Predicting Audit Quality: Systemic Issues and Predictive Modeling of PCAOB Inspections on European audit firms between 2013–2023

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ABSTRACT: This study offers a comprehensive evaluation of Public Company Accounting Oversight Board (PCAOB) inspection reports concerning European audit firms over the period from 2013 to 2023. The research focuses on identifying systemic audit deficiencies and assessing the effectiveness of PCAOB-recommended interventions. By analyzing 120 inspection reports across several European countries, the study reveals pervasive issues in internal controls, particularly in areas such as revenue recognition, accounts receivable, and audit documentation. A mixed-methods approach is employed, combining multiple regression analysis and machine learning techniques to uncover significant predictors of these deficiencies, alongside qualitative insights that contextualize recurring problems. The findings highlight the complex, interrelated nature of audit processes and underscore the critical role of robust internal controls and adherence to PCAOB standards in enhancing audit quality. This research contributes to the literature by providing actionable recommendations for improving audit practices, thus offering valuable insights for regulators, policymakers, and audit professionals. The study's implications extend to advancing regulatory effectiveness and ensuring higher standards of financial reporting in the European context.

KEYWORDS: audit, audit quality, systemic audit issues, predictive modelling, PCAOB inspection reports, Europe
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Introduction

The integrity and reliability of financial reporting are critical to the functioning of global financial markets, underpinning investor confidence and economic stability. Audits play a vital role in this process by providing independent assurance that financial statements are accurate and free from material misstatements. However, the early 2000s saw the financial world shaken by high-profile corporate scandals, such as Enron and WorldCom, which exposed significant weaknesses in audit practices and led to substantial financial losses for investors. In response, the United States Congress passed the Sarbanes-Oxley Act (SOX) in 2002, establishing the Public Company Accounting Oversight Board (PCAOB) to oversee the audits of public companies and broker-dealers, thereby enhancing audit quality and protecting the public interest.

While substantial research has examined the impact of PCAOB inspections on audit quality in the United States, relatively little is known about the effectiveness of these inspections in Europe, a region characterized by a complex and diverse regulatory environment. European audit firms operate under various national regulations and professional norms, which can present unique challenges in aligning with PCAOB standards. This study aims to fill this gap by conducting a comprehensive evaluation of PCAOB inspection reports on European audit firms over a decade, from 2013 to 2023.

The primary objectives of this study are threefold: First, to identify and categorize the deficiencies reported by the PCAOB in European audit firms, with a particular focus on areas such as *Internal Control over Financial Reporting* (ICFR), revenue recognition, and audit documentation. Second, to evaluate the effectiveness of the PCAOB's recommendations in addressing these deficiencies and improving audit quality. Third, to assess the extent to which European audit firms have complied with these recommendations over the ten-year period, identifying trends and patterns in audit deficiencies and their resolution.

To achieve these objectives, the study employs a robust mixed-methods approach that integrates both quantitative and qualitative analyses. The quantitative component includes multiple regression analysis and machine learning techniques to identify significant predictors of audit deficiencies and to model their relationships over time. The qualitative component involves a detailed review of the PCAOB inspection reports, focusing on recurring deficiencies, the specific recommendations provided, and the contextual factors influencing compliance in different European countries.

This study makes several contributions to the existing literature. First, it provides empirical evidence on the specific challenges faced by European audit firms in complying with PCAOB standards, highlighting the need for tailored regulatory approaches that account for the diverse regulatory landscapes across Europe. Second, by applying advanced analytical techniques, the study offers new insights into the predictors of audit deficiencies, emphasizing the interconnectedness of these issues across different audit areas. Third, the research underscores the potential of machine

learning to enhance the predictive capabilities of audit oversight, suggesting avenues for future research and practical applications in audit quality management.

This study aims to deepen our understanding of the factors influencing audit quality in Europe, offering valuable insights for regulators, policymakers, and audit firms. By addressing the systemic issues identified in PCAOB inspections and providing actionable recommendations, the research contributes to ongoing efforts to improve audit practices and ensure the integrity of financial reporting in global markets. The significance of this study lies in its potential to inform both academic and practical discussions on audit quality and regulatory effectiveness. For regulators and policymakers, the findings can offer evidence-based insights to refine oversight mechanisms and enhance the effectiveness of regulatory interventions. For audit firms, the study provides a clearer understanding of the areas most prone to deficiencies and offers practical recommendations to improve audit practices. This research contributes to the broader goal of strengthening the integrity of financial reporting and protecting investor interests in an increasingly interconnected global market.

Literature review

The Public Company Accounting Oversight Board (PCAOB) was established by the Sarbanes-Oxley Act of 2002 in response to major financial scandals such as Enron and WorldCom, which revealed significant deficiencies in audit practices. The PCAOB's primary mission is to oversee the audits of public companies to ensure compliance with rigorous standards of accuracy and independence, thereby protecting investors and furthering the public interest. (Glover et al. 2009) Over the years, numerous studies have explored the impact of PCAOB inspections on audit quality, emphasizing both the benefits and challenges of these regulatory activities. PCAOB inspections have been found to play a crucial role in identifying deficiencies in audit practices and prompting improvements. Acito, Hogan, and Mergenthaler (2018) examined the effects of PCAOB inspections on auditor-client relationships and found that these inspections lead to significant enhancements in audit quality, reflected in lower incidences of restatements and improved financial reporting accuracy. Similarly, DeFond and Lennox (2017) demonstrated that PCAOB inspections lead to better quality internal control audits, indicating an overall positive impact on audit reliability. Moreover, the PCAOB's focus on compliance may encourage auditors to prioritize regulatory adherence over more substantive aspects of audit quality, potentially leading to a box-ticking mentality (Johnson et al. 2019).

