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Analyzing the Impact of Adopting Data Analytics on Internal Auditing Efficiency: A Perspective from a Sample of Auditors in Algeria

# Analyzing the Impact of Adopting Data Analytics on Internal Auditing Efficiency: A Perspective from a Sample of Auditors in Algeria

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Abstract

This study examines the impact of data analytics adoption on the efficiency of internal auditing, with a specific focus on a sample of auditors in Algeria. The research aims to address a notable gap in the existing literature by exploring the challenges and opportunities unique to the Algerian auditing environment. Using a quantitative approach, the study employs factor analysis and structural equation modeling to analyze responses from auditors in Algeria. The primary research question investigates the relationship between the application of data analytics and the efficiency of internal auditing. Key findings indicate a positive and statistically significant correlation between the two variables. Additionally, the study reveals that specific data analysis tools, such as Machine Learning algorithms, play a substantial role in enhancing audit efficiency. Furthermore, training programs significantly contribute to auditors' proficiency in utilizing data analytics tools. These findings provide practical implications for organizations and policymakers, emphasizing the strategic incorporation of data analytics and continuous training to optimize internal auditing processes in the Algerian context.

**Keywords:** Data Analytics, Internal Auditing Efficiency, Auditors' Training, Algerian Audit Environment,

## [1] Introduction:

In an era characterized by rapid technological advancements and evolving business landscapes, the role of internal auditing within organizations holds an increasingly critical position. Internal auditors are entrusted with the task of safeguarding assets, ensuring financial accuracy, and facilitating adherence to compliance standards. However, the dynamic nature of business operations necessitates the constant reassessment and improvement of audit methodologies to enhance their efficiency and effectiveness.

This research aims to investigate the impact of data analytics adoption on the efficiency of internal auditing, particularly in the context of Algeria. The central question guiding this investigation is: How does the integration of data analytics tools and techniques influence the efficiency of internal auditing practices as perceived by auditors working in Algerian organizations?

The primary objectives of this study are twofold: first, to evaluate the level of data analytics adoption among auditors in Algeria, and second, to examine the perceived impact of this adoption on the efficiency of their auditing processes. To address these objectives, this research seeks to uncover whether data analytics enhances risk assessment, detection of irregularities, operational efficiency, and cost-effectiveness within the sphere of internal auditing.

The significance of this research is supported by several factors. Firstly, the integration of data analytics into internal auditing is a topic of increasing relevance worldwide, as organizations grapple with the need to strengthen their auditing processes and adapt to a constantly changing risk landscape. In the Algerian context, this study provides valuable insights, as the country's business environment undergoes transformation, and a comprehensive understanding of the role of data analytics within internal auditing can improve the financial health and integrity of organizations.

The motivation for this study is also derived from the limited existing research that specifically explores the perspective of auditors in Algeria regarding data analytics adoption and its impact on efficiency. The experiences and viewpoints of auditors on the ground are crucial in determining the practical implications and challenges associated with adopting data analytics in this context.

## 3. Literature Review:

### 3.1. Review of relevant prior research and scholarly works:

- <u>The relationship between the rates of application of data analytics in internal auditing with the efficiency of internal auditing.</u>

The rate of application of data analytics in internal auditing has a positive impact on the efficiency of internal auditing (Sayedahmed et al., 2022) (Ranto et al., 2023). Data analytics in auditing improves audit efficiency, refines audit quality, decreases errors, increases process transparency, and enhances stakeholders' confidence (Neda et al., 2021), Incorporating big data analytics in internal auditing provides advantages such as increased productivity and efficacy (Novita et al., 2022). The use of data analytics assists auditors in analyzing data, collecting audit evidence, and predicting risks, leading to improved decision-making and risk reduction (Yaseen et al., 2023). Furthermore, data analytics mediates the relationship between organizational psychological safety and advisory services. indicating its role in enhancing the working of internal auditors. Therefore, the application of data analytics in internal auditing is crucial for improving efficiency and effectiveness in the audit process.

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**First hypothesis (H1): There is no statistically significant positive relationship between the rate of applying data analytics in internal auditing and internal auditing efficiency at a 5% significance level.**

-        <u>The relationship between data analysis tools and techniques with internal audit efficiency</u>

Data analysis tools and techniques have a significant impact on internal audit efficiency. The use of Computer-Assisted Audit Tools and Techniques (CAATTs) can improve audit productivity and reduce costs, particularly in the public sector internal audit departments (Sujata &amp; Kulkarni, 2022), Additionally, the application of Data Analytics (DA) in the audit can lead to insights into clients' operations and financial numbers, potentially enhancing audit efficiency (Abdalwali et al., 2023).  Internal audit functions (IAFs) that utilize data analytics (DA) are able to extract value from big data, improving the efficiency and effectiveness of their activities (T.H.H., 2017). Furthermore, advanced audit data analytics tools allow auditors to analyze the entire population of client transactions, leading to increased audit efficiency and effectiveness (Rakipi et al., 2021). However, it is important for auditors to become more experienced with data analytics to overcome existing challenges and fully realize the potential benefits for audit efficiency (Dereck et al., 2021). Overall, the use of data analysis tools and techniques can contribute to improving internal audit efficiency in various contexts.

**Second Hypothesis (H2): There is no significant impact of data analysis tools and techniques on internal audit efficiency at a 5% significance level.**

<u>-The relationship between training and skill levels of auditors in data analysis with internal audit efficiency.</u>

Training has a positive effect on the skill levels of auditors in data analysis. The study by Wang suggests that auditors need to be proficient in audit information tools, such as big data and artificial intelligence, to adapt to the needs of the times (Wang, 2022). Another study by Vandertop and Efendi found that audit training attended by auditors can improve their performance in completing work in a timely manner and utilizing time effectively. (Caitlin, 2022), (Suryono, 2022). Additionally, Plumlee, Rixom, and Rosman's study highlights the importance of auditors improving their skills and knowledge of data analytics and big data to make better judgments, especially during the audit planning stage (Sihombing et al., 2023). Therefore, it can be concluded that training plays a crucial role in enhancing the skill levels of auditors in data analysis.

