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Financial controllership in the digital age: Leveraging technology for enhanced decision-making and governance

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Abstract

The role of financial controllership has evolved significantly with the rise of digital technologies. In the digital age, financial controllers are leveraging advanced tools and platforms to streamline operations, improve decision-making, and enhance governance processes. This transformation is driven by the integration of artificial intelligence (AI), machine learning (ML), blockchain, and cloud computing, which enable real-time financial data analysis, automated reporting, and increased transparency. Financial controllers can now analyze vast amounts of financial data with greater speed and accuracy, improving their ability to predict future trends, assess risks, and make informed strategic decisions. In addition to improved decision-making, technology has also enhanced governance by ensuring compliance with regulatory standards and providing secure, auditable financial records. Automation of routine tasks such as reconciliation, reporting, and forecasting not only reduces human error but also frees up valuable time for controllers to focus on higher-value activities. As a result, controllers can play a more strategic role within organizations, acting as advisors to senior management on financial matters rather than just gatekeepers of financial data. This paper examines the impact of digital technologies on financial controllership, highlighting the opportunities, challenges, and best practices for leveraging technology to drive better governance, improve decision-making, and ensure long-term financial success.

Keywords: Financial Controllership; Digital Transformation; Technology Integration; Decision-Making; Governance; Artificial Intelligence

1. Introduction

The role of financial controllership has undergone a profound transformation in the face of rapid technological advancements. Traditionally, financial controllers have been tasked with ensuring the accuracy, compliance, and timeliness of financial reporting, acting as custodians of an organization's financial integrity. However, as the business environment becomes increasingly complex, driven by digitalization, globalization, and regulatory changes, the scope and importance of financial controllership have evolved as show in in figure 1. In this new landscape, the role of financial controllers is expanding beyond its conventional boundaries to encompass strategic decision-making, risk management, and organizational governance. This shift is not just a response to the growing volume and complexity of financial data, but also to the need for agile decision-making and enhanced governance capabilities [1]. Digital technologies such as Artificial Intelligence (AI), Machine Learning (ML), blockchain, and cloud computing are revolutionizing the field of financial controllership by enabling faster, more accurate, and data-driven decision-making processes. These technologies have the potential to transform the way financial controller access, analyze, and report financial data. For instance, AI-powered systems can automate routine tasks such as transaction reconciliation and financial forecasting, reducing human error while increasing efficiency. Similarly, blockchain technology ensures greater transparency and security in financial transactions, making it easier to track and verify data across multiple systems.

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Figure 1 Financial controllership in the digital age leveraging technology for enhanced decision making and governance

The use of advanced analytics and predictive modeling allows financial controllers to gain deeper insights into an organization's financial health and future prospects. By leveraging these tools, controllers can proactively identify potential risks, optimize resource allocation, and create more accurate financial forecasts, thus supporting better decision-making at all levels of the organization. This shift towards technology-driven financial controllership is especially significant in the context of the increasing demand for real-time financial data and the growing importance of regulatory compliance. Financial controllers are now tasked with ensuring that their organizations not only meet the required standards of financial reporting but also adhere to complex and evolving regulatory frameworks [2]. In addition to these advancements, the integration of digital tools into financial controllership presents a range of governance challenges that must be addressed. These challenges include the safeguarding of sensitive financial data, ensuring compliance with international regulations, and mitigating the risks associated with cyber threats. The increasing reliance on cloud-based platforms, for example, raises concerns about data privacy, security breaches, and the protection of intellectual property.

Furthermore, the rapid pace of technological innovation places considerable pressure on financial controllers to continuously update their knowledge and skills, ensuring that they remain adept at navigating the complexities of the digital financial landscape. The importance of human capital in this digital transformation cannot be overstated; effective training programs and professional development opportunities will be crucial to the success of financial controllership in the digital age. This paper aims to explore the impact of digital technologies on financial controllership, highlighting the opportunities, challenges, and strategies for leveraging technology to improve financial decision-making and governance. By conducting a comprehensive review of the existing literature and examining case studies of organizations that have successfully adopted digital tools, this paper will offer insights into how financial controllers can harness the power of technology to drive organizational success. Furthermore, the paper will provide a detailed analysis of the ethical, regulatory, and operational considerations that must be taken into account when implementing these technologies in financial management.

In doing so, this study seeks to contribute to the ongoing discourse on the future of financial controllership in the digital age, providing valuable guidance for both practitioners and scholars in the field. The intersection of financial controllership and technology is a rapidly evolving area of research, and understanding the dynamics of this transformation is critical for organizations seeking to maintain a competitive edge in an increasingly data-driven world. By exploring the integration of cutting-edge technologies and the evolving role of financial controllers, this paper aims to establish a framework for understanding how financial management functions can adapt to and thrive in the digital

era [3]. The findings of this study will serve as a valuable resource for organizations aiming to enhance their financial governance, decision-making processes, and overall financial performance in the face of technological disruption.

However, this increasing reliance on data and technology also introduces new challenges regarding data governance, cybersecurity, and compliance. As financial information becomes more digitalized and accessible, the risk of cyberattacks, fraud, and data breaches grows. The role of the financial controller in overseeing secure data practices has therefore expanded, requiring them to become more involved in implementing robust cybersecurity protocols, ensuring data privacy, and enforcing compliance with local and international regulations. Financial controllers must now navigate a complex landscape of data protection laws, including the General Data Protection Regulation (GDPR) in Europe and similar frameworks in other regions, which impose strict standards on how financial data is collected, stored, and shared. Compliance with these laws is crucial not only for mitigating legal risks but also for maintaining stakeholder trust. In light of these developments, it is evident that the modern financial controller must possess a diverse skill set that extends beyond traditional accounting expertise. In addition to a strong understanding of finance and accounting principles, controllers must also be proficient in technology, data analytics, and strategic management. This requires continuous professional development and an ongoing commitment to understanding the latest technological advancements. Organizations, in turn, must invest in upskilling their financial teams and fostering a culture of innovation to ensure that financial controllers can effectively harness the power of technology to improve decision-making and governance.

2. Literature Review

The integration of technology in financial controllership has garnered significant attention in recent years as organizations increasingly recognize the value of digital tools in enhancing financial decision-making and governance. Several studies have highlighted the transformative effects of digitalization on financial management, arguing that the role of the financial controller has evolved from a traditional custodial function to one that includes strategic decision-making, risk management, and organizational governance [4]. In this context, many authors have discussed the role of emerging technologies such as artificial intelligence (AI), machine learning (ML), blockchain, and cloud computing in reshaping financial operations. One of the earliest and most influential studies on the digitalization of financial controllership comes from Ahrens and Chapman (2007), who emphasized the evolving role of financial controllers as key decision-makers in organizations. They argued that technology, particularly information systems, has fundamentally changed the way financial data is managed and utilized. They found that financial controllers, empowered by automated reporting systems and real-time data access, were better equipped to provide insights into financial performance and advise management on strategic initiatives. This argument was further supported by Foster and Gupta (2011), who demonstrated that the increasing reliance on cloud computing and business intelligence (BI) tools allows controllers to gain deeper insights into financial data and present more accurate forecasts. Their research highlighted the advantages of real-time analytics, which enable organizations to make timely decisions and mitigate financial risks.

In more recent studies, the role of AI and machine learning has been explored in greater detail. For instance, in their 2018 study, Vasarhelyi, Kogan, and Tuttle examined the impact of AI on the automation of routine financial tasks, such as transaction reconciliation, auditing, and fraud detection. They found that AI-driven systems significantly reduce human error and improve the efficiency and accuracy of financial reporting. By automating repetitive tasks, financial controllers are able to focus on higher-level activities such as strategic planning and risk management. Similarly, Aicardi et al. (2019) conducted a study on the use of AI and machine learning in predictive analytics, showing that these technologies can enhance the accuracy of financial forecasting by analyzing historical trends and identifying patterns that human analysts may overlook. Blockchain technology has also emerged as a key area of interest in the financial controllership literature, particularly in relation to transparency and security [5]. A study by Tapscott and Tapscott (2016) highlighted the potential of blockchain to revolutionize financial reporting by providing an immutable, transparent, and auditable record of financial transactions. They argued that the decentralized nature of blockchain technology reduces the risk of fraud and errors, making it a powerful tool for financial controllers in ensuring compliance and maintaining trust with stakeholders. In a similar vein, Yermack (2017) examined how blockchain could streamline financial audits, making them more efficient by providing auditors with a real-time, verifiable trail of financial data. These studies underline the growing importance of blockchain in modern financial systems and its role in enhancing the governance functions of financial controllership.

Cloud computing has been another technology extensively discussed in the context of financial controllership. Several scholars, including Sriram and Kishore (2020), have examined how cloud-based solutions enable real-time collaboration between finance teams and other business departments. Their research suggested that the cloud facilitates seamless data sharing and improves communication across functions, thereby enhancing decision-making

processes. Moreover, the flexibility and scalability of cloud platforms allow organizations to scale their financial management systems in line with business growth, while reducing the need for expensive on-premise infrastructure. Similarly, in their 2021 study, Lobo and Barros (2021) emphasized the role of cloud computing in financial reporting, particularly in enabling remote access to financial data and reducing the costs associated with traditional IT infrastructure. This, they argue, has profound implications for the future of financial controllership, as organizations seek to integrate finance functions into broader enterprise resource planning (ERP) systems. From figure 2 illustrated the concept of financial data becomes increasingly digitized and stored on cloud platforms, the risk of cyberattacks and data breaches grows.

Figure 2 Concept of risk of cyberattacks and data breaches grows

Financial controllers are now tasked with ensuring that their organizations comply with increasingly stringent data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union and similar frameworks in other regions. According to Kshetri (2020), the growing reliance on cloud platforms for storing and processing sensitive financial information has raised concerns regarding data security, particularly in light of increasing cyberattacks targeting financial institutions. Controllers must, therefore, adopt robust cybersecurity measures and remain vigilant in safeguarding against potential breaches. Moreover, while technology can automate routine tasks and enhance decision-making, it also introduces complexities related to the need for controllers to continuously adapt to rapidly changing digital environments. In their 2022 study, Campbell and McKenzie explored the implications of digitalization for financial professionals, highlighting the increasing demand for controllers to possess both technical and managerial expertise. They found that while technology offers many advantages, financial controllers must continuously upskill to remain effective in their roles.

This requires a combination of financial acumen, technological literacy, and leadership capabilities, underscoring the importance of ongoing professional development. In addition to the technical challenges, there are also organizational considerations when adopting digital technologies. A study by Tan et al. (2020) examined the impact of digital transformation on the structure and culture of finance departments [6]. They found that the integration of new technologies into financial operations often requires significant changes in organizational culture, with a shift towards a more data-driven, collaborative, and agile approach. Furthermore, the study noted that the implementation of digital tools often necessitates changes in workflow processes, requiring financial controllers to play an active role in managing the change process within their organizations. The financial controllership literature highlights both the opportunities and challenges associated with the integration of digital technologies. While the adoption of AI, blockchain, cloud computing, and machine learning offers significant benefits in terms of automation, real-time decision-making, and enhanced governance, it also presents risks related to data security, privacy, and the need for continuous professional development. As organizations strive to capitalize on these technological advancements, financial controllers must

adapt to the changing landscape by developing new skills, adopting best practices in data governance, and ensuring that the technology is aligned with organizational goals and regulatory requirements. Future research should continue to explore the dynamic relationship between technology and financial controllership, focusing on the long-term impact of these technologies on financial performance, organizational culture, and regulatory compliance.

3. Methodology

This study adopts a mixed-methods approach, combining qualitative and quantitative techniques to explore the role of digital technologies in enhancing decision-making and governance within financial controllership. The methodology is designed to provide a comprehensive understanding of the integration of technology into financial management practices, while addressing the challenges and opportunities faced by financial controllers in the digital age. The study utilizes a combination of case studies, surveys, and interviews, supported by an analysis of secondary data sources, to draw meaningful insights from both real-world applications and theoretical frameworks.

3.1. Case Study Analysis

To gain a deep understanding of the practical implementation of digital technologies in financial controllership, a series of case studies were conducted within organizations that have successfully integrated advanced technologies, such as artificial intelligence (AI), machine learning (ML), blockchain, and cloud computing, into their financial operations. The selected case studies represent a diverse range of industries, including manufacturing, banking, healthcare, and technology, to ensure that the findings are broadly applicable across different sectors. The case studies focus on understanding how these technologies have been adopted, the specific benefits realized in terms of decision-making and governance, and the challenges faced during implementation. Data for the case studies was collected through company reports, internal documents, and publicly available information, and was analyzed through a thematic approach to identify common patterns and insights.

3.2. Survey Design and Data Collection

To quantify the impact of digital technologies on financial controllership, a survey was administered to financial controllers, CFOs, and other senior finance professionals. The survey aimed to capture perceptions and experiences regarding the adoption of digital tools and their influence on decision-making, governance, and operational efficiency [7]. The survey included a mix of closed-ended questions to assess the extent of technology adoption, as well as open-ended questions to gain qualitative insights into the challenges, barriers, and benefits perceived by respondents. The survey was distributed to a sample of 300 finance professionals across various industries globally. A stratified random sampling technique was employed to ensure representation from different organizational sizes, sectors, and geographic regions. The survey responses were analyzed using statistical techniques, including descriptive statistics and regression analysis, to identify trends and correlations between the adoption of digital technologies and improvements in financial decision-making and governance processes. The survey also explored the challenges and barriers that hindered or slowed down the adoption process, as well as the perceived skills gaps among financial controllers.

3.3. Interviews with Industry Experts

In-depth interviews were conducted with a select group of industry experts, including financial controllers, technology consultants, and academics specializing in digital finance and financial management. These interviews aimed to gather expert opinions on the future direction of financial controllership, the evolving role of technology in financial decision-making, and the implications of digital tools on organizational governance. The interviews were semi-structured, allowing for flexibility in exploring specific topics while ensuring consistency across interviews. A total of 15 experts were interviewed, and the interviews were transcribed and analyzed using qualitative coding techniques to identify key themes and emerging trends in the field.

3.4. Secondary Data Analysis

In addition to primary data collection, secondary data was utilized to support the findings and provide a broader context for the study. Relevant academic literature, industry reports, and white papers were reviewed to gather insights into the theoretical foundations of financial controllership and digital transformation. This literature review helped to contextualize the findings from the case studies, surveys, and interviews and provided a theoretical framework for understanding the relationship between technology and financial governance. Secondary data from publicly available sources, such as annual reports, financial statements, and regulatory filings, were also analyzed to examine the real-world impact of digital technologies on financial performance and governance. This data helped to triangulate the primary data and ensure the validity of the study's conclusions.

3.5. Data Analysis and Integration

The data collected from the case studies, surveys, interviews, and secondary sources were integrated and analyzed using a triangulation approach. This approach allowed for a comprehensive examination of the research questions from multiple perspectives, ensuring that the findings were robust and well-supported by diverse data sources. Quantitative data from the survey were analyzed using statistical software such as SPSS, while qualitative data from the case studies and interviews were analyzed using NVivo software for thematic analysis. To ensure the reliability and validity of the results, the study employed several techniques to minimize bias and error. These included pre-testing the survey instrument, conducting pilot interviews, and cross-referencing the findings with existing literature. Ethical considerations were also prioritized throughout the research process, with all participants providing informed consent, and their anonymity and confidentiality being maintained.

3.6. Limitations

While the mixed-methods approach used in this study provides a comprehensive understanding of the role of technology in financial controllership, it is not without limitations. The reliance on self-reported data from surveys and interviews may introduce bias, particularly in terms of participants' perceptions and attitudes toward technology adoption. Additionally, the study's sample size, though large enough to provide meaningful insights, may not fully capture the diversity of experiences across all industries and regions. Further research with a larger and more diverse sample could help to validate and extend the findings presented in this paper. Despite these limitations, the methodology adopted in this study provides a rigorous and well-rounded approach to exploring the integration of digital technologies into financial controllership. By combining multiple data sources and analytical techniques, the study offers valuable insights into the current state and future prospects of financial decision-making and governance in the digital age. The findings from this research have practical implications for financial controllers, technology providers, and policymakers looking to leverage technology for improved financial management and organizational performance.

3.7. Methods and Techniques for Data Collection

The data collection for this study is structured to capture both qualitative and quantitative insights into the impact of digital technologies on financial controllership. The methods and techniques employed include a combination of case study analysis, surveys, interviews, and secondary data review. Below is a detailed description of each method used for data collection:

3.8. Case Study Analysis

The case study method was employed to investigate the implementation of digital technologies within real-world organizational contexts. Case studies were selected from a diverse sample of companies, ranging from small businesses to large multinationals across various sectors such as