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Article

Big Data-Based Internal Control and its Impact on Improving Financial Reporting Quality

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Abstract: Contemporary work environments face escalating challenges due to the massive and enormous volumes of financial and operational data produced by economic units, which has led to making Big Data technologies one of the key tools for developing internal control systems and improving the quality of financial reports. The current research aims to study the role of Big Data-based internal control systems in enhancing the credibility, accuracy, and transparency of financial reports in Iraqi economic units. This is achieved by developing a theoretical framework that links internal control practices with advanced data analysis tools, and then practically testing this framework through a targeted questionnaire directed at a sample of employees in internal control departments, financial accounting, and risk management. The research concludes that integrating Big Data tools into the design of internal control for economic units is crucial to mitigate financial errors and detect manipulation early, which strengthens investor confidence and achieves a competitive advantage for economic units. The findings of this research contribute to bridging the knowledge gap, whether at the local or regional level, by demonstrating the potential of investing in digital transformation to develop internal control environments and improve the quality of financial reports in Iraq.

Keywords: Internal Control (IC), Big Data (BD), Financial Reporting (FR)

1. Introduction

It is observed that the global business environment is undergoing a radical transformation due to the massive flow of data produced by the digital revolution, which is known as big data. Traditional internal control systems have failed to handle this quantity and type of data effectively, creating an urgent need to adopt advanced analysis tools and techniques capable of enhancing and improving the effectiveness of internal control, as well as achieving financial transparency. Investors and stakeholders rely on financial report quality to understand the financial situation of economic units; however, diversity, volume, and complexity in the sources of data may weaken the quality of these reports if not processed through modern control mechanisms. Big data can therefore serve as a strategic factor that enables internal control systems of economic units to move from traditional detection roles into more proactive prevention and prediction roles; especially relevant is how big data-based internal control can strengthen financial report quality in an environment like Iraq, where economic units are challenged with volatility, changing regulations, and weak digital infrastructure.

2. Research Methodology

2.1 Research Problem

Although big data is used nowadays to make financial and administrative decisions

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today, many Iraqi economic units rely on multiple traditional internal control systems that are not capable of dealing with such large amounts of diverse data; this may cause weakening in the quality of financial reports from several perspectives (accuracy, transparency, reliability), which affects investor confidence and the stability of economic units. Therefore, based on the above, the research problem can be formulated into a main question:

What is the impact of big data-based internal control systems on improving the quality of financial reports in Iraqi economic units?

2.2 Research Significance:

The research aims to achieve a set of objectives as follows:

1. To identify the reality of applying big data techniques and tools in the internal control environment of Iraqi economic units.
2. To measure the impact of big data-based internal control on improving the quality of financial reports (such as accuracy, transparency, reliability, and appropriateness).
3. To determine the level of awareness among employees in the fields of financial accounting and internal controling of the importance of utilizing big data to support internal control.
4. Providing a set of practical recommendations that aim to contribute to the development of internal control systems in a manner that aligns with the digital transformation and the requirements of strong governance.

2.3 Research Importance

The importance of the study is manifested in several aspects and in the following ways:

1. **Theoretical importance**: The current research adds to the accounting literature by linking the concept of internal control with big data, which is one of the fields that is relatively new, whether in the Arab or Iraqi environment.
2. **Practical importance**: The current research provides a practical framework that helps Iraqi economic units develop internal control systems by utilizing big data tools, thereby improving the quality of financial reports and enhancing investor confidence.
3. **Social importance**: The research contributes to increasing the level of financial transparency and disclosure, which leads to strengthening confidence in the national economy and supporting the investment environment.

2.4 Research Hypotheses

Based on the research problem and to achieve the research objectives, the following hypotheses can be formulated:

The main hypothesis:

1. **H0:** There is no statistically significant evidence that internal control systems based on Big Data improve the quality of financial reports in Iraqi economic units.
2. **H1:** There is statistically significant evidence that internal control systems based on Big Data improve the quality of financial reports in Iraqi economic units.

From these main hypotheses, the following sub-hypotheses can be derived:

1. Accuracy:

- **H0-1:** There is no statistically significant evidence for the use of Big Data tools in internal control over the accuracy of financial reports.
- **H1-1:** There is statistically significant evidence for the use of Big Data tools in internal control over the accuracy of financial reports.

2. Transparency:

- **H0-2**: There is no statistically significant evidence of the use of Big Data tools in internal control for financial reporting transparency.
- **H1-2**: There is statistically significant evidence of the use of Big Data tools in internal control for financial reporting transparency.

3. **Reliability:**

- **H0-3:** There is no statistically significant evidence of the use of Big Data tools in internal control over the reliability of financial reports.
- **H1-3:** There is statistically significant evidence of the use of Big Data tools in internal control over the reliability of financial reports.

4. **Relevance:**

- **H0-4:** There is no statistically significant evidence of the use of Big Data tools in internal control over the relevance of financial reports to the needs of decision-makers.
- **H1-4:** There is a statistically significant evidence of the use of Big Data tools in internal control for financial reporting compliance with the needs of decision-makers.