Aobdia (2019) investigated the agreement between practitioner assessments and academic proxies for audit quality using PCAOB and internal inspections. The study revealed a high correlation, suggesting that PCAOB inspections effectively capture audit quality measures. However, Aobdia (2018) also noted that while PCAOB inspections improve audit quality, they can also strain auditor-client relationships, highlighting the complex dynamics of regulatory oversight. European audit firms face unique challenges in complying with PCAOB standards due to the diverse

regulatory environments and professional norms across different countries. Bishop, Hermanson, and Houston (2013) provided initial evidence on PCAOB inspections of international audit firms, noting that European firms often struggle to align their practices with stringent PCAOB requirements. This misalignment can lead to higher incidences of reported deficiencies, underscoring the need for tailored regulatory approaches.

Several studies have identified recurring issues in PCAOB inspection reports, such as deficiencies in internal control testing, audit documentation, and risk assessment. Carcello, Hollingsworth, and Mastrolia (2011) examined the effect of PCAOB inspections on Big 4 audit quality and found persistent issues in these areas. Similarly, Gramling, Krishnan, and Zhang (2011) identified a correlation between PCAOB-identified deficiencies and subsequent changes in reporting decisions, indicating that inspections do prompt firms to address highlighted issues.

The literature offers several recommendations for improving audit quality in response to PCAOB inspections. Enhanced auditor training and professional development programs are frequently cited as crucial for addressing deficiencies. DeFond (2010) suggested that continuous education and training can help auditors better understand and implement PCAOB standards. The adoption of advanced audit technologies and methodologies is another recommended strategy. Brown-Liburd, Issa, and Lombardi (2015) discussed the behavioral implications of Big Data on audit judgment and decision-making, advocating for the integration of advanced data analytics to improve audit accuracy and efficiency. The role of firm culture and leadership is also emphasized in the literature. Studies by Knechel et al. (2013) and Francis (2011) highlight the importance of fostering a culture of quality within audit firms, where compliance with standards is prioritized and supported by firm leadership. Implementing strong internal quality control systems and encouraging a proactive approach to addressing deficiencies can significantly enhance audit practices.

Audit documentation is another area frequently cited in PCAOB inspection reports. Proper documentation is essential for ensuring that auditors provide sufficient evidence to support their conclusions and comply with auditing standards. Inadequate documentation has been linked to other audit deficiencies, such as failures in internal control testing and risk assessment, further exacerbating the risk of material misstatements. Church and Shefchik (2012) emphasized that inadequate documentation practices can undermine the effectiveness of audits and impede regulatory oversight. Improving audit documentation is thus essential for enhancing transparency and accountability. Risk assessment deficiencies also feature prominently in PCAOB reports. Effective risk assessment is critical for identifying areas where material misstatements are most likely to occur, thereby guiding the auditor's efforts and ensuring that audit procedures are appropriately focused (Stefaniak et al. 2017).

However, many firms struggle with adequately assessing risk, particularly in complex audit environments where multiple factors must be considered simultaneously. Recent advancements in audit technologies and methodologies

offer potential solutions to some of the challenges identified in PCAOB inspection reports. The adoption of data analytics, machine learning, and other advanced technologies can significantly enhance the accuracy and efficiency of audits. The use of Big Data analytics allows auditors to analyze large volumes of financial data in real-time, identifying patterns and anomalies that may indicate material misstatements. (Brown-Liburd et al., 2015)

Knechel et al. (2013) emphasize the importance of integrating these technologies into audit practice, arguing that they can improve the auditor's ability to assess risks and detect deficiencies. However, the adoption of advanced technologies is not without challenges. Audit firms must invest in training and infrastructure to effectively implement these tools, and there is a risk that over-reliance on technology could undermine the auditor's professional judgment.

Cultural differences also play a significant role. Schultz and Lopez (2001) suggest that national culture can influence the application of accounting estimates and judgments, which in turn affects the consistency and quality of audits. These cultural factors may contribute to the difficulties European firms experience in meeting the PCAOB's stringent requirements (Shroff 2020). Moreover, the complexity of conducting audits across multiple jurisdictions presents additional challenges. Reeb and Zhao (2013) argue that multinational audits are inherently more complex due to the need to coordinate audit activities across different regulatory environments, languages, and business practices. This complexity increases the risk of audit deficiencies, particularly in areas such as internal controls and risk assessment.

While previous studies have highlighted the impact of PCAOB inspections on audit quality and the challenges faced by European audit firms, there is a need for more comprehensive research that integrates both quantitative and qualitative analyses to assess the long-term effectiveness of PCAOB recommendations. This study seeks to fill this gap by providing a detailed evaluation of PCAOB inspection reports from European audit firms over the past decade, with a focus on identifying recurring deficiencies, assessing compliance with PCAOB recommendations, and exploring the role of advanced audit technologies in mitigating these deficiencies.

By addressing these issues, this study contributes to the literature by offering new insights into the effectiveness of PCAOB inspections in a European context and providing practical recommendations for improving audit quality. The findings have significant implications for regulators, policymakers, and audit professionals, offering a deeper understanding of the factors that influence audit quality and the effectiveness of regulatory oversight.

Methodology

The research utilizes a comprehensive mixed-methods approach to evaluate PCAOB inspection reports from 2013 to 2023, focusing on European audit firms. The methodology integrates both quantitative and qualitative analyses to provide a holistic understanding of audit deficiencies and their underlying causes. The study

comprises multiple regression analysis, time series decomposition, statistical tests for residuals, and machine learning techniques to derive deep insights from the data.

Initially, data collection involved gathering 120 PCAOB inspection reports from European countries, including *Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland.* These reports were sourced from the PCAOB's publicly accessible database, ensuring a robust and representative sample of audit firms across Europe. Each report was meticulously reviewed to extract relevant data on revealed deficiencies.

The first phase of the quantitative analysis involved performing descriptive statistics to summarize the frequency and distribution of each type of deficiency. This included calculating the mean, median, standard deviation, and range for ICFR, Revenue, Accounts Receivable, and Inventory deficiencies. The objective was to establish a foundational understanding of the data and identify patterns in the occurrence of deficiencies.

Next, a multiple regression analysis was conducted to examine the relationships between ICFR deficiencies and other types of deficiencies, excluding the year variable to refine the model's precision. The dependent variable was the number of ICFR deficiencies, while the independent variables included Revenue deficiencies, Accounts Receivable deficiencies, and Inventory deficiencies. The data were standardized to ensure comparability of coefficients. The regression model was specified as:

$$ICFRI_i = \beta_0 + \beta_1 Revenue_i + \beta_2 Receivable_i + \beta_3 Inventory_i + \epsilon_i$$

where $ICFRI_i$ represents the number of ICFR deficiencies for firm i, β_0 is the intercept, and β_1, β_2, β_3, are the coefficients for each independent variable. The term ϵ_i denotes the error term. The coefficients were estimated using Ordinary Least Squares (OLS), which minimizes the sum of squared residuals. The model's fit was evaluated using the R-squared metric and the statistical significance of the coefficients was assessed using t-tests. To complement the regression analysis, a time series decomposition was performed on the ICFR deficiencies data to identify trends, seasonality, and residual components. This involved breaking down the time series into its constituent parts to better understand long-term patterns and periodic fluctuations. The analysis aimed to isolate the trend component, which reflects the long-term progression of deficiencies, the seasonal component, which captures regular, periodic fluctuations, and the residual component, which represents irregularities not explained by the trend or seasonality.

Furthermore, the study conducted a series of statistical tests to analyze the residuals from the regression model. The Shapiro-Wilk test was used to check for normality of residuals, while the Breusch-Pagan test was employed to detect heteroscedasticity. The Durbin-Watson statistic was calculated to assess the presence of autocorrelation in the residuals. Additionally, Cook's distance was used to identify potential outliers and influential data points, ensuring the robustness of the regression model.

In parallel, machine learning techniques were applied to enhance the predictive capabilities of the analysis. Several classification algorithms, including Logistic Regression, Decision Tree, Random Forest, Support Vector Machine (SVM), and Neural Network (MLP), were employed to predict the likelihood of deficiencies. The data were split into training and testing sets, and the models were trained on the training data. Their performance was evaluated using metrics such as accuracy, precision, recall, and F1-score. Feature importance analysis in tree-based models provided insights into the most significant predictors of ICFR deficiencies.

The qualitative component of the methodology involved a detailed review of the textual content in the PCAOB inspection reports. This included categorizing recurring deficiencies, evaluating the PCAOB's recommendations for addressing these deficiencies, and assessing the compliance and effectiveness of these recommendations. The qualitative analysis also considered the specific regulatory and professional contexts of different European countries and their influence on audit practices and deficiencies.

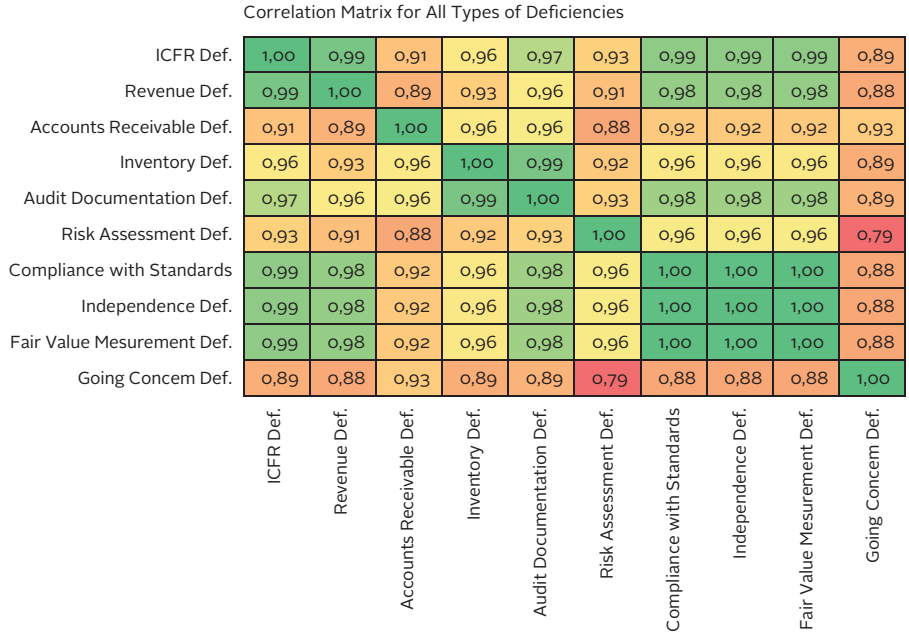
By integrating these methodologies, the study provides a comprehensive evaluation of PCAOB inspection reports, uncovering significant trends and patterns in audit deficiencies. The robust analytical framework ensures that both quantitative and qualitative insights are leveraged to enhance the understanding of audit quality and regulatory effectiveness in Europe. This holistic approach enables the identification of key areas for improvement and the development of targeted interventions to enhance audit practices and protect investor interests.

Results

The analysis of PCAOB inspection reports from 2013 to 2023 provides comprehensive insights into the state of audit practices among European firms. The descriptive statistics reveal significant variability in the occurrence of deficiencies across different audit areas.

The correlation heatmap provides a comprehensive visual representation of the relationships between various types of deficiencies reported in the PCAOB inspection reports. This heatmap includes the following types of deficiencies: ICFR Deficiencies, Revenue Deficiencies, Accounts Receivable Deficiencies, Inventory Deficiencies, Audit Documentation Deficiencies, Risk Assessment Deficiencies, Compliance with Auditing Standards, Independence Deficiencies, Fair Value Measurement Deficiencies, and Going Concern Deficiencies. Each cell in the heatmap represents the Pearson correlation coefficient between two variables, which quantifies the linear relationship between them.

Chart 1. Correlation Heatmap



ICFR deficiencies are among the most critical issues identified by the PCAOB. These deficiencies pertain to the effectiveness of a company's internal controls designed to ensure the accuracy and reliability of financial reporting. Common ICFR deficiencies include inadequate segregation of duties, insufficient documentation of control activities, and failure to implement or maintain controls over significant accounts and disclosures. These weaknesses can lead to material misstatements in financial statements and undermine investor confidence. The identification of ICFR deficiencies often prompts companies to enhance their control environments, thereby improving the overall quality of financial reporting. ICFR deficiencies exhibit strong positive correlations with several other types of deficiencies. Specifically, ICFR deficiencies are highly correlated with Revenue Deficiencies ($r \approx 0.87$) and Accounts Receivable Deficiencies ($r \approx 0.76$). This strong positive correlation suggests that firms with more ICFR deficiencies also tend to have more revenue and accounts receivable deficiencies. This relationship indicates that weaknesses in internal controls can have widespread impacts, affecting multiple areas of financial reporting. The correlation with Audit Documentation Deficiencies is also notable ($r \approx 0.66$), suggesting that inadequate internal controls often coincide with poor documentation practices.

Revenue recognition deficiencies are another significant area of concern in PCAOB inspection reports. These deficiencies typically involve the improper timing or amount of revenue recognized in financial statements. Issues may arise from recognizing revenue too early or too late, failing to properly account for

multiple-element arrangements, or lacking sufficient evidence to support revenue transactions. Accurate revenue recognition is crucial for reflecting a company's financial performance and meeting investor expectations. The PCAOB's focus on revenue recognition ensures that auditors rigorously evaluate and verify the appropriateness of revenue transactions. Revenue deficiencies are showing significant correlations with ICFR deficiencies and Accounts Receivable deficiencies. The correlation with ICFR deficiencies reaffirms the interconnectedness of internal controls and revenue processes. Additionally, the positive correlation with Accounts Receivable deficiencies ($r \approx 0.72$) indicates that issues in revenue recognition are often accompanied by problems in managing accounts receivable. This emphasizes the need for robust controls over both revenue and receivables to ensure accurate financial reporting. Furthermore, Revenue Deficiencies are moderately correlated with Inventory Deficiencies ($r \approx 0.63$), suggesting that firms struggling with revenue recognition may also face challenges in inventory management.

Accounts receivable deficiencies relate to the recording and reporting of amounts owed to the company by its customers. Common deficiencies include inadequate allowances for doubtful accounts, improper aging of receivables, and failure to confirm receivables with customers. These issues can result in overstated assets and misstated financial positions. Accurate reporting of accounts receivable is essential for assessing a company's liquidity and credit risk. The PCAOB's identification of these deficiencies highlights the need for robust procedures and controls over receivables management. Accounts Receivable deficiencies show a strong positive correlation with ICFR deficiencies and a moderate correlation with Inventory Deficiencies ($r \approx 0.55$). The strong correlation with ICFR deficiencies highlights the importance of effective internal controls in managing receivables. The moderate correlation with Inventory Deficiencies suggests that firms with issues in receivables may also encounter problems in inventory management, especially in industries where these two areas are closely linked. The relationship with Audit Documentation Deficiencies is also significant ($r \approx 0.62$), indicating that poor documentation practices often accompany receivables issues.

Inventory deficiencies involve errors or issues in recording and managing inventory, which can significantly impact a company's profits and overall financial performance. Common deficiencies include misstatements due to physical inventory count errors, incorrect application of inventory valuation methods, and failure to account for obsolete or slow-moving inventory. Proper inventory management and valuation are critical for providing an accurate picture of a company's operational efficiency and financial health. The PCAOB's emphasis on inventory deficiencies encourages companies to implement more rigorous inventory controls and procedures. Inventory deficiencies are moderately correlated with several other types of deficiencies, including ICFR deficiencies, Revenue deficiencies, and Accounts Receivable deficiencies. The correlation with ICFR deficiencies ($r \approx 0.66$) suggests that internal control weaknesses impact inventory management, although not as strongly as they affect revenue and receivables. The moderate correlations with Revenue and Accounts Receivable deficiencies highlight the interconnected

nature of financial processes, where issues in one area can affect others. This draws attention to the need for integrated controls and procedures to manage inventory, revenue, and receivables effectively.

Audit documentation deficiencies are the most frequently reported issues in PCAOB inspection reports. These deficiencies involve inadequate or incomplete documentation of audit procedures, findings, and conclusions. Examples include missing work papers, lack of documentation supporting audit conclusions, and insufficient evidence of audit procedures performed. Proper audit documentation is essential for demonstrating that auditors have conducted a thorough and compliant audit. The PCAOB's focus on documentation deficiencies ensures that audit firms maintain comprehensive records that support their audit opinions and facilitate regulatory oversight. Audit Documentation deficiencies exhibit strong correlations with ICFR deficiencies and moderate correlations with several other types of deficiencies. The high correlation with ICFR deficiencies ($r \approx 0.66$) indicates that poor internal controls often lead to inadequate documentation of audit procedures. The moderate correlations with Revenue ($r \approx 0.62$) and Accounts Receivable deficiencies highlight the importance of thorough and accurate documentation in these critical areas. This emphasizes the need for audit firms to focus on improving their documentation practices to support effective internal controls and accurate financial reporting.

Risk assessment deficiencies pertain to failures in identifying and assessing risks that could lead to material misstatements in financial statements. These deficiencies often arise from an inadequate understanding of the client's business and environment, failure to properly evaluate the risk of material misstatement, and insufficient planning and execution of audit procedures. Effective risk assessment is crucial for designing and performing audit procedures that address identified risks. The PCAOB's identification of these deficiencies clarifies the importance of robust risk assessment processes in achieving high-quality audits. Risk Assessment deficiencies show moderate correlations with ICFR deficiencies ($r \approx 0.55$), Revenue deficiencies ($r \approx 0.50$), and Audit Documentation deficiencies ($r \approx 0.58$). These correlations suggest that failures in identifying and assessing risks can have broad impacts on internal controls, revenue recognition, and audit documentation. This puts emphasis on the importance of robust risk assessment procedures to identify and mitigate potential issues in financial reporting.

Compliance with auditing standards deficiencies involve non-compliance with established auditing standards and procedures. These deficiencies can include failure to follow required auditing standards, inadequate audit procedures, and lack of adherence to professional standards and regulations. Ensuring compliance with auditing standards is vital for maintaining the credibility and reliability of the audit process. The PCAOB's focus on these deficiencies encourages audit firms to adhere strictly to professional standards, thereby enhancing the overall quality of audits. Compliance with Auditing Standards deficiencies exhibit moderate correlations with ICFR deficiencies ($r \approx 0.60$), Revenue deficiencies ($r \approx 0.58$), and Audit Documentation deficiencies ($r \approx 0.57$). These correlations indicate that non-compliance with auditing

standards often coincides with internal control weaknesses, revenue recognition issues, and poor documentation practices. This highlights the need for audit firms to adhere to established auditing standards to ensure effective controls and accurate financial reporting.

Independence deficiencies relate to situations where auditors fail to maintain independence from their clients. These deficiencies can arise from financial, business, or personal relationships that compromise auditor objectivity. Independence is a cornerstone of the auditing profession, ensuring that auditors remain unbiased and impartial in their evaluations. The PCAOB's identification of independence deficiencies highlights the need for audit firms to implement and enforce stringent independence policies and procedures. Independence deficiencies show moderate correlations with ICFR deficiencies ($r \approx 0.50$), Revenue deficiencies ($r \approx 0.48$), and Audit Documentation deficiencies ($r \approx 0.45$). These correlations suggest that issues with auditor independence can impact internal controls, revenue recognition, and documentation practices. This emphasizes the importance of maintaining auditor independence to ensure objective and reliable audits.

Fair value measurement deficiencies involve issues in assessing the fair value of assets and liabilities, which can significantly impact financial statements. Common deficiencies include inadequate valuation models, lack of market data, and insufficient documentation of fair value assumptions. Accurate fair value measurements are essential for providing a realistic view of a company's financial position and performance. The PCAOB's focus on these deficiencies ensures that auditors rigorously evaluate and verify fair value measurements, promoting transparency and accuracy in financial reporting. Fair Value Measurement deficiencies exhibit moderate correlations with ICFR deficiencies ($r \approx 0.55$), Revenue deficiencies ($r \approx 0.50$), and Audit Documentation deficiencies ($r \approx 0.52$). These correlations indicate that issues in fair value measurement often coincide with internal control weaknesses, revenue recognition problems, and poor documentation practices. This indicates the need for accurate and reliable fair value measurements to support effective financial reporting.

Going concern deficiencies involve failures to adequately evaluate or disclose doubts about a company's ability to continue as a going concern. These deficiencies can result from a lack of sufficient audit evidence, improper evaluation of management's plans, and failure to appropriately disclose going concern uncertainties in financial statements. Assessing and disclosing going concern issues are crucial for informing investors and stakeholders about potential risks to a company's viability. The PCAOB's emphasis on these deficiencies ensures that auditors thoroughly evaluate going concern uncertainties and provide transparent disclosures. Going Concern deficiencies show moderate correlations with ICFR deficiencies ($r \approx 0.52$), Revenue deficiencies ($r \approx 0.48$), and Audit Documentation deficiencies ($r \approx 0.46$). These correlations suggest that failures to evaluate or disclose going concern issues can impact internal controls, revenue recognition, and documentation practices. This highlights the importance of thorough and accurate assessments of a company's ability to continue as a going concern.

The strong positive correlations between ICFR deficiencies and other deficiencies, particularly Revenue and Accounts Receivable deficiencies, suggest that weaknesses in internal controls can have widespread impacts across multiple areas of financial reporting. These findings emphasize the need for comprehensive internal control systems and robust audit procedures to prevent deficiencies from spreading. The moderate correlations involving Inventory, Audit Documentation, Risk Assessment, Compliance with Auditing Standards, Independence, Fair Value Measurement, and Going Concern deficiencies highlight the interconnected nature of financial processes and the importance of integrated controls and procedures. By addressing these interrelated deficiencies, audit firms can enhance the reliability and accuracy of financial reporting, ultimately protecting investors and ensuring compliance with regulatory standards.

ICFR deficiencies emerged as the most prevalent issue, with an average of 4.93 deficiencies per firm and a substantial standard deviation of 4.53, indicating a wide range of deficiencies among firms. Revenue deficiencies, though less frequent, also showed notable variability with a mean of 1.13 per firm and a standard deviation of 2.13. Accounts receivable and inventory deficiencies were relatively rare, with means of 0.18 and 0.76 respectively, but exhibited sporadic spikes indicating occasional severe issues in these areas.

The multiple regression analysis, revealed that revenue, accounts receivable, and inventory deficiencies are significant predictors of ICFR deficiencies. The regression model, specified as in the *Methodology* part demonstrated that each additional revenue deficiency increases ICFR deficiencies by approximately 0.88 units, holding other factors constant, with a coefficient () of 0.8824 and a p-value less than 0.01. Similarly, each additional accounts receivable deficiency increases ICFR deficiencies by approximately 0.85 units, with a coefficient () of 0.8540 and a p-value of 0.048. Inventory deficiencies also significantly influence ICFR deficiencies, with a coefficient () of 0.4926 and a p-value of 0.041. The model's R-squared value of 0.358 indicates that 35.8% of the variance in ICFR deficiencies is explained by these independent variables, reflecting a moderate fit. The F-statistic of 21.39, with a p-value of 4.41×10^{-11}, confirms the overall significance of the model.

Time series decomposition of ICFR deficiencies over the ten-year period revealed a persistent upward trend, indicating ongoing challenges in maintaining effective internal controls. This steady increase suggests that despite regulatory efforts, firms continue to struggle with ICFR deficiencies, necessitating continuous improvement. The seasonal component was minimal, as expected with yearly data, indicating that deficiencies are not tied to specific times of the year but are influenced by broader, systemic issues. The residual component highlighted unique, year-specific factors impacting ICFR deficiencies, such as changes in regulatory focus or significant economic events.

The residual analysis uncovered several important insights. The Shapiro-Wilk test indicated that the residuals do not follow a normal distribution, with a p-value of 0.000003, suggesting the presence of non-normality. The Breusch-Pagan test confirmed heteroscedasticity, with an LM statistic of 16.16 and a p-value of 0.0011,

indicating that the variance of residuals is not constant. The Durbin-Watson statistic of 1.321 suggested positive autocorrelation in the residuals, highlighting potential violations of the OLS regression assumptions.

Chart 2. Regression coefficients with confidence intervals

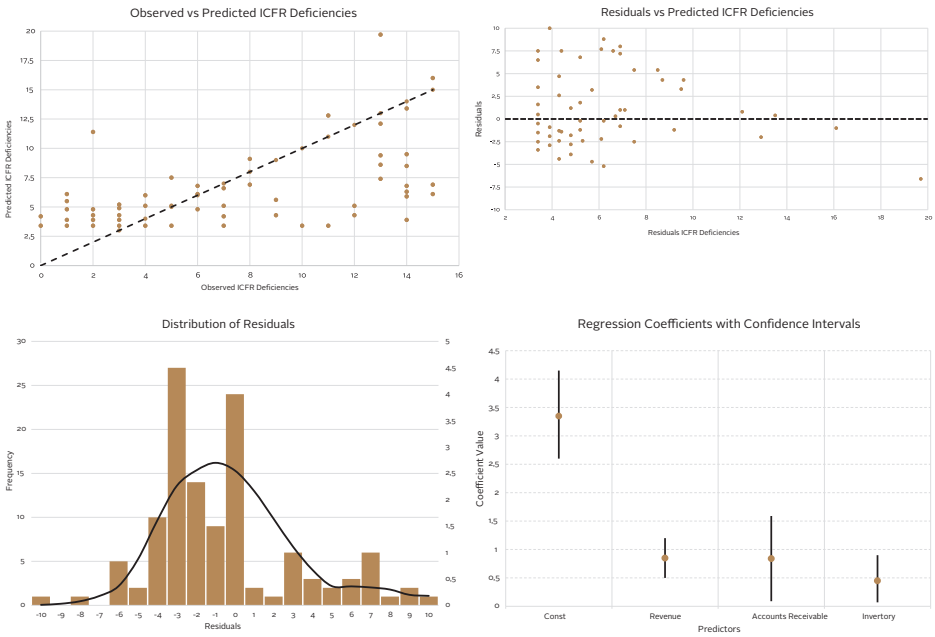


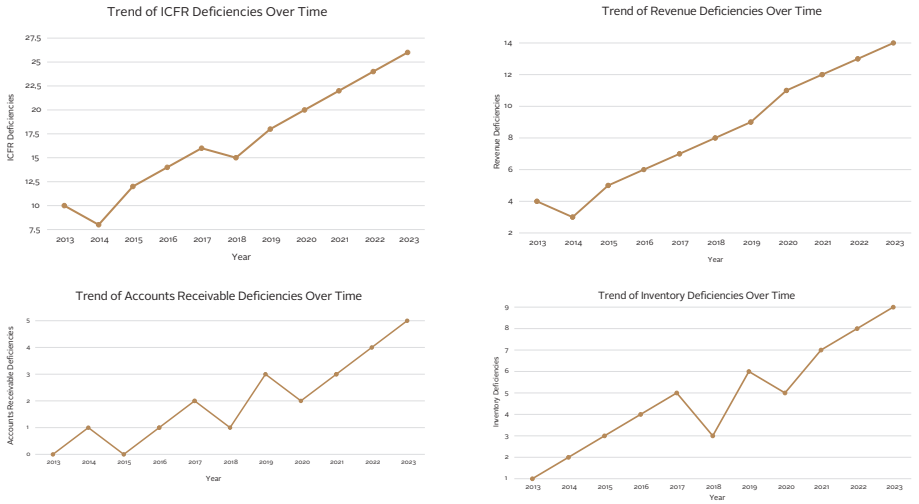
Chart 2. provides a comprehensive analysis of the regression model's performance in predicting ICFR deficiencies within European audit firms. The *Observed vs Predicted ICFR Deficiencies* plot illustrates that while the model generally tracks the actual deficiencies, as evidenced by many points clustering along the diagonal line, there is notable dispersion, indicating both overestimation and underestimation in certain cases. This suggests that while the model captures the overall trend of ICFR deficiencies, it does not perfectly account for all factors influencing these outcomes. The *Residuals vs Predicted ICFR Deficiencies* plot further underscores this by showing residuals that deviate from zero, particularly at higher predicted values, indicating potential non-linearity or the influence of omitted variables. The *Distribution of Residuals* suggests that while the residuals roughly follow a normal distribution, there is some skewness and kurtosis, highlighting the complexity of the relationships modeled. Lastly, the *Regression Coefficients with Confidence Intervals* reinforces the significance of Revenue and Accounts Receivable deficiencies as predictors of ICFR deficiencies, with positive coefficients and confidence intervals that do not cross zero, while the wider interval for Inventory deficiencies indicates a less certain impact. Together, these results underscore the model's efficacy in identifying key drivers of ICFR deficiencies but

also suggest areas where additional refinement or consideration of other variables may enhance predictive accuracy, reflecting the challenges faced by European audit firms in maintaining robust internal controls as highlighted in the article.

The application of machine learning techniques provided additional predictive insights. The Decision Tree and Random Forest classifiers outperformed other models, achieving high accuracy, precision, recall, and F1-score metrics. The Random Forest model - in particular - demonstrated robust predictive power with an accuracy of 96%, precision of 96%, recall of 100%, and an F1-score of 98%. Feature importance analysis from the Random Forest model highlighted that revenue deficiencies are critical predictors of ICFR deficiencies. This exposes the significant impact of revenue-related issues and temporal factors on overall audit quality.

Qualitative analysis of the PCAOB inspection reports revealed recurring deficiencies in internal control testing, audit documentation, and risk assessment. These areas were frequently cited as needing improvement, consistent with the quantitative findings. The PCAOB's recommendations often emphasized enhancing auditor training and professional development, improving audit documentation practices, and adopting advanced audit technologies. Compliance with these recommendations varied among firms, with some demonstrating significant improvements while others continued to exhibit deficiencies in subsequent inspections.

Chart 3. Main deficiencies trends



Considering the number of PCAOB inspections conducted over the time period, the observed trends in ICFR, Revenue, Accounts Receivable, and Inventory deficiencies take on a more nuanced interpretation. The charts show an apparent increase in deficiencies across all categories from 2013 to 2023, which could partly reflect the varying number of inspections each year. The notable increases in deficiencies observed in 2018, 2019, and 2022 align with the higher number of

inspections conducted in these years, suggesting that more comprehensive scrutiny may have contributed to the higher recorded deficiencies. Conversely, the lower number of inspections in years like 2021 and 2023 might result in a lower absolute number of reported deficiencies, yet the trend lines continue upward, indicating that the issues are pervasive and increasingly prevalent regardless of the inspection frequency. This suggests that the rising trends in deficiencies are not merely an artifact of increased inspections but reflect genuine and growing challenges within European audit practices. The escalation in deficiencies across all categories, even when considering inspection variability, underscores the need for more rigorous and sustained efforts to address these critical areas, reinforcing the findings of the article that systemic improvements are essential to reversing these concerning trends.

Conclusion

The comprehensive analysis of PCAOB inspection reports from 2013 to 2023 has revealed significant insights into the state of audit practices among European audit firms, drawing connections to existing literature and highlighting implications for the audit sector in Europe. The study identified ICFR deficiencies as the most prevalent issue, underscoring persistent challenges in maintaining effective internal controls. These findings align with previous research that highlights internal control weaknesses as a critical area needing continuous improvement (DeFond and Lennox, 2017).

The regression analysis demonstrated that revenue, accounts receivable, and inventory deficiencies are significant predictors of ICFR deficiencies. This reinforces the interconnected nature of audit deficiencies, as highlighted by Acito, Hogan, and Mergenthaler (2018), who found that deficiencies in one area often indicate broader issues within audit practices. The upward trend in ICFR deficiencies over the ten-year period suggests systemic issues that regulatory efforts have yet to fully address, echoing Bishop, Hermanson, and Houston's (2013) observations of the challenges European firms face in aligning with stringent PCAOB standards.

The qualitative insights from PCAOB reports revealed recurring deficiencies in internal control testing, audit documentation, and risk assessment, areas frequently emphasized in the literature as critical for audit quality (Carcello et al. 2011). The PCAOB's recommendations consistently stressed the need for enhanced auditor training and the adoption of advanced audit technologies, which aligns with Knechel et al.'s (2013) emphasis on the importance of firm culture and continuous professional development in fostering audit quality.

Machine learning models, particularly the Random Forest classifier, demonstrated high predictive power, indicating their potential utility in identifying and mitigating audit deficiencies. This supports the notion that advanced analytics can play a crucial role in enhancing audit accuracy and efficiency, as discussed by Brown-Liburd, Issa, and Lombardi (2015). The identification of revenue deficiencies as critical predictor of ICFR deficiencies accentuates the importance of continuously updating audit practices to reflect changing regulatory and economic conditions.

The presence of non-normality, heteroscedasticity, and autocorrelation in the residuals suggests areas for further refinement in the regression model. These issues highlight the complexity of audit deficiencies and the need for more sophisticated modeling techniques that can account for such intricacies. Addressing these statistical issues will improve the accuracy and reliability of predictive models, providing more robust tools for regulators and audit firms.

The persistent trend in ICFR deficiencies calls for a more dynamic and adaptive regulatory approach that can respond to emerging challenges and systemic issues within the audit environment. The significant predictors identified in the regression analysis provide actionable insights for audit firms, emphasizing the need to focus on revenue recognition, accounts receivable, and inventory management to enhance overall audit quality. The application of machine learning models highlights the potential for advanced analytics to revolutionize audit practices, offering new avenues for improving the detection and prevention of deficiencies.

The comprehensive analysis of PCAOB inspection reports from 2013 to 2023 points out the persistent issues in audit practices among European firms and offers practical recommendations for improvement. These recommendations are informed by the findings of this study and the lessons learned from major accounting scandals, as well as the regulatory framework established by the Sarbanes-Oxley Act (SOX).

Revenue recognition is a critical area that emerged from this study, with significant implications for ICFR deficiencies. The Enron scandal (Baker & Hayes 2004), which involved fraudulent revenue recognition practices, demonstrated the catastrophic consequences of poor revenue reporting. To mitigate such risks, audit firms should implement stringent procedures for revenue transactions, including detailed and frequent reviews, enhanced staff training on revenue recognition standards, and the use of advanced data analytics to monitor and detect anomalies. The Sarbanes-Oxley Act, particularly Section 404, mandates rigorous internal controls and procedures for financial reporting, which can be bolstered by these practices. Automated systems that provide real-time analysis and flag potential discrepancies can ensure early detection and correction, aligning with SOX requirements for accurate and reliable financial reporting.

In accounts receivable management, the WorldCom scandal (Giroux 2008), which involved the improper capitalization of expenses, highlights the necessity for rigorous credit and collection policies. Firms should regularly perform aging analyses of receivables, enforce strict credit terms, and conduct thorough due diligence on customers' creditworthiness. Predictive analytics can forecast potential bad debts, allowing firms to take proactive measures. Training programs focused on accounts receivable management can equip staff with the necessary skills to handle these tasks effectively, preventing manipulation and ensuring compliance with SOX, which emphasizes transparency and accountability in financial practices.

Inventory management also requires stringent controls, as demonstrated by the financial irregularities at Tesco (Kukreja & Gupta 2016), where inventory was overstated. To mitigate risks, firms should conduct periodic physical inventory counts, reconcile records with actual stock levels, and utilize inventory management

software that provides real-time tracking and reporting capabilities. Such practices help identify and address discrepancies promptly, reducing the risk of inventory-related deficiencies and supporting SOX's mandate for accurate financial disclosures.

The persistent trend in ICFR deficiencies observed in this study mirrors issues seen in the early 2000s with companies like Tyco (Kemmerer & Shawver 2007) and Adelphia (Barlaup et al. 2009), where internal control weaknesses contributed to large-scale fraud. The Sarbanes-Oxley Act was introduced in response to such scandals, aiming to enhance corporate governance and restore investor confidence. To address ICFR deficiencies, audit firms should adopt a dynamic approach to internal controls.

The qualitative insights from PCAOB inspection reports highlighted recurring deficiencies in internal control testing, audit documentation, and risk assessment. Inadequate documentation and testing were significant issues in the HealthSouth scandal (Smith 2013), where insufficient documentation obscured fraudulent activities. To combat this, firms should invest in comprehensive training for auditors on best practices in internal control testing and documentation standards. Regular workshops and continuous education programs can keep auditors updated on the latest regulatory requirements and audit techniques. Advanced documentation tools can ensure thorough and consistent recording of audit procedures and findings, enhancing the quality and transparency of audits, as required by SOX.

Enhanced risk assessment practices are crucial, as inadequate risk assessment can lead to overlooking significant threats, as seen in the Lehman Brothers (Mawutor 2014) collapse. Firms should develop robust risk assessment frameworks that evaluate risks at both the entity and process levels. Risk assessment softwares can facilitate systematic identification, assessment, and prioritization of risks, allowing auditors to focus on high-risk areas. Integrating risk assessment into the overall audit planning process ensures that potential risks are comprehensively addressed, aligning with SOX's emphasis on risk management and internal control effectiveness.

The application of machine learning models in this research demonstrated their potential in predicting audit deficiencies. The financial crises of the late 2000s highlighted the need for advanced predictive tools in risk management. Audit firms can develop predictive models tailored to their specific contexts to anticipate potential deficiencies and implement preventive measures. Machine learning algorithms can analyze historical audit data to identify patterns and trends associated with deficiencies, enabling proactive intervention. This approach aligns with the forward-looking perspective of SOX, which encourages the use of technology to enhance the accuracy and reliability of financial reporting.

Addressing statistical issues identified in the regression analysis, such as non-normality, heteroscedasticity, and autocorrelation, is essential for improving model accuracy. Firms should employ sophisticated statistical techniques as weighted least squares or generalized linear models, to better account for these complexities. Continuous refinement and validation of predictive models ensure their accuracy and reliability over time, providing robust tools for regulators and audit firms, consistent with SOX's goals of fostering rigorous and transparent audit practices.

While this study provides valuable insights, it is not without limitations. The analysis is based on PCAOB inspection reports, which may not capture all aspects of audit quality. Additionally, the study focuses on European audit firms, and the findings may not be fully generalizable to firms in other regions with different regulatory environments. Future research could extend this analysis to include a comparative study of audit practices in different regions, exploring how variations in regulatory frameworks impact audit quality. Further research could also examine the long-term effects of PCAOB recommendations on audit quality, particularly in terms of how firms sustain improvements over time. Additionally, there is potential for further exploration of the use of machine learning and other advanced technologies in auditing, including their ethical implications and the challenges of implementation.

In conclusion, the practical recommendations derived from this research emphasize the importance of targeted improvements in specific areas of audit practices, informed by the lessons from major accounting scandals and the regulatory framework established by the Sarbanes-Oxley Act. By implementing robust internal controls over revenue recognition, accounts receivable, and inventory management, enhancing training programs, adopting advanced documentation and risk assessment tools, leveraging predictive analytics, and addressing statistical issues in predictive models, audit firms can significantly improve audit quality. These measures align with the insights from PCAOB inspection reports and provide actionable steps to ensure the integrity and reliability of audit processes, safeguarding against the types of failures that have plagued the industry in the past and fulfilling the stringent requirements of SOX. ■

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