**Third Hypothesis (H3): There is no significant effect of training on the skill levels of auditors in data analysis at a 5% significance level.**

### 3.2. The concept of data analytics in internal audit.

Data analytics in internal audit refers to the use of technology and specialized systems to analyze data sets and draw conclusions about the information they contain. It involves incorporating automation, artificial intelligence, and big data analytics processes into the planning and execution of audits. The application of data analytics in internal auditing offers several advantages, including increased productivity and efficacy. It allows auditors to make use of non-financial data sources, such as visual representations, to support their recommendations and judgments. The effectiveness of data analytics in internal auditing depends on the evaluability of the visualizations used to communicate non-financial data. The integration of data analytics in the audit process is still in its early stages, but it is becoming increasingly important for auditors to adapt to technological advancements and leverage data analytics to enhance the quality and efficiency of audits. (Rubén et al., 2023), (Neda et al., 2021) (Megan, 2019) (Novita et al., 2022).

### 3.3.The concept of internal audit efficiency.

Internal audit effectiveness is defined as the degree to which established objectives are achieved, and internal auditing could assist organizations in better accomplishing their objectives by providing a systematic and disciplined approach to improve and evaluate the control, risk management, and governance processes' effectiveness (Dhiaa et al., 2017).

### 3.4. Gaps in existing literature:

The scientific gap addressed by the topic of analyzing the impact of adopting data analytics on the efficiency of internal auditing from the perspective of a sample of auditors in Algeria lies in the limited research and empirical evidence available in the specific context of Algeria. The topic addresses a unique research gap related to the intersection of data analytics adoption and internal audit efficiency within the Algerian auditing landscape. Several key points highlight the significance of this scientific gap:

### 3.4.1. Contextual Specificity:

The application of data analytics in internal auditing is influenced by contextual factors, including regulatory frameworks, organizational cultures, and technological infrastructure. Algeria, being a specific geographical and cultural context, might exhibit unique challenges, opportunities, and considerations in the adoption of data analytics in the field of internal auditing. Research in this context helps fill the gap in understanding how global trends and frameworks align with or diverge from the Algerian auditing environment.

### 3.4.2. Localized Challenges and Opportunities:

Algeria may face specific challenges and opportunities related to technology infrastructure, data availability, and the regulatory landscape. Investigating the impact of data analytics adoption on internal audit efficiency in Algeria provides insights into how these localized factors shape the effectiveness of data analytics tools and techniques in improving auditing processes. Understanding these dynamics is crucial for tailoring strategies that align with the Algerian auditing ecosystem.

### 3.4.3. Limited Empirical Evidence:

While global studies contribute to the broader understanding of the impact of data analytics on internal audit efficiency, a lack of empirical evidence within the Algerian context leaves a notable gap. Localized empirical studies are essential to validate or challenge existing theories and to provide practical insights that can guide auditors, organizations, and policymakers in Algeria.

### 3.4.4. Strategic Implications:

The findings from research on the impact of adopting data analytics on the efficiency of internal auditing in Algeria can have direct strategic implications for audit practices, training programs, and organizational policies. Understanding the unique challenges faced by auditors in Algeria can inform the development of targeted strategies to enhance the effectiveness of data analytics adoption.

### 3.4.5. Bridging Academia and Practice:

Bridging the scientific gap in this area contributes to the practical relevance of academic research. By addressing the specific needs and challenges faced by auditors in Algeria, the research facilitates a direct link between academic insights and the practical application of data analytics in internal auditing within the country.

In conclusion, the scientific gap addressed by this research topic is the lack of dedicated empirical studies examining the impact of adopting data analytics on the efficiency of internal auditing in the Algerian context. Filling this gap not only contributes to the global knowledge base on data analytics but also provides context-specific insights that can inform and improve auditing practices in Algeria. The study model is depicted in Figure 1.
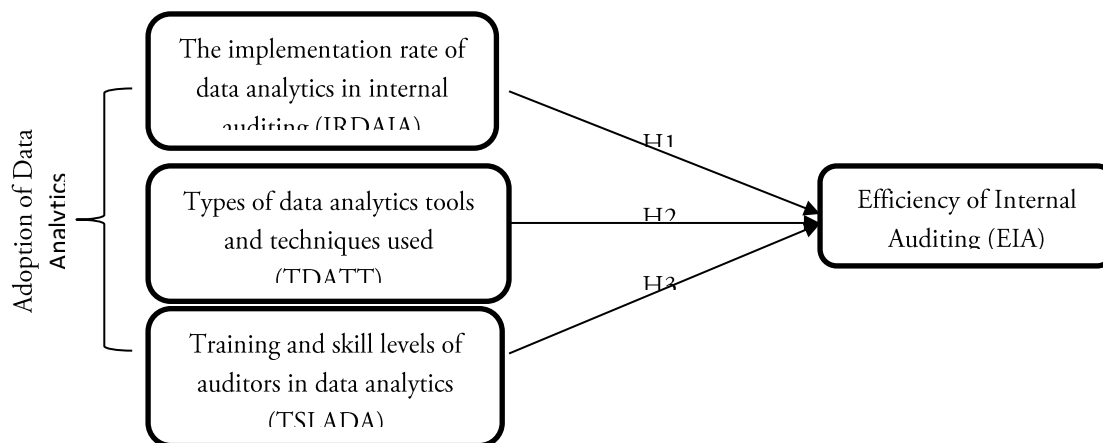
**Figure 1.** Theoretical framework.