2.5 Research Limits

1. Subjective boundaries: The current study is limited to examining the relationship between internal control systems and big data on one hand, and the quality of financial reports on the other hand.
2. Geographical boundaries: The Iraqi economic units (a group of public and private Iraqi banks in Karbala Governorate).
3. Temporal boundaries: The data and opinions of the sample study will cover the period (2023–2025).
4. Human boundaries: Employees in internal control, accounting, and risk management in the economic units included in the research.

3. Theoretical Aspect

3.1 Definition of Internal Control

3.1.1 The Concept and Definition of Internal Control

Internal control is an integrated management system aimed at achieving a reasonable level of assurance that the economic unit's objectives will be achieved efficiently and effectively, while ensuring compliance with laws and regulations, protecting assets, and the accuracy of financial information. Academic definitions of this concept have varied according to the organizational and functional context, as defined by the American Institute of Certified Public Accountants (AICPA) as a process aimed at achieving objectives related to operational efficiency, financial reporting reliability, and compliance with laws, regulations, and policies (AICPA, 2018).

The COSO Committee, however, provided a broader definition, considering it a process affected by individuals in the organization, designed to provide reasonable assurance of achieving objectives related to operational effectiveness and efficiency, financial reporting reliability, and compliance with laws and regulations (COSO, 2013: 5) In the same context, Arens et al. view internal control as including all policies and procedures established by management to ensure the achievement of organizational objectives, including preventing and detecting errors and fraud, and ensuring the accuracy of accounting records (Arens et al., 2018: 278)

It is noted that most definitions share the emphasis that internal control is not merely accounting procedures, but rather a comprehensive system that includes the control environment, risk assessment, control activities, information and communication, and ongoing monitoring mechanisms. These are the elements that form the integrated framework of internal control according to the COSO model (Moeller, 2016: 42). The importance of this system lies in its ability to reduce operational and financial risks, enhance stakeholder confidence, and achieve alignment between strategic objectives and daily operations.

3.1.2 Objectives of Internal Control According to the COSO Framework

Internal control is one of the fundamental pillars in building strong governance systems, as it aims to ensure the integrity of operations, achieve efficiency, and comply with systems. The renowned COSO outline has established a clear organization of

internal control purposes, which is widely used in public and private organizations to assess the effectiveness of audit schemes and develop them (COSO, 2013: 5)

a. Ensuring the efficiency and efficiency of working processes: Internal control aims to improve organizational presentation by organizing workflows, plummeting waste, and enhancing output.
b. Empirical evidence: Internal control is designed for providing reliable financial reports and avoid erroneous or manipulated information which can lead management to make wrong decisions.
c. Compliance with laws, regulations, and statutes: Internal control safeguards against noncompliance with internal policies and external legislation, preventing legal risks and reputational damage.
d. Strengthening the protection of assets and resources: Establish mechanisms for protecting the use and preservation of assets and resources.
e. Early detection of risks and reply: Internal control delivers tools to identify possible risks, and facilitates the acceptance of rapid and effective remedial actions.
f. Supporting slide and accountability within the organization: Enhances the clarity of events and the distribution of errands, which contributes to building an official culture based on punishment and trust.

3.1.3 Components of Internal Control

The five components of the COSO internal control framework are a basic building block in designing an effective internal control system within organizations; their functional interactions were confirmed to be critical for improving corporate governance quality and reaching operational, financial, and organizational goals (Rae et al. 2017). Moreover, understanding these relationships is important because the weakness in one of them can weaken the entire system. These components are: (Rae et al., 2017: 30-31)

a. Control Environment is the foundation for internal control: ethics, tone at the top, governance structure.
b. Risk Assessment identifies potential risks that could prevent achieving objectives, determine their impact and likelihood.
c. Control Activities are policies and procedures that respond to risk, such as segregation of duties or periodic reviews.
d. Information and Communication refers to the flow of information throughout the organization to make timely decisions.
e. Monitoring Activities monitors the performance of the control system continuously or periodically so that gaps can be identified and corrective actions taken.
f. These components are functionally interrelated, and the weakness in any one component will weaken the entire system as well as the relationship between them.

3.1.4 Contemporary Challenges of Internal Control in Light of Digital Transformation

In this context of fast changing digital business environments, traditional models can no longer keep up with the pace of technological advancements and we are witnessing fundamental changes in the internal control system (Ceia et al., 2025: 405). In particular, the introduction of artificial intelligence and other digital technologies in internal control systems poses both an opportunity for increased efficiency as well as a new risk that calls for radical redesign of audit mechanisms. These include:

a. Weak digital infrastructure readiness in many organizations that prevents integration between audit systems and modern technologies.
b. Lack of qualified human capabilities to understand how to use artificial intelligence tools and analyze big data within an audit context.
c. The increasing breadth of cyber risks, which are not detectable by traditional methods, and therefore the need for proactive audit tools based on machine learning.

d. Challenges of regulatory compliance under changing legislation related to data protection and privacy, which require continuous updates to monitoring policies.
e. Difficulty in institutional adaptation to flexible monitoring models, especially in organizations with bureaucratic structures or stagnant organizational cultures.

The study concluded that the effectiveness of internal monitoring in the digital age depends on the organization's ability to adopt a dynamic monitoring approach, based on real-time data analysis, integration between technology and governance, and developing a flexible organizational culture.

3.1.5 Internal Control from an Information and Technical Perspective

Under the rapid digital transformation, internal control has become a dynamic system that goes beyond traditional paper-based and hierarchical models, transforming into an integrated information structure based on accounting information systems (AIS) and smart technologies in its design and implementation. Wadesango et al. (2022: 4) indicated that information systems play a crucial role in the development of internal control, by enabling organizations to track operational and financial processes in real time, providing accurate reports that support decision-making, thereby enhancing performance efficiency and reducing opportunities for manipulation or corruption.

Modern literature shows that internal control in information technology environments requires flexible and adaptable models, addressing digital risks and strengthening technical governance. Gulesin (2023: 99) developed a comprehensive internal control model for technology companies, addressing the changing challenges in digital work environments, and providing a systematic framework for risk management and resource optimization, adaptable to the nature of operational processes. This model highlights the importance of internal control as a strategic tool in enhancing digital governance, not just an organizational mechanism.

On the other hand, Lal (2014: 7) addressed internal control from a functional perspective, considering it an information system aimed at ensuring the reliability of financial reports, reducing operational risks, through the use of secure databases, encryption systems, and automated verification mechanisms. This approach shows that internal control has become dependent on advanced analytical tools that process data and produce measurable performance indicators, reshaping the relationship between information and audit.

Applied studies have shown that weaknesses in internal control are often associated with the absence of appropriate information infrastructure, or the inability of employees to handle digital systems, which leads to gaps in verification and an increase in the likelihood of financial manipulation or corruption. Institutions that have adopted integrated digital systems for internal control have been able to improve the quality of reports, reduce audit time, and increase transparency in operations.

As a result, with the growing volume and complexity of data generated by operational and financial activities, the need to handle big data as a fundamental component in the development of internal control has emerged, which will be addressed in the following sections.

3.2 Big Data

3.2.1 The Concept and Definition of Big Data

Big Data is one of the most prominent concepts that have reshaped the cognitive and functional structure of institutions in the digital age, referring to enormous and diverse amounts of data produced at an extremely high speed, requiring advanced analytical tools to extract value from it. A study by (De Mauro et al., 2015: 422) has shown that Big Data is not defined solely by its volume but by its ability to influence strategic decisions, where they defined it as a set of information described by the characteristics of volume, variety, velocity, and value, which requires new analytical techniques to extract knowledge from it.

On the other hand, a study by (Ylijoki & Porras, 2016: 69) addressed the concept from a structural perspective, considering Big Data as a result of the digitization and transformation of human activities, which produces continuous flows of diverse data, and is viewed as both a technical and social phenomenon. This definition highlights the cultural and technological aspects of Big Data, considering it not just as digital inputs but as a dynamic representation of lived reality.

Whereas (Ceia et al., 2025: 403) focused on the functional aspect, defining big data as a multi-source information structure used to support decision-making through smart analytical tools, and considered it a fundamental component in the shift towards digital governance models. This definition highlights the close relationship between big data and internal control, particularly in the context of government and financial institutions.

3.2.2 Characteristics of Big Data

Big data characteristics are the cornerstone for understanding its structure and applications, as big data is typically defined by a set of dimensions known as the 5V's, which are: Volume, Velocity, Variety, Veracity, and Value. These characteristics are not only used to describe data but also to identify the technical challenges associated with its storage, processing, and analysis, which calls for advanced information systems like MapReduce and Hadoop. We will summarize these characteristics in some detail: (Qader et al., 2020: 2)

a. Volume: Refers to the enormous amount of data produced daily from multiple sources such as smart devices, social media, sensors, and financial transactions. According to Singh & Singh (2012), the global volume of data reached 2.72 zettabytes in 2012 and is doubling at an accelerated rate (Qader et al., 2020: 3)
b. Velocity: Describes the speed at which data is generated and flows, especially in systems that require real-time processing such as surveillance systems, financial markets, or Internet of Things applications. A study (Seo, 2019: 10) has shown that velocity is a major challenge in designing analysis algorithms, where parallel processing techniques are required to avoid delays
c. Variety: Refers to the diversity of data formats, from structured data (Structured) such as tables, to unstructured data (Unstructured) such as images, video, and text. This variety complicates integration and analysis processes, requiring tools capable of handling multiple data patterns (Qader et al., 2020: 4).
d. Veracity: Concerns the quality and accuracy of data, as big data often contains noise or incomplete information, requiring cleaning and validation processes to ensure the reliability of analytical results (Bhardwaj et al., 2022: 2).
e. Value: Is considered the property most closely related to the final objective of data use, where data is measured not only by its volume but also by its ability to generate actionable insights, and achieve tangible economic or operational benefits. Seo (2019: 11) confirmed that value is a critical criterion in evaluating the viability of investing in big data technologies.

These characteristics show that big data is not just a quantitative phenomenon but a cognitive and technical system that requires advanced analytical tools, distributed computing architectures, and precise information governance models. Understanding these characteristics is also considered a fundamental entry point for leveraging big data in internal control, decision-making, and strategic planning, which will be addressed in the following sections.

3.2.3 Internal Control Based on Big Data

The internal control has undergone a fundamental transformation in its conceptual and tool-based structure due to the development of big data technologies, where institutions now rely on advanced analytical models that enable real-time monitoring of financial and operational processes, thereby enhancing the ability of audit systems to predict risks and detect deviations before they escalate. This methodology is an

extension of the concept of continuous audit, which relies on the real-time flow of data and the application of artificial intelligence and machine learning algorithms in analyzing behavioral patterns and financial transactions. (Zhou, 2023: 118)

Modern literature shows that big data-based internal control contributes to improving the quality of internal control by reducing reliance on random sampling, transitioning towards comprehensive analysis of all transactions, thereby reducing the likelihood of overlooking errors or omissions. Additionally, this methodology allows for classifying operations by risk level, directing audit efforts towards critical high-priority areas, which enhances the efficiency of regulatory resource allocation (Zhou, 2023: 120). In the same context, applied studies indicate that institutions adopting this methodology managed to reduce the risk response time by more than 40%, achieving a higher level of financial reporting transparency, particularly in banking and financial services companies that handle large volumes of daily data (Zhou, 2023: 124).

From a technical perspective, this methodology relies on integrating data analysis platforms with institutional resource planning (ERP) systems, enabling the linking of operational data with financial data in a unified analytical environment. The use of techniques such as natural language processing (NLP) and sentiment analysis has become part of internal control tools, particularly in analyzing unstructured data like email messages and employee reports, providing additional indicators about organizational behavior and potential risks. The literature emphasizes that this integration of big data and internal control not only represents a technological advancement but also reflects a shift in the philosophy of control toward data-driven predictive models (Zhou, 2023: 126).

3.2.4 The Role of Big Data Analytics in Forecasting, Fraud Detection, and Risk Management

Big data analytics are vital tools in the modern business environment, enabling organizations to transition from traditional models to smart systems capable of predicting, uncovering, and responding instantly to risks. In the realm of prediction, predictive analytics models based on machine learning are used to analyze behavioral and historical patterns, allowing for the estimation of future demand, market changes, or even financial failure probabilities before they occur, by integrating multiple sources including transaction data, customer behavior, and economic indicators (Financial Crime Academy, 2025: 3)

As for fraud detection, big data analytics have proven effective in identifying abnormal activities through techniques such as network analysis, outlier detection, and device fingerprinting. For example, classification algorithms are used to identify fraudulent patterns that exceed the capabilities of traditional systems, such as small repeated transactions or the use of devices associated with multiple accounts exhibiting suspicious behavior (Big Data Interviews, 2025: 5). A practical study has shown that using Apache Spark platform with ensemble learning models reduced fraud by 40% in the e-commerce sector.

And in the field of risk management, these analyses enable the construction of dynamic models to assess operational and credit risk exposure by analyzing real-time data from sensors, transactions, and external sources such as market data or blacklists. They are also used to identify weaknesses in processes, and to generate early warnings that help in making proactive decisions to protect assets and reduce losses (HyperVerge, 2025: 4)

3.3 Financial Reporting

3.3.1 The Concept of Financial Reporting

Financial reports are fundamental pillars in the accounting information system, as they aim to provide reliable and relevant financial information to internal and external stakeholders, thereby supporting their economic decisions. Financial reports are defined

as organized periodic outputs that reflect the financial performance and financial position of the entity over a specific period, in accordance with accepted accounting principles and standards (Scott, 2022: 45). These reports typically include the balance sheet, income statement, cash flow statement, as well as accompanying notes that explain accounting policies and assumptions used. The importance of financial reports lies in their ability to achieve transparency and accountability, and to provide a basis for analyzing profitability, liquidity, and operational efficiency. They are also used as a control tool to assess compliance with financial systems and relevant regulations, and are considered a primary reference in internal and external audit processes. Modern literature has confirmed that the quality of financial reports is closely linked to the effectiveness of corporate governance, the degree of financial management independence, and the extent to which international standards for financial reporting are applied (Scott, 2022: 48).

3.3.2 The Importance of Financial Reporting

Financial reports are fundamental tools in supporting good governance and economic decision-making, as they provide quantitative and qualitative information that reflects the financial performance and financial position of the entity, and contribute to evaluating operational efficiency, profitability, and liquidity. Their importance lies in being a financial communication channel between the institution and its stakeholders, including investors, creditors, regulatory bodies, and senior management. A study (Alsharairi, 2023: 57) has confirmed that accurate and transparent financial reports enhance investor confidence, reduce information gaps, thereby contributing to improving financial market efficiency and lowering the cost of capital.

Financial reports are also used as a supervisory tool to assess compliance with accounting policies and international standards, and are considered a primary reference in internal and external audit processes. Modern literature highlights that the quality of financial reports is closely related to the effectiveness of internal control, the independence of financial management, and the extent of applying disclosure and transparency principles. In the governmental context, financial reports are a means to evaluate the efficiency of public spending and achieve financial accountability, especially in light of the shift toward program and performance budgets (Alsharairi, 2023: 60).

The importance of financial reports is not limited to their media function; rather, it extends to forming the basis for financial analysis, forecasting, and strategic planning, making them one of the main pillars in making informed decisions based on reliable data.

3.3.3 Types of Financial Reporting

Financial reports vary according to their purpose, the nature of the information they provide, and the target audience, and they can be classified into four main types: (IFRS Foundation, 2022: 18) (Al-Debei & Al-Lozi, 2023: 42)

a. **Fundamental financial statements**, which include the balance sheet, income statement, cash flow statement, and statement of changes in equity. These are periodic reports prepared according to international accounting standards and are used to assess the overall financial performance of the entity.
b. **Managerial financial reports**, which are internal reports used to support operational and tactical decision-making, such as cost reports, variance analysis, and budgetary forecasts. These are not published and are designed according to the needs of management.
c. **Sectoral financial reports**, which are used to clarify the performance of specific units or sectors within the entity. They contribute to analyzing profitability and operational efficiency at the departmental level, especially in multi-activity organizations.

d. **Financial reports**, which are prepared for specific purposes such as audit reports, tax compliance reports, or environmental and social disclosure reports, and reflect unconventional information that meets the requirements of regulatory authorities or investors with special interests.

Qualitative pillars for the quality of financial reports

Financial reporting quality is one of the core concepts in modern accounting, as it is closely related to the ability of financial information to support decision-making, achieve transparency and accountability, and comply with international standards. The International Accounting Standards Board (IASB) has identified a set of qualitative characteristics that form the theoretical basis for evaluating financial reporting quality, and the key ones can be analyzed as follows (Barth & Landsman (2023: 76),

(Bushman & Smith, 2022: 41), IFRS Foundation, 2022: 33), (Dechow et al., 2021: 19)

a. **Accuracy**: Refers to the extent to which financial information is free from material errors or intentional or unintentional distortions, and is considered a fundamental condition for achieving an honest representation of the economic reality. Accuracy enables users to rely on the data in evaluating financial performance and reduces the likelihood of making incorrect decisions. High levels of accuracy in financial reports contribute to improving the credibility of the institution before investors and regulatory bodies, and enhance the efficiency of resource allocation.
b. **Transparency**: Measures the clarity of financial information and how easily users with reasonable knowledge can access and understand it. Transparency is especially critical in building trust between the institution and its stakeholders in complex regulatory environments or those marked by high uncertainty, and reduces information gaps, increases the effectiveness of external oversight, and acts as a signal of quality governance.
c. **Reliability**: This implies that it provides complete, unbiased, and verifiable information about economic reality, which is a more extended definition of faithful representation that enhances users' confidence in published reports. Research has demonstrated that institutions with reliable financial reporting lower their cost of capital and increase the attractiveness of investment, particularly in emerging markets.
d. **Relevance**: It refers to the ability of financial information to affect users' decisions by providing data with predictive value (Predictive Value) or confirmatory value (Confirmatory Value). It is considered a dynamic quality that requires the information provided to be related to the economic context and future decisions. It has been confirmed that relevant financial reports contribute to improving the efficiency of financial markets and reducing information asymmetry between trading parties.

Indicated that (Barth & Landsman, 2023: 78) these characteristics do not operate in isolation, but rather form a comprehensive system that contributes to improving the quality of financial reports. Accuracy enhances credibility, transparency contributes to understanding relevant information, and credibility is a condition for achieving effective transparency. Additionally, the quality of financial reports is measured by the extent to which these characteristics are integrated, not by their individual presence, which highlights the importance of systematically designing reports according to the International Accounting Standards Framework.

3.4 Internal Control Based on Big Data and Its Role in Improving the Quality of Financial Reporting

Under the rapid digital transformation, traditional internal controling has become insufficient to address the complexities of the modern financial environment, prompting institutions to adopt data-driven auditing methodologies (Big Data Analytics). This transformation is not merely a technological update but represents a fundamental

restructuring in the design and implementation of internal controls, where artificial intelligence, machine learning, and data mining techniques are used to identify patterns, predict risks, and assess financial compliance in real-time (Alles, 2021: 9).

This intelligent auditing contributes to improving the quality of financial reports through several interconnected mechanisms: Yoon et. al., 2022: 113)) , Tang & Karim 2023: 88))

a. First: Enhancing accuracy and reliability, as tools for big data analytics enable comprehensive examination of all financial transactions, thereby reducing the likelihood of manual errors or accounting manipulation. Additionally, institutions that apply data analytics in internal controling achieve higher levels of financial disclosure quality and reduce information gaps between management and investors.
b. Second: Early detection of risks and deviations, where these methodologies allow tracking of unusual patterns that may indicate fraudulent practices or weaknesses in financial policy compliance. Therefore, data-driven interior audit contributes to refining transparency and consolidation the confidence of regulatory bodies in available intelligences.
c. Third: Supporting active audit decisions, as these skills enable the generation of Key Risk Pointers (KRIs) used to guide interior audit towards high-risk areas, thereby causal to improving the efficiency of regulatory resource distribution and enhancing the quality of reports subsequent from these processes.
d. Fourth: Integrating with Financial Reporting Systems: Big data analytics can be integrated with financial reporting systems that include intelligent internal control tools connected to the platforms for preparing the financial statements so they can automatically verify consistency between operational and financial data, reducing reporting time and improving reliability.

This integration of big data analytics into internal control is not simply a technical option but a strategic necessity in an environment characterized by complexity, speed, and increasing disclosure requirements to maintain the quality of the financial reports with respect to international standards such as IFRS and COSO, or build sustainable confidence with stakeholders.

4. The Practical Aspect of the Research

The applied aspect of the research is the request phase aimed at testing the hypotheses future and verifying their constancy with the applied reality in the study setting. After addressing the theoretical foundations related to the concept of Big Data-based internal control and its role in improving the quality of financial reports, it became necessary to move to the practical aspect in order to demonstrate the actual impact of these systems on Iraqi economic units. To achieve this, a scientific questionnaire was prepared based on the conceptual frameworks presented in the theoretical part, in line with the main hypothesis and its branches, containing two main axes:

- Axis One: Big Data-based internal control as the independent variable (X).
- Axis Two: Improvement of financial report quality as the dependent variable (Y), embodied in its dimensions, which include accuracy, transparency, reliability, and suitability.

A total of (75) questionnaires were distributed to a sample of accountants, auditors, and employees in financial departments of a group of public and private banks in Karbala governorate, and (68) valid questionnaires for statistical analysis were retrieved with a suitable response rate for the purposes of the study.

Based on the responses of the sample, appropriate statistical analyses will be conducted using a set of statistical methods to test hypotheses and confirm their field validity, leading to results that can contribute to enriching the scientific and practical aspects of the study topic, as follows:

4.1 The Correlation Between the Independent and Dependent Variables

Statement of the strength of the relationship between the independent variable represented by internal control based on Big Data tools and the dependent variable represented by the quality of financial reports, the correlation coefficient (R) and the determination coefficient (R^2) were used through the Model Summary model. This analysis is one of the most important statistical tests that contribute to clarifying the nature of the relationship between the research variables, and the extent to which the independent variable can explain the variation in the dependent variable. Understanding this relationship contributes to testing the main research hypothesis, which states the existence of an effect of Big Data-based internal control systems in improving the quality of financial reports.

Table 1. Correlation and Explanation Ratio between (Big Data-Based Internal Control and Financial Reporting Quality).

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.991[a]	.982	.982	.61991
a. Predictors: (Constant), x				
b. Dependent Variable: y				

The statistical interpretation: From table 1 Model Summary, it is found that the coefficient of determination R Square (independent variable, dependent variable) reached (.982), meaning the proportion of the dependent variable's explanation reached 98.2% based on the independent variable. The same applies to the adjusted determination coefficient Adj R Square. Also, the Pearson correlation coefficient ® reached (991.), indicating a strong positive correlation, and the Std. Error of the Estimate reached (0.6199).

The accounting interpretation: The results of table 1 indicate that the correlation coefficient (R) reached 0.991, which is a very high value indicating a very strong positive relationship between big data-based internal control systems and the quality of financial reports in the studied economic units. Moreover, the determination coefficient (R^2) of 0.982 explains that 98.2% of the changes in financial report quality can be explained by the effectiveness of big data-based internal control systems, which is a high proportion reflecting the strength of the explanation. Therefore, this result indicates that the application of big data techniques in internal control procedures significantly contributes to improving the characteristics of financial reports in terms of accuracy, transparency, reliability, and appropriateness, which enhances their credibility for users such as management, auditors, and decision-makers.

4.2 Analysis of Variance between Variables

To verify the statistical significance of the model and measure the strength of the explanatory relationship between big data-based internal control systems and the quality of financial reports, an analysis of variance (ANOVA) was conducted. This test aims to determine whether the independent variables significantly contribute to explaining the variance in the dependent variable, through the F-value and its statistical significance. The use of ANOVA is considered a crucial step to ensure the model's suitability for the research and its ability to test its hypotheses.

Table 2. Analysis of Variance between Variables.

ANOVA[a]						
	Model	**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	1377.167	1	1377.167	3583.727	.000[b]
	Residual	25.363	66	.384		
	Total	1402.529	67			

The statistical interpretation: Through table 2 above, it is indicated that there are differences between the studied variables according to Fisher's scale (F), where the significance level (Sig) was less than (0.05). This means that the calculated (F) value (3583.727) is greater than the table value, which indicates the suitability of the model for hypothesis testing. That is, there is a relationship between the independent variable and the dependent variable.

The accounting interpretation: The results of table 2 indicate that the (F) value reached 3583.727 with a significance level (Sig.) of 0.000, which is less than the adopted significance level (0.05), meaning that the statistical model is highly significant. And internal control systems based on big data contribute meaningfully to explaining the variation in the quality of financial reports. Therefore, this result reflects that the adoption of institutions for control mechanisms based on big data analysis enables them to enhance the quality of the financial information provided, where it contributes to improving data accuracy, increasing transparency levels, and increasing the credibility and suitability of financial reports to meet the needs of their users. This proves that internal control based on big data techniques represents an effective and crucial factor in enhancing the reliability of the accounting system and the financial reports resulting from it.

4.3 Analysis of Regression Coefficient between Variables

After confirming the statistical significance of the model through variance analysis (ANOVA), the analysis of regression coefficients was conducted to determine the direction of the relationship between internal control systems based on big data (independent variable) and financial report quality (dependent variable), and to measure the extent of the impact that the independent variable has on the dependent variable. This test helps to determine whether changes in internal control systems based on big data have a positive or negative impact on financial report quality, as well as the significance of this impact.

Table 3. Statement of the Effect of Independent Variable, Independent Variable, Dependent Variable.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.168	.676		-.101-	.020
	x	1.132	.019	.991	59.864	.000
a. Dependent Variable: y						

Through table 3 above, it shows us the values of the regression coefficients where the constant value reached (0.168) and the value of B_1 is equal to (1.132), which is called the slope of the regression. This means that every time the independent variable changes by one unit, the dependent variable will increase by an amount of (1.132), indicating an inverse relationship between the independent variable and the dependent variable. We also note through the (t) test that there is an effect between the independent variable and the dependent variable since the value reached (Sig=0.00) is less than the assumed value (0.05), which confirms the hypothesis that there is an effect of the independent variable on the dependent variable.

$$\boldsymbol{y = 0.168 + 1.132x} \qquad \textbf{....(3-1)}$$

The results of the regression coefficient explained in the table above indicate that the value of B for the independent variable (Big Data-based internal control systems) was 1.132 and the significance level (Sig.=0.000) is less than (0.05), which indicates a positive and statistically significant relationship. This means that any improvement of one unit in

Big Data-based internal control systems corresponds to an improvement of (1.132) in financial reporting quality.

The results also showed that the standardized Beta value (0.991) is very high, which explains that Big Data-based internal control systems represent the most influential variable in explaining changes in financial reporting quality. Meanwhile, the high value of T=59.864 confirms the strength of this effect and its importance.

From an accounting perspective, it can be said that these results reflect the active role of Big Data techniques in enhancing the efficiency of internal control, by improving the accuracy of accounting information, increasing the level of transparency and reliability, and achieving alignment with the needs of decision-makers. Thus, the main and sub-hypotheses of the research have been validated, which are as follows:

1. **Primary Hypothesis:**

- **H1:** There is a statistically significant effect of BD -based IC systems on improving the quality of FR in Iraqi economic units.

2. Sub hypotheses:

- **H1-1:** There is a statistically important effect of using BD tools in IC on the accuracy of FR.
- **H1-2:** There is a statistically important evidence of the use of BD tools in IC for FR transparency.
- **H1-3:** There is a statistically significant evidence of the use of BD tools in IC over the credibility of FR.
- **H1-4:** There is a statistically significant evidence of the use of BD tools in IC for FR compliance with decision-makers' needs.

These findings support all the alternative hypotheses (H1) and reject the null hypotheses (H0), thus verifying what was initially hypothesized by research. In sum, it can be stated that big data applications in internal control system design and implementation directly contribute to improving the accuracy, transparency, reliability, and appropriateness of financial reports provided for decision-makers.

4.4 Analysis of Regression Residuals

The standard residual distribution of the regression model was examined using the graph shown above, which represents the Histogram of the regression residuals. The graph indicates that most values cluster around zero, and the residual distribution follows approximately the shape of the normal curve (Normal Distribution) drawn above the bars, suggesting that the basic assumption of the residual distribution in linear regression has been met.

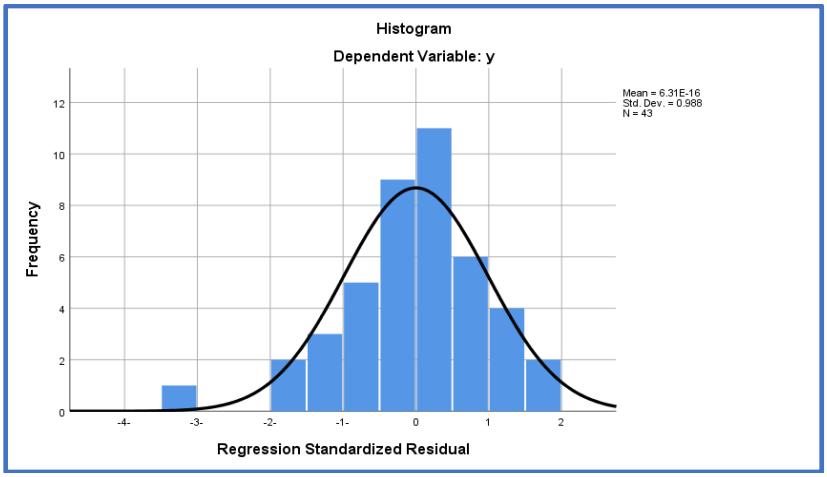

Figure 1. Frequency Diagram of Standardized Residuals in the Regression.

These results indicate that the used regression model for estimating the impact of big data-based internal control systems on financial reporting quality is valid and interpretable with normally distributed residual variation, making results derived from the regression analysis accurate, reliable, and strengthening the health to accept the alternative hypotheses (H1) and reject null hypotheses (H0).

4.5 Analysis of the Distribution of Standardized Residuals to Verify the Validity of the Accounting Regression Model

The residuals distribution test is an essential step for linear regression-based accounting models because it ensures neutral or unbiased estimates that will help improve the accuracy of accounting predictions from the model. In this case, we should see normally distributed residuals to achieve neutrality and lack of bias in the estimate. This will ensure improved accuracy in the derived accounting results using the model.

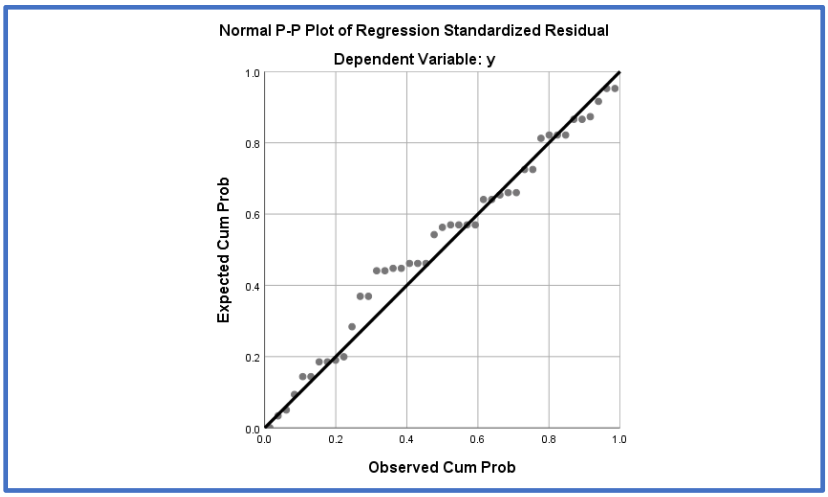

Figure 2. Cumulative Normal Probability Diagram of Standardized Residuals.

A natural P-P plot can be employed to examine if the assumption that the residuals follow a normal distribution in the regression is valid (a necessary condition for the validity of accounting conclusions based on the model), where residuals are plotted in this form as their cumulative observed probabilities versus their expected cumulative probabilities from an ideal normal distribution.

The gray dots are the residuals and the diagonal line is an ideal normal distribution; points near the diagonal indicate that the residuals follow a roughly normal shape with no major deviations. This normal distribution of residuals implies that the accounting model under which the relationship between variables was analyzed has high statistical reliability, making its use in accounting estimates more accurate, less likely to be biased by methodological errors, and less likely to produce inaccurate results that can lead to mistakes when using it for financial forecasting, policy evaluation, or internal control decisions.

5. Conclusions

The researcher reached a set of conclusions, which are as follows:

a. Big data tools should be integrated into the design of internal controls for economic units to minimize errors and early identify manipulation..
b. Existing literature indicates that quality of financial reports is contingent upon effective internal control systems, particularly in the context of complex digital environments.

c. The application of big data techniques supports institutions' ability to detect errors and fraud and enhances financial forecasting.
d. Institutions with well-developed information systems are better able to produce high-quality, transparent financial reports that integrate supervision and technology.
e. Institutions relying on advanced information systems and integrated digital systems are more capable of producing financial reports characterized by accuracy and transparency, which is evidence of the effectiveness of the connection between internal control tools and modern technologies.
f. This lack of consistent standards for applying digital analysis tools to internal control results in wide variance among institutions with regard to report quality.

Recommendations

These points are presented as proposed practical measures to address challenges and maximize the benefits derived from the study:

a. The necessity of developing intelligent control systems using real-time big data analysis, improving risk response.
b. Strengthening training and development programs for financial and auditing personnel on the modern analysis tools and artificial intelligence techniques.
c. Implementing integrated data models that link operational and financial activities to provide consistent reporting.
d. Review the regulatory and legislative policies in terms of alignment with digital supervision requirements and data protection.
e. Establish a national standard framework for applying digital analysis tools in internal supervision, ensuring uniform application across institutions.

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