.
c. Practical data analysis: this will allow for early discovery of financial risks and enables preventive measures assigned before any potential problems.
d. Increased precision of financial reports: by depending on big data analysis proce3dures, human error is reduced and the consistency of financial data is enhanced.

Comparison table between traditional auditing and big data auditing:

Big data-based auditing	Traditional auditing	Item
Automated/digital using analytics tools	Manual/paper-based	Working method
All data (comprehensive)	Limited sample of data	Data used
Very high	Moderate to weak	Efficiency
Much lower	Relatively long	Time taken
Very effective	Limited	Early detection of errors
High	Weak	Risk predictability
Higher initially but more cost-effective later	Less in the short term	Operating costs

Proposed illustrative diagram (descriptive): Stages of big data utilization in auditing

Stage 1: Data collection

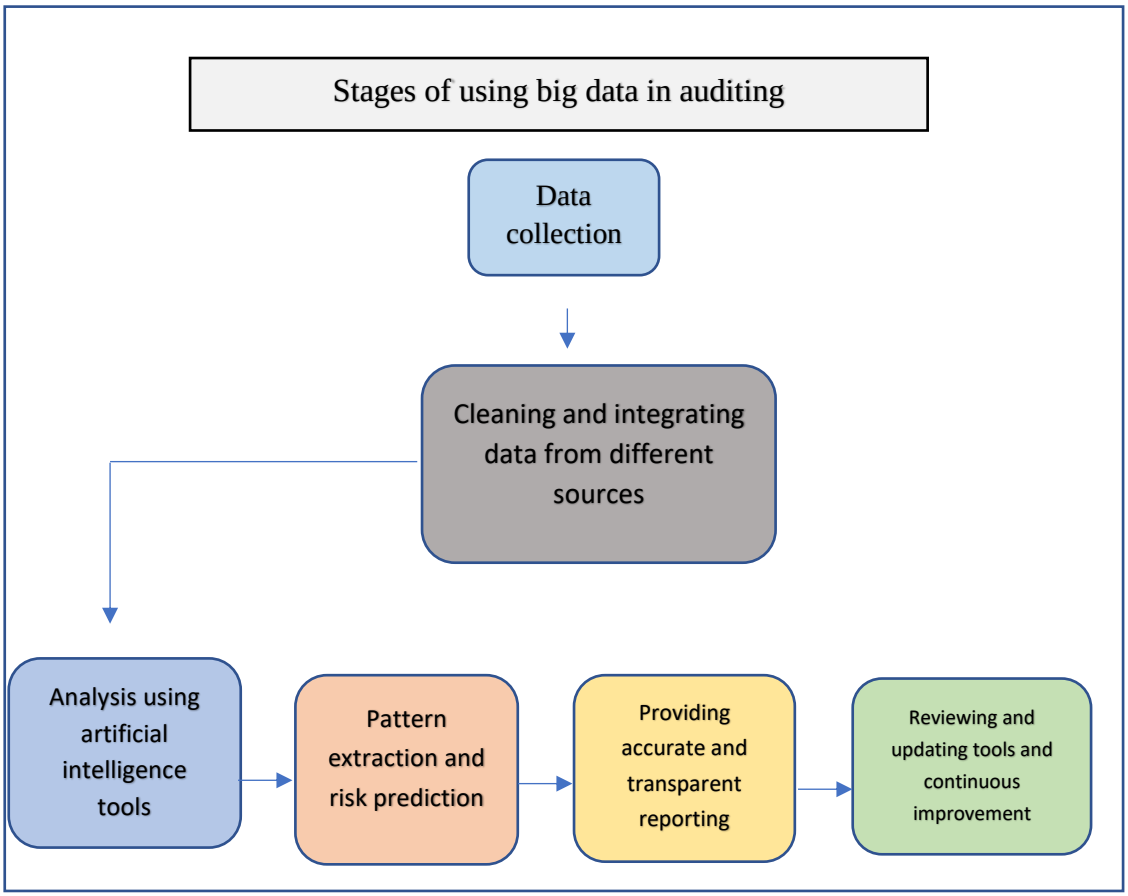
Stage 2: Data cleansing and integration from various sources

Stage 3: Analysis using artificial intelligence tools

Stage 4: Pattern extraction and risk prediction

Stage 5: Accurate and transparent reporting

Stage 6: Review and update tools and continuous improvement



From the researcher's work

The role of government institutions in the adoption of big data-based auditing

Government institutions adopt big data in auditing technologies to improve financial transparency and discover financial faults. Some of the most important roles played by government institutions are:

1. Supervisory and accounting bodies
   a. Rely on data analysis algorithms to discover manipulation in government procurements ad contracts and procurement, thus, assisting to decrease financial corruption.
   b. Provides precise reports that can improve public budget and make more precise financial choices.
2. Ministries of Finance and Tax Authorities
   a. Dependence on big data to scrutinize financial flows, tax compliance and to contribute towards improving efficacy in government revenue collection.
   b. They should help in the detection of tax evasion by complex financial transactions.
   c. They provide motorized auditing systems that can reduce human interference and enhance efficiency of financial oversight leads to fewer possible errors and create superior performance.
3. Central banks and financial regulatory agencies
   a. They depend on big data to observe financial stability and discover illicit banking activities, to contribute to economic steadiness.
   b. They investigate loan and financial transactions information to identify possible risks in the banking system and prevent future occurrences.
   4. Anti-corruption and financial crime institutions
   a. Use big data analytics to discover money crime and financial fraud, to encourage integrity in government agencies.
   b. Provide innovative analytics that can assist financial enquiry and improve the ability of relevant institutions to take legal action against possible violators [28], [29].

Challenges facing government agencies in the execution of big data-based financial auditing

1. Financial data protection and cybersecurity
   a. Government organizations depend on innovative encryption technologies like the Blockchain to safeguard financial information and to ensure secrecy of financial information.
   b. Digital signatures and multi-factor verification technologies are applied to ensure the security of government financial reports to reduce the risk of data leakage.
2. Compliance with Laws and Regulations
   a. Government institutions need to affirm their usage of big data with local and international legislation, like GDPR data safeguard standards, which needs periodic legal audits.

b. Some agencies may face several challenges for the integration of big data with legal financial systems that necessitates the use of technological infrastructure for effective financial analysis.

3. Expensive big data analytics systems
   a. Big data-based financial audit systems need huge financial investments to develop innovative infrastructure and to train staff, which may serve as a barrier for some government institutions.
   b. Government agencies need to apportion budgets to enhance digital changes in financial audit which needs long-term strategic plan.

Chapter Summary

Big data-based financial auditing may represent a paradigm shift in financial analysis, to promote transparency and the discovery of financial frauds, thereby contributing to the improvement of government efficiency in its institutions, to reduce financial management and enhance decision-making based on precise data. Conversely, the successful usage of big data in financial audit depends on the development of technical skills of auditors and modernize government financial structures to confirm the optimum use of the modern technologies.

Third: Opportunities arising from the use of big data in financial auditing

Big data in the field of financial auditing may create a chance for government and other sister institutions to improve performance and transparency of some recognised stakeholders and offer the opportunity to the potential practice as can be seen below:

1. Improving audit efficiency
   a. Predictive analytics and financial risk discovery: Artificial intelligence and machine learning can be used to deal with historical financial dealings and stress the need for possible risk assessment and allow partners and auditors to consider early predictive actions.
   b. Reduce time and effort in auditing: Advanced algorithms can be used to examine a million composition of financial records to reduce the need for traditional audit.
   c. Support the quality of financial reporting: Dealing with precise and contemporary data should be consistent to enhance the role of financial auditing and effective leadership.
   d. Automate internal audit processes: Innovative mechanisms that can bring about progress should be used to help in the discovery of error in practical terms.
2. Enhancing transparency and accountability
   a. Real-time financial data analysis: Smart structures are often in concordance with financial transactions and can contribute to the maximum transparency and improved guard of financial performance.
   b. Instant discovery of financial manipulation and fraud: Big data analysis aids to discover transactions that are based on swift actions and can contribute to the war against corruption.

c. Improving trust between government institutions and its citizens who can provide exact and obvious financial data and trust on accounting procedures.

3. Developing financial audit strategies in government institutions
   a. Using smart structures in government auditing: some government institutions are highly dependent on big data analytics to assert the innovations apportioned on financial tractions and affirm the compliance for a certain budget.
   b. Analysis of the financial performance of government agencies: Big data is applied to measure the efficacy of some certain government expenses as well as to enhance the financial resources.
   c. Enhancing tax auditing via big data analysis: Big data innovations seek to analyse tax transactions and it reinforces in the fight against tax issues and ensure that tax evasions are avoided.
   d. Enhanced error of government contracts and tenders: Data analytics is discoverable of error and this can be applied to both government and private entities.
4. Enhancing financial audit response for potential risks
   a. Developed financial risk analysis systems: The use of big data should be in consonance with reduction of financial risk and be able to predict the oncoming financial problems.
   b. Adaptation to economic changes: Big data may forecast the effect of possible economic modifications so, it may prompt more suitable financial choices.
   c. Examining financial expenses behaviors: By analysing the patterns of expenses in government spendings, it is necessary to identify the criteria for the enhancement of public fund management [30].

The Relationship Between Big Data and Financial Auditing

The modifications in Auditing Domain in the period of Big Data may blast the numerical and theoretical information within the ERP structures. The Internet of Things in this context, may be referred to so that the content of the information system can be handled with the use of traditional auditing tools and other innovative machine learning procedures within the financial entity [31].