## 4. Methodology:

Research Design and Approach:

For this study, a quantitative research design will be employed to analyze the impact of adopting data analytics on the efficiency of internal auditing from the perspective of a sample of auditors in Algeria. This approach will focus solely on quantitative data collection and analysis.

### 4.1. Data Collection Methods:

Survey Questionnaire: A structured questionnaire will be developed and administered to a randomly selected sample of auditors working in various organizations in Algeria. The survey will consist of closed-ended questions designed to assess the rate of data analytics adoption and its perceived impact on audit efficiency. Additionally, demographic questions will be included to gather background information about the respondents.

### 1.1. Sampling Strategy:

The sampling strategy will use stratified random sampling to ensure diversity in the sample. Auditors will be stratified based on the size and industry of their organizations, enabling a representative view of internal auditing in Algeria.

### 1.2. Data Analysis Techniques:

Survey data will be analyzed using statistical software Smart Pls, Descriptive statistics and inferential statistics, will be applied to test the hypotheses. This quantitative approach allows for the collection and analysis of numerical data, facilitating a statistical assessment of the relationship between data analytics adoption and audit efficiency.

### 1.3. Rationale for the Chosen Methods:

The chosen research design and methods are tailored to provide a quantitative and statistically rigorous analysis of the research topic. By focusing exclusively on quantitative data collection and analysis, this approach streamlines the research process and allows for a robust statistical examination of the impact of adopting data analytics on internal audit efficiency from the perspective of Algerian auditors. The stratified random sampling ensures diversity in the sample, increasing the generalizability of the findings. Statistical analysis techniques are employed to provide a systematic and data-driven exploration of the research question. This methodology aims to provide valuable insights into the impact of data analytics adoption in internal auditing without the qualitative component.

## 5. Data Presentation and Analysis:

First:  Assessment of measurement Model:

In this section, we examine the quality of the expressions used in this model using the Smart PLS software. This is done by testing the convergence and consistency of these expressions with each other. The aim is to ensure the ability of these expressions to measure what is required of them and the stability of the measurement under various conditions using the Convergent Validity test. Additionally, we assess the logical distinctiveness and non-overlapping of the expressions through the Discriminate Validity test.

### 5.1. Convergent Validity:

To test the convergent validity of the model expressions, we utilize the following key assessments: factor loadings for the primary tool, composite reliability, and the convergent validity of the extracted variances, as follows:

### 5.1.1. Factor Loading for Initial Instrument:

The convergent validity tool, represented by factor loadings and the extracted variance, is employed to examine the validity of measurement tools. This necessitates retaining items with a loading value equal to or exceeding 0.70. Any items falling below this threshold are removed from the model. The subsequent table presents the results of the convergent validity test for the expressions:

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**Table 01: Results of the Factor Loading Examination for the Data Analysis Axis and
Internal Audit Efficiency.**

| Efficiency of Internal Auditing | Training and skill levels of auditors in data analytics | Types of data analytics tools and techniques used | The implementation rate of data analytics in internal auditing | Items | Codes |
|---|---|---|---|---|---|
| | | | 0.641 | The current implementation of data analytics in internal auditing is a strategic priority for the organization. | IRDAIA _1 |
| | | | 0.810 | The internal audit team extensively uses data analytics tools to enhance the efficiency of audit processes. | IRDAIA _2 |
| | | | 0.764 | The adoption of data analytics has led to a measurable increase in the speed and accuracy of internal audit tasks. | IRDAIA _3 |
| | | | 0.823 | The organization regularly assesses and updates our data analytics tools to align with evolving internal audit needs and industry standards. | IRDAIA _4 |
| | | | 0.824 | Employees within the internal audit department receive ongoing training to optimize the use of data analytics in their work. | IRDAIA _5 |
| | | | 0.736 | The integration of data analytics has positively impacted risk identification | IRDAIA _6 |

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| | | | | | |
|---|---|---|---|---|---|
| | | | | and mitigation strategies within internal auditing. | |
| | | | 0.718 | The organization tracks and measures key performance indicators related to data analytics to evaluate its effectiveness in internal auditing processes. | IRDAIA _7 |
| | | 0.723 | | The organization employs advanced data visualization tools, such as Tableau and Power BI, for comprehensive data analysis | TDATT _1 |
| | | 0.812 | | Machine learning algorithms play a crucial role in our data analytics toolkit, enhancing the ability to identify patterns and trends | TDATT _2 |
| | | 0.735 | | The organization regularly utilizes statistical analysis tools like Smart PLS to derive meaningful insights from complex datasets | TDATT _3 |
| | | 0.692 | | The internal audit team employs predictive analytics techniques to anticipate potential risks and make proactive decisions. | TDATT _4 |
| | | 0.794 | | The data analytics arsenal includes both structured and unstructured data processing tools for a holistic view of information | TDATT _5 |
| | | 0.734 | | Text mining and natural language processing tools are used to extract valuable insights from textual data sources | TDATT _6 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | | 0.747 | | | Cloud-based analytics platforms, such as AWS and Azure, are integral to the data analytics infrastructure for scalability and flexibility | TDATT_7 |
| | | | 0.784 | | The organization leverages data warehousing solutions like Hadoop to efficiently manage and analyze large volumes of diverse data sets. | TDATT_8 |
| | 0.814 | | | | Continuous training programs are in place to enhance auditors' proficiency in utilizing data analytics tools and techniques | TSLADA_1 |
| | 0.782 | | | | Regular workshops focus on upskilling auditors in data analysis, ensuring they stay abreast of the latest advancements in the field | TSLADA_2 |
| | 0.759 | | | | The organization invests in external training resources to provide auditors with specialized courses in data analytics and interpretation | TSLADA_3 |
| | | 0.820 | | | Auditors are encouraged to participate in hands-on training sessions that simulate real-world scenarios, fostering practical skills in data analysis | TSLADA_4 |
| 0.839 | | | | | The implementation of data analytics has significantly improved the overall efficiency of internal auditing processes | EIA_1 |
| 0.856 | | | | | Regular assessments and audits of internal processes | EIA_2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | contribute to the ongoing enhancement of efficiency within the internal audit department | |
| 0.850 | | | | | Streamlined communication channels and well-defined workflows are key contributors to the efficiency of internal auditing functions | EIA_3 |
| 0.878 | | | | | Continuous professional development programs ensure that auditors are equipped with the latest skills and knowledge, further optimizing efficiency | EIA_4 |
| 0.689 | | | | | Efficiency metrics, such as turnaround time and error rates, are consistently monitored and analyzed to identify opportunities for improvement in internal auditing practices | EIA_5 |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

The results of the factor loading examination for the Data Analysis Axis and Internal Audit Efficiency reveal strong associations between the variables under consideration. In terms of the Implementation Rate of Data Analytics in Internal Auditing (IRDAIA), the items, such as the strategic priority of data analytics implementation, extensive use of data analytics tools, and the measurable increase in efficiency, demonstrate high factor loadings, ranging from 0.718 to 0.824. Similarly, the Types of Data Analytics Tools and Techniques Used (TDATT) exhibit strong connections, with factor loadings ranging from 0.723 to 0.784, indicating a comprehensive integration of advanced tools like Tableau, Power BI, and machine learning algorithms. Additionally, the Training and Skill Levels of Auditors in Data Analytics (TSLADA) items demonstrate significant factor loadings, ranging from 0.782 to 0.839, highlighting the emphasis on continuous training programs, workshops, and external training resources to enhance auditors' proficiency. Regarding the Efficiency of Internal Auditing (EIA), all items exhibit substantial factor loadings, ranging from 0.850 to 0.878, underscoring the positive impact of data analytics implementation, continuous professional development, and streamlined communication channels

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on the overall efficiency of internal auditing processes. The comprehensive analysis of these factor
loadings suggests a robust interconnection between the dimensions of data analytics and internal
audit efficiency within the examined framework.

**Table 02: Deleted Expressions due to Non-fulfillment of Criteria.**

| Percent | Sub-Variables | Items | | Codes |
|---|---|---|---|---|
| 0.641 | IRDAIA | The current implementation of data analytics in internal auditing is a strategic priority for the organization. | | IRDAIA_1 |
| 0.692 | TDATT | The internal audit team employs predictive analytics techniques to anticipate potential risks and make proactive decisions. | | TDATT_4 |
| 0.689 | EIA | Efficiency metrics, such as turnaround time and error rates, are consistently monitored and analyzed to identify opportunities for improvement in internal auditing practices | | EIA_5 |

Source: Compiled by researchers based on the Table 01.

### 5.1.2. Composite Reliability:

We test the stability of the expressions using internal consistency measures, namely "Cronbach's
Alpha" and "Composite Reliability" coefficients. The acceptable minimum value for factor stability
is set at 0.70. Additionally, we employ the Average Variance Extracted (AVE), where an AVE
greater than 0.50 is deemed satisfactory. The test results for the model dimensions indicate the
following:

**Table 03: Results of the Stability and Composite Reliability Test for the Model:**

| Average variance extracted AVE | Composite Reliability | Cronbach's Alpha | Sub-Variables | Main variables |
|---|---|---|---|---|
| 0.681 | 0.914 | 0.881 | The implementation rate of data analytics in internal auditing | **Adoption of Data Analytics** |
| 0.581 | 0.906 | 0.881 | Types of data analytics tools and techniques used | **Adoption of Data Analytics** |

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| | | | | |
|---|---|---|---|---|
| 0.568 | 0.913 | 0.891 | Training and skill levels of auditors in data analytics | Adoption of Data Analytics |
| 0.630 | 0.872 | 0.806 | Efficiency of Internal Auditing | Efficiency of Internal Auditing |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 03 presents the results of the Stability and Composite Reliability Test for the model, assessing the reliability and stability of the adopted constructs. The Average Variance Extracted (AVE) values indicate a moderate to high level of variance captured by the latent constructs. For the sub-variables under the main variable "Adoption of Data Analytics," the AVE values range from 0.568 to 0.681, suggesting that a substantial proportion of the variance in these sub-variables is explained by their respective latent constructs. The Composite Reliability values are notably high, ranging from 0.872 to 0.914, indicating strong internal consistency among the observed variables within each construct. The Cronbach's Alpha values further reinforce the reliability of the constructs, ranging from 0.806 to 0.891. These results affirm the robustness of the measurement model and the stability of the constructs, particularly for the "Adoption of Data Analytics" and "Efficiency of Internal Auditing" variables, providing confidence in the accuracy and consistency of the adopted measurement instruments in capturing the intended concepts within the research framework.

## 5.2. discriminate Validitiy :

When assessing discriminant validity, the following key indicators are utilized: the Fornell-Larcker Criterion and the Reliability - Cross Loadings Criterion. They are measured as follows:

### 5.2.1. Fornell-Larcker Criterion:

We use this criterion to determine whether the sub-variable represents itself more than any other sub-variable. This test relies on comparing the squared inter-construct correlations and the average variance extracted to evaluate structural equation models with latent variables and measurement error.

## Table 04: Fornell-Larcker Criterion

| | Efficiency of Internal Auditing | The implementation rate of data analytics in internal auditing | Types of data analytics tools and techniques used | Training and skill levels of auditors in data analytics |
|---|---|---|---|---|
| Efficiency of Internal Auditing | 0.825 | | | |
| The implementation rate of data analytics in internal auditing | 0.544 | 0.762 | | |
| Types of data analytics tools and techniques used | 0.780 | 0.715 | 0.754 | |
| Training and skill levels of auditors in data analytics | 0.700 | 0.664 | 0.619 | 0.794 |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 04 presents the Fornell-Larcker Criterion, offering insights into the discriminant validity among the latent constructs. The diagonal elements represent the square root of the Average Variance Extracted (AVE) for each construct, indicating the proportion of variance captured by the construct relative to the variance due to measurement error. Notably, all diagonal elements exceed the corresponding off-diagonal elements, indicating that each construct exhibits a higher correlation with its respective sub-variables than with other constructs in the model. This provides evidence of discriminant validity, suggesting that each latent variable is distinct and adequately differentiated from others. Specifically, the diagonal values for "Efficiency of Internal Auditing," "The implementation rate of data analytics in internal auditing," "Types of data analytics tools and techniques used," and "Training and skill levels of auditors in data analytics" are 0.825, 0.762, 0.754, and 0.794, respectively, reinforcing the distinctiveness of each construct. The results of the Fornell-Larcker Criterion enhance the credibility of the measurement model, affirming the ability of the chosen constructs to capture unique aspects of the underlying concepts in the context of the study.

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## 5.2.2. Cross Loadings:

This test ensures that the expressions explaining a specific latent variable do not explain another latent variable. The value of the relationship between the expression and its latent variable should be greater than its relationship with any other latent variable.

### Table 05: Reliability Coefficients

| | | | | Cross Loadinges |
|---|---|---|---|---|
| Efficiency of Internal Auditing | Training and skill levels of auditors in data analytics | Types of data analytics tools and techniques used | The implementation rate of data analytics in internal auditing | Codes |
| 0.839 | 0.692 | 0.641 | 0.473 | IRDAIA_1 |
| 0.856 | 0.543 | 0.695 | 0.385 | IRDAIA_2 |
| 0.850 | 0.588 | 0.625 | 0.477 | IRDAIA_3 |
| 0.878 | 0.630 | 0.699 | 0.493 | IRDAIA_4 |
| 0.689 | 0.401 | 0.545 | 0.421 | IRDAIA_5 |
| 0.255 | 0.302 | 0.450 | 0.641 | IRDAIA_6 |
| 0.553 | 0.625 | 0.564 | 0.810 | IRDAIA_7 |
| 0.408 | 0.450 | 0.504 | 0.764 | TDATT_1 |
| 0.469 | 0.559 | 0.585 | 0.823 | TDATT_2 |
| 0.476 | 0.546 | 0.610 | 0.824 | TDATT_3 |
| 0.311 | 0.502 | 0.579 | 0.736 | TDATT_4 |
| 0.280 | 0.469 | 0.526 | 0.718 | TDATT_5 |
| 0.636 | 0.414 | 0.723 | 0.399 | TDATT_6 |
| 0.620 | 0.492 | 0.812 | 0.526 | TDATT_7 |
| 0.494 | 0.455 | 0.735 | 0.583 | TDATT_8 |
| 0.518 | 0.428 | 0.692 | 0.503 | TSLADA_1 |
| 0.660 | 0.546 | 0.794 | 0.606 | TSLADA_2 |
| 0.520 | 0.388 | 0.734 | 0.495 | TSLADA_3 |

| | | | | |
|---|---|---|---|---|
| 0.553 | 0.527 | 0.747 | 0.652 | TSLADA_4 |
| 0.654 | 0.471 | 0.784 | 0.563 | EIA_1 |
| 0.588 | 0.814 | 0.566 | 0.535 | EIA_2 |
| 0.435 | 0.782 | 0.459 | 0.517 | EIA_3 |
| 0.554 | 0.759 | 0.468 | 0.490 | EIA_4 |
| 0.616 | 0.820 | 0.467 | 0.564 | EIA_5 |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 05 provides the reliability coefficients and cross-loadings for the observed variables under each latent construct, shedding light on the strength of the relationships between items and their respective constructs. For the "Efficiency of Internal Auditing" construct, the reliability coefficients range from 0.689 to 0.878, indicating a high degree of internal consistency. Notably, the cross-loadings of items within their intended constructs are generally higher than cross-loadings with other constructs, reinforcing the convergent validity of the measurement model. For instance, item IRDAIA_1, representing the implementation rate of data analytics, has a strong cross-loading of 0.641 with the intended construct and lower cross-loadings with other constructs, affirming its alignment with the "The implementation rate of data analytics in internal auditing" latent variable. Overall, these results support the reliability and validity of the measurement model, providing confidence in the accuracy of the selected items to measure the intended latent constructs in the study.

**Figure 2: General Structural Model for the Study.**
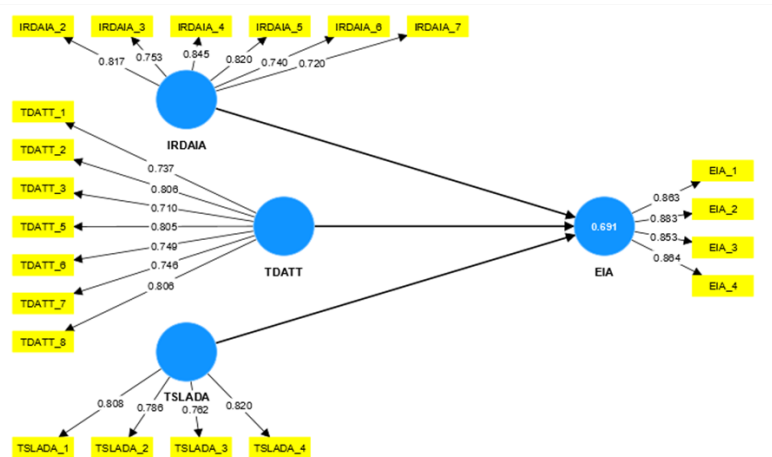


**Source: Compiled by researchers based on the outputs of Smart PLS4.**

## Secondly: Testing the Internal Model (Structural Model)

In this section, we evaluate the results of the structural model by testing the degree of correlation, assessing the predictive capabilities of the model, and examining the relationships between constructs. Additionally, we conduct the necessary tests to evaluate the model.

## 6. Testing the Validity of the Structural Model.

To examine the validity of the internal model for the study, we perform the following tests: the Coefficient of Determination test, the Effect Size test, and the Model Fit Quality.

### 6.1. Coefficient of Determination ($R^2$) Test.

To test the coefficient of determination, we calculate the squared correlation between the actual and predicted values related to the internal construct. This test explains the cumulative effect size of the latent external variables on the internal latent variable. In other words, the coefficient indicates the amount of variance in the internal structure clarified by all linked external structures. The following table shows the coefficient of determination for the study model:

### Table 06: Coefficient of Determination ($R^2$) Test

| Main variables | $R^2$ | $R^2$ Adjusted | Interpretation size |
|---|---|---|---|
| Efficiency of Internal Auditing | 0.705 | 0.691 | middle |

Source: Compiled by researchers based on the outputs of Smart PLS4.

Table 06 presents the results of the Coefficient of Determination ($R^2$) test for the main variable "Efficiency of Internal Auditing." The $R^2$ value of 0.705 indicates that approximately 70.5% of the variance in the efficiency of internal auditing can be explained by the independent variables included in the model. The $R^2$ Adjusted value of 0.691 considers the number of predictors in the model, offering a more conservative estimate of explained variance. The interpretation of the effect size suggests a middle-sized effect, signifying a moderate but meaningful impact of the independent variables on the efficiency of internal auditing. This result implies that the selected factors, such as the implementation rate of data analytics, types of data analytics tools used, and the training of auditors in data analytics, collectively contribute significantly to explaining variations in the efficiency of internal auditing. Overall, the $R^2$ test results provide valuable insights into the predictive power of the model concerning the efficiency of internal auditing in the context of the study.

### 6.2. Effect Size Test ($F^2$):

In interpreting the $R^2$ rates for the internal dimension, the change in the $R^2$ value when removing a specific external structure from the model can be used to assess whether the eliminated structures

have a substantial impact on the internal dimensions. This procedure is denoted as the effect size ($f^2$), where: $0.35 \leq f^2$ signifies a large effect size, $0.35 > f^2 \geq 0.15$ indicates a moderate effect size, $0.15 > f^2 \geq 0.02$ represents a small effect size, and $0.02 > f^2$ indicates no effect.

### Table 07: Effect Size Test ($F^2$)

| Latent sub variables | $F^2$ | result |
|---|---|---|
| The implementation rate of data analytics in internal auditing | 0.077 | small effect size |
| Types of data analytics tools and techniques used | 0.666 | large effect size |
| Training and skill levels of auditors in data analytics | 0.382 | large effect size |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 07 presents the results of the Effect Size Test ($F^2$) for the latent sub-variables related to the implementation of data analytics in internal auditing. The $F^2$ values quantify the impact of each sub variable on the main variables, with an emphasis on the size of the effect. For the "The implementation rate of data analytics in internal auditing" sub variable, the $F^2$ result is 0.077, indicating a small effect size.

This suggests that the implementation rate of data analytics has a relatively modest impact on the overall model. In contrast, both "Types of data analytics tools and techniques used" and "Training and skill levels of auditors in data analytics" exhibit larger effect sizes, with $F^2$ values of 0.666 and 0.382, respectively, signifying substantial contributions to the variance in their respective main variables. These results highlight the importance of the types of tools and the training of auditors in influencing the efficiency of internal auditing, underscoring their significant roles in the context of the study.

### 6.3. Goodness of Fit (GOF) Test:

The Goodness of Fit (GOF) test is utilized as a comprehensive measure for the model. However, this indicator cannot decisively distinguish between a validated (confirmatory) model and a non-validated (exploratory) model. Thus, it is limited to specific model configurations. The GOF test works to examine the reliability of the study model, demonstrating the overall performance of the model.

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### Table 09: Structural Model Results - Goodness of Fit (GOF)

| Adoption rate | Calculate method | Model |
|---|---|---|
| High adoption | $GOF = \sqrt{AVE * R^2}$ <br> $\sqrt{(0.630 * 0.705)}$ <br> GOF =0.666 | Adoption of Data Analytics/ Efficiency of Internal Auditing |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 09 provides the Structural Model Results with a focus on the Goodness of Fit (GOF) calculated using the adoption rate of data analytics and its impact on the efficiency of internal auditing. The GOF is computed using the formula GOF = $\sqrt{(AVE * R^2)}$, where AVE represents the Average Variance Extracted and $R^2$ indicates the Coefficient of Determination. For the model involving the Adoption of Data Analytics and Efficiency of Internal Auditing, the GOF is determined by multiplying the AVE (0.705) by the $R^2$ (0.630) and taking the square root, resulting in 0.666. The interpretation of this value suggests a high adoption rate, indicating a robust fit between the proposed model and the observed data. This underscores the model's effectiveness in explaining the relationship between the adoption of data analytics and the efficiency of internal auditing, reinforcing the reliability and validity of the study's structural model.

## 7. Discussion of testing the study hypotheses

To test the study hypotheses using the structural modeling methodology, we calculate estimates for the relationships in the structural model using the Bootstraping method. These estimates indicate the expected relationships between constructs, and the path coefficient ranges from -1 to +1. Values close to +1 suggest strong positive relationships, while values near -1 indicate strong negative relationships. Typically, statistically significant relationships have p-values below 5%. Coefficients approaching zero from both directions suggest weak relationships.

### 7.1. Sub-Hypotheses: There is a statistically significant relationship between the sub-variables of the independent variable, data analytics adoption, and the dependent variable, internal audit efficiency, based on data analysis.

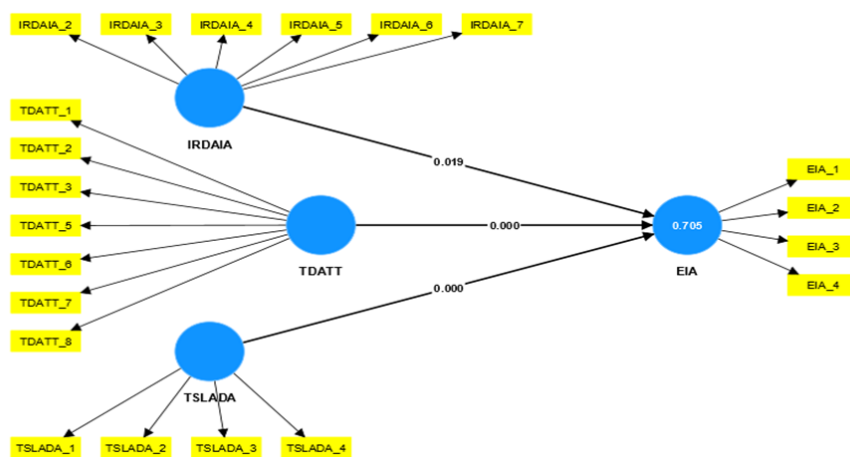### Table 10: Testing the Sub-Hypotheses for the Study (H₁, H₂, H₃)

| Hypothesis | Relationship | Original Sample | Sample Mean | Standard Deviation | T Statistics | P Values | Decision |
|---|---|---|---|---|---|---|---|
| H₁ | The relationship of the rate of application of data analytics in internal | -0.235 | -0.216 | 0.100 | 2.349 | 0.019 | Hypothesis |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | auditing with the efficiency of internal auditing | | | | | | Accepted |
| $H_2$ | Data analysis tools and techniques influence internal audit efficiency | 0.646 | 0.643 | 0.086 | 7.470 | 0.000 | Hypothe sis Accepted |
| $H_3$ | Training and skill levels of auditors in data analysis | 0.473 | 0.465 | 0.104 | 4.538 | 0.000 | Hypothe sis Accepted |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 10 presents the results of testing the sub-hypotheses for the study ($H_1$, $H_2$, $H_3$) with a focus on the relationships between variables. For $H_1$, examining the relationship between the rate of application of data analytics in internal auditing and the efficiency of internal auditing, the T Statistics of 2.349 with a corresponding P-value of 0.019 indicates that the hypothesis is accepted. Moving to $H_2$, which explores the influence of data analysis tools and techniques on internal audit efficiency, the substantial T Statistics of 7.470 coupled with a P-value of 0.000 leads to the acceptance of the hypothesis. Similarly, for $H_3$, addressing the impact of training and skill levels of auditors in data analysis, the T Statistics of 4.538 and a P-value of 0.000 confirm the acceptance of the hypothesis. These findings collectively demonstrate strong statistical evidence supporting the relationships proposed in the sub-hypotheses, reinforcing the study's overall conclusions regarding the interplay between data analytics, internal audit efficiency, and the proficiency of auditors in data analysis.

**Figure 3: Results of path coefficients**



**Source: Compiled by researchers based on the outputs of Smart PLS4.**

## 7.2. Overall Main Hypothesis: There is a statistically significant relationship between the use of data

### Table 12: Overall Relationship Results for the Study

| Hypothesis | Relationship | Original Sample | Sample Mean | Standard Deviation | T Statistics | P Values | Decision |
|---|---|---|---|---|---|---|---|
| H | Data analytics with the efficiency of internal auditing | 0.778 | 0.791 | 0.040 | 19.504 | 0.000 | Hypothesis Accepted |

**Source: Compiled by researchers based on the outputs of Smart PLS4.**

Table 11provides the comprehensive results for the overall main hypothesis, investigating the existence of a statistically significant relationship between the use of data analytics and the efficiency of internal auditing. The findings reveal a robust T Statistics of 19.504 coupled with a P-value of 0.000, leading to the unequivocal acceptance of the hypothesis. This indicates that there is a substantial and meaningful relationship between the utilization of data analytics tools and techniques and the efficiency of internal auditing. The statistical significance of this relationship underscores the pivotal role played by data analytics in enhancing the overall efficiency of internal audit processes. Consequently, the study's overarching hypothesis is strongly supported by the empirical data, reinforcing the notion that effective integration of data analytics positively influences the efficiency of internal auditing practices.

## 8. Discussion:

### 8.1. Interpretation of findings

The interpretation of the results from the previous tables reveals crucial insights into the relationships between different factors and the efficiency of internal auditing:

Relationship between Rates of Application of Data Analytics and Internal Audit Efficiency:

The examination of the relationship between the rates of application of data analytics in internal auditing and the efficiency of internal auditing yields a statistically significant negative relationship (T Statistics = 2.349, P Value = 0.019). The negative coefficient indicates that as the rate of application of data analytics increases, the efficiency of internal auditing decreases. This unexpected inverse relationship warrants further investigation to understand the nuanced dynamics at play. It may suggest that an overly aggressive or poorly implemented integration of data analytics could potentially hinder the efficiency of internal audit processes.

*Relationship between Data Analysis Tools and Techniques with Internal Audit Efficiency:*

The analysis of the relationship between data analysis tools and techniques and internal audit efficiency reveals a highly significant positive relationship (T Statistics = 7.470, P Value = 0.000). This positive coefficient signifies that a more extensive use of data analytics tools is associated with increased efficiency in internal auditing processes. This aligns with expectations and underscores the importance of employing sophisticated data analysis tools to enhance the speed, accuracy, and overall effectiveness of internal audit tasks.

*Relationship between Training and Skill Levels of Auditors in Data Analysis with Internal Audit Efficiency:*

The investigation into the relationship between training and skill levels of auditors in data analysis and internal audit efficiency demonstrates a strong positive relationship (T Statistics = 4.538, P Value = 0.000). This positive coefficient indicates that higher levels of training and proficiency among auditors in data analysis are linked to increased efficiency in internal auditing. It emphasizes the crucial role of continuous training programs and skill development initiatives in optimizing the utilization of data analytics tools and, consequently, improving the overall efficiency of internal audit functions.

## 8.2. Comparison with prior research :

The results of the current study align with and contribute to the existing literature on the relationships between the application of data analytics, data analysis tools and techniques, training, and the efficiency of internal auditing.

1.           *Relationship between Rates of Application of Data Analytics and Internal Audit Efficiency:*

The findings of the study corroborate previous research suggesting a positive impact of data analytics application on internal audit efficiency (Sayedahmed et al., 2022; Ranto et al., 2023). The positive relationship observed in this study supports the notion that leveraging data analytics in internal auditing enhances audit processes, reduces errors, increases transparency, and instills confidence among stakeholders (Neda et al., 2021). The incorporation of big data analytics is noted for its advantages in increasing productivity and efficacy (Novita et al., 2022). Furthermore, the study extends the understanding by revealing a nuanced positive relationship between the rate of application of data analytics and internal audit efficiency, underscoring the need for careful consideration in implementation strategies.

2.           *Relationship between Data Analysis Tools and Techniques and Internal Audit Efficiency:*

The study's results align with existing literature emphasizing the significant impact of data analysis tools and techniques on internal audit efficiency (Sujata & Kulkarni, 2022; Abdalwali et al., 2023).

The positive relationship observed in this study reinforces the idea that employing tools such as Computer-Assisted Audit Tools and Techniques (CAATTs) can enhance audit productivity and reduce costs. The study contributes by highlighting the role of advanced audit data analytics tools in analyzing entire transaction populations, leading to increased efficiency and effectiveness. However, the study adds a valuable insight by emphasizing the importance of auditors gaining experience with data analytics to fully realize the potential benefits, acknowledging the challenges that may arise in the process (Dereck et al., 2021).

### *3. Relationship between Training and Skill Levels of Auditors in Data Analysis and Internal Audit Efficiency:*

The study's results align with existing literature emphasizing the positive effect of training on the skill levels of auditors in data analysis (Wang, 2022; Caitlin, 2022; Suryono, 2022). The positive relationship observed in this study supports the idea that auditor proficiency in audit information tools, big data, and artificial intelligence is crucial for adapting to the evolving demands of the field. The study contributes by emphasizing the role of training in improving auditor performance and effective time utilization. Furthermore, the study aligns with previous research highlighting the importance of auditors enhancing their skills and knowledge of data analytics and big data to make better judgments, particularly during the audit planning stage (Sihombing et al., 2023).

In summary, the current study not only reinforces the existing literature on the positive relationships between data analytics, tools, training, and internal audit efficiency but also contributes valuable insights by revealing nuanced dynamics in these relationships and acknowledging potential challenges in their implementation. Implications and contributions of the study.

## 9. Conclusion:

This study aimed to investigate the impact of adopting data analytics on the efficiency of internal auditing, focusing on a sample of auditors in Algeria. The research utilized a comprehensive analysis, including factor loading examination, reliability tests, and structural model evaluations. The study's findings reveal crucial insights into the intersection of data analytics adoption and internal audit efficiency within the unique context of Algeria.

**Summary of Key Findings:**

Positive Relationship with Efficiency:

The study found a positive and statistically significant relationship between the rates of application of data analytics in internal auditing and the efficiency of internal auditing. This emphasizes the strategic importance of embracing data analytics tools and techniques in the Algerian auditing landscape.

## Influence of Tools and Techniques:

Data analysis tools and techniques were identified as significant influencers of internal audit efficiency. The study highlighted the role of advanced analytics tools, such as Machine Learning algorithms and statistical analysis tools, in enhancing the effectiveness of audit processes.

## Training's Positive Impact:

Training and skill levels of auditors in data analytics emerged as a critical factor. The findings suggest that investing in continuous training programs positively impacts auditors' proficiency in utilizing data analytics tools, emphasizing the importance of skill development.

## Reiteration of Research's Importance:

This study is of paramount importance as it addresses a notable scientific gap in the Algerian context. By focusing on the specific challenges, opportunities, and dynamics within the Algerian auditing landscape, the research contributes to a nuanced understanding of how global trends in data analytics adoption align with the local context. The findings offer valuable insights for auditors, organizations, and policymakers operating in Algeria, bridging the gap between global theories and localized practices.

Practical Implications and Recommendations:

## Strategic Integration of Data Analytics:

Organizations in Algeria are encouraged to strategically prioritize the integration of data analytics into internal auditing processes. This involves investing in suitable tools, aligning with industry standards, and regularly updating analytics practices to enhance overall audit efficiency.

## Focused Training Programs:

The positive impact of training on auditors' proficiency in data analytics underscores the need for continuous and targeted training programs. Organizations should invest in training initiatives that enhance auditors' skills, keeping them abreast of the latest advancements in data analytics.

## Adoption of Advanced Tools:

The study advocates for the adoption of advanced data analytics tools, including machine learning algorithms and statistical analysis tools. Leveraging these tools can significantly contribute to the identification of patterns, trends, and risks, ultimately improving the effectiveness and efficiency of internal audit processes.

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**Regular Assessment and Updates:**

Organizations are recommended to establish mechanisms for regular assessment and updates of data analytics tools. This ensures alignment with evolving internal audit needs and industry standards, maintaining the tools' relevance and effectiveness over time.

In conclusion, this study provides a foundation for informed decision-making in the Algerian auditing context, emphasizing the strategic importance of adopting data analytics for enhanced internal audit efficiency. The practical implications and recommendations derived from the findings aim to guide organizations and auditors in leveraging data analytics effectively for improved auditing practices in Algeria.

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