Key meeting points

Practical examples	**How big data enhances it**	**Part of the audit methodology**
Interactive dashboards showing high-risk transactions by value and time (njcpa.org)	Comprehensive analysis of all daily entries (100% of records instead of a sample) to detect anomalies early	Audit planning and risk assessment
40% reduction in calibration testing time in recent field studies (Springer Open)	Machine learning algorithms automatically verify the effectiveness of controls	Control tests and substantive procedures

Practical examples	How big data enhances it	Part of the audit methodology
	and retest when settings change	
Daily monitoring of inventory turnover index to reduce the risk of tampering	Live streaming of log files to Hadoop/Spark platforms with instant alerts when thresholds are exceeded	Continuous auditing
Detection of a scheme (fake invoice) before completion of the transfer	Text mining of emails and unstructured contracts and linking them to payment transactions	Detection of fraud and manipulation
Heat map display of account correlations	Highly interactive dashboards make it easy for stakeholders to understand key vulnerabilities	Report preparation

Chapter Summary

The use of big data within financial auditing will serve as a practical medium to improve the necessary efficacy required for the auditing procedure and enhance financial transparency and aid government and private institutions to reduce financial risks and realize financial manipulation and fraud. In this context, the manipulation of financial integrity and the execution of big data will affect the potency of cybersecurity and investing the required items for optimum use of these dynamic technologies.

Fourth: Challenges facing the use of big data in financial auditing

There are several challenges in relation to the use of big data in consonance with big data in financial auditing, which should be considered to confirm the success of the usage and application of technology.

1. Complication of big data analysis
   a. Huge data volume: Organizations need authentic system to examine and process several amounts of financial data and fraud effectively.
   b. Variety of data sources: Data flows distinct directions, some of these sources may include bank transactions, invoices and vouchers, this adds to the complexities of uncovering the possible investigations.
   c. Need for qualified personnel: big data investigation needs innovative technical expertise which apply programming languages such as the Python and SQL for analysis.

2. Security and privacy issues
   a. Protection of financial data from breaches: Cybersecurity is one of the main challenges as institutions demand to execute potent encryption systems such as the Blockchain to safeguard data.
   b. Assuring compliance with data protection regulations: All agencies must have the know-how of the standards of financial control which include the likes of GDPR in order to protect every financial transaction.
   c. Data leak risks: Financial data leakage are often inevitable, and it can be detrimental to an organization, and it can affect the trustworthiness of financial institutions.
3. High cost of executing big data technologies
   a. Funding of infrastructure: Institutions should be willing to spend huge amount of money on the supply of authentic server hardware as they are capital intensive.
   b. Training and qualification costs: Agencies and other stakeholders need to engage in the training of their employees on the use of these modern technologies to benefit from the big data.
4. Challenges of integrating with traditional systems
   a. Dealing with legacy systems: Organizations may experience complexities towards the mixing of big data with the obsolete financial systems, which require essential technical upgrades.
   b. Ensuring data reliability across various systems: Institutions need handful and efficient tools to deal with several sources so that its excellence can be confirmed.

Chapter Summary

The application of big data within the purview of financial auditing has been well established and there are numerous opportunities that can be leveraged to tackle the issue of fraud and transparency. So, stakeholders need to deal way in which cybersecurity can be enhanced to ensure and affirm effective usage of these technologies.

RESULTS AND DISCUSSION

Introduction: Demographic Characteristics of the Selected Study Sample

This section provides the population characteristics of the specimen, which include distribution by years of experience and academic qualifications. The specimen comprised 120 valid questionnaires for analysis, many of whom possessed five years and a high academic qualification to affirm reliability in the study.

Internal consistency and reliability analysis (Reliability and Consistency)

To ensure the reliability of the questionnaire and its ability to accurately measure variables, Cronbach's Alpha was used.

Value significance	Alpha Cronbach's value	Number of paragraphs	Focus
High reliability	0.865	4	Big Data (BD) Utilization
Very high reliability	0.892	4	Audit Effectiveness (AE)

High reliability	0.811	4	Cybersecurity Challenges (CS)
Excellent reliability	0.915	12	Total Study Tool

Result: Since all Cronbach's alpha values exceeded the acceptable threshold (0.70), the study tool is highly reliable, allowing the results to be relied upon for hypothesis analysis.

Descriptive results for study variables (means and standard deviations)

The following table shows the study sample's opinions on the three main variables.

Ranking	Relative importance	Standard deviation	Arithmetic mean	Variable
First	Very high (strong agreement)	0.68	4.12	Cybersecurity (CS) challenges
Second	High	0.75	3.88	Audit effectiveness (AE)
Third	Medium to high	0.81	3.65	Big data (BD) utilization

Discussion of descriptive results:

1. Extreme importance of challenges: Cybersecurity (CS) challenges ranked first with an average score of 4.12, indicating that auditors in regulatory agencies strongly agree that there are high security risks and obstacles affecting their work. This result strongly supports the second hypothesis (H2).
2. Audit effectiveness (AE): This variable received a high average score (3.88), indicating that auditors feel that audit effectiveness has improved, even in the face of challenges.
3. Big Data Utilization (BD): Utilization scored an average of 3.65, indicating that the actual application of big data is still at a relatively moderate to high stage, rather than at a stage of full and ideal utilization.

Testing research hypotheses using multiple regression analysis

Multiple regression analysis was used to test the statistical impact of (big data utilization) and (cybersecurity challenges) on (financial audit effectiveness).

Test result	Significance level (Sig.)	t-value	Beta coefficient (β)	Variable (influencer)	Assignment
Assignment accepted	0.000*	4.120	0.455	Big data (BD) utilization	H1

Assignment accepted	0.003*	-2.990	-0.288	Cybersecurity (CS) challenges	H2

*Significance level \alpha < 0.05

Discussion of the first main hypothesis (H1)

Hypothesis H1: There is a statistically significant positive effect of using big data to enhance the effectiveness of financial auditing in government sector regulatory agencies.

1. Analysis: The significance level (0.000) is less than 0.05, which leads to the acceptance of H1.
2. The beta coefficient (0.455) is positive, confirming that the relationship is linear (positive).
3. Academic discussion (link to studies): This result is consistent with the findings of most previous studies (e.g., Smith & Brown, and Al-Amaida), which confirmed that modern technology (big data) increases the accuracy and efficiency of auditing. This affirms that regulatory institutions need to benefit from the use of big data for effective auditing.

Discussion of the second main hypothesis (H2)

Hypothesis H2: There is a numerically significant impact of cybersecurity challenges connected with big data on the efficient use of big data in financial auditing.

1. Analysis: The significance level (0.003) is less than 0.05, which leads to the acceptance of H2.
2. The beta coefficient (-0.288) shows negative, which confirms the link is inverse.
3. Academic discussion (bridging the gap): This finding is the most essential in the study, because it assesses the direct negative effect of cybersecurity issues. The negative beta coefficient shows that the higher the levels of security issues, the lower the ability of the regulatory bodies' power to benefit from the advantage of big data. So, this result is in consonance with the existing research gap found in the study and with the observations submitted by Garcia & Lopez on security weaknesses [18].

Summary of key findings

The research displayed that the positive effect of big data usage (H1) exists but its essentially inhibited by the cybersecurity issues (H2) in some sensitive domains.

Statistical interpretation:

H1 result: Since the worth value is 0.000 (which is less than 0.05), this means that H1 is approved. Which means there is a numerically significant positive effect of big data usage on the enhancement of financial audit efficacy.

The positive beta coefficient (0.455) approves the positive association.

Result of hypothesis H2: Since there is significance value of 0.003 (which seems to be less than 0.05), this means the hypothesis H@ is approved. And the significant negative impact of cybersecurity challenges connected with big data efficient deployment.

The negative beta coefficient (-0.288) authorizes that an increase in challenges lessens employment efficacy.

CONCLUSION

Fundamental Finding : There is a numerically essential and potent effect of big data usage to enhance the efficacy of financial auditing and confirms the improvement of the excellence and efficiency of control procedures in government institutions, which seems reliable with the recent literature. The study also found a numerically significant negative effect of cybersecurity challenges connected with big data on efficient usage, as concerns about data security and the lack of specialized personnel represent the most significant and sensitive obstacle limiting the ability of oversight agencies to fully benefit from big data. The descriptive results further showed that the level of big data employment remains at an intermediate stage, while levels of agreement on the existence of security challenges were at the highest levels. **Implication :** The findings imply that regulatory bodies should develop a stern and updated cybersecurity governance framework to balance advanced data analysis with international cybersecurity standards, such as ISO 27001, to protect the integrity of government financial information. The proven positive effect of big data usage also supports a strategic shift toward continuous and deterrent auditing, enabling earlier detection of risks and fraud through comprehensive transaction analysis. **Limitation :** The government sector environment appears highly sensitive to cyber risks before achieving full technological integration, as evidenced by the discrepancy between the intermediate level of big data employment and the high level of perceived security challenges. This structural and technical condition constrains the optimal utilization of big data despite its demonstrated effectiveness in improving audit performance. **Future Research :** Future studies are encouraged to conduct comparative analyses of cybersecurity challenges and audit effectiveness between government and private sectors, develop AI-based financial audit models integrated with cybersecurity controls, and examine the impact of recent national regulations and legislation on fostering big data adoption within regulatory agencies.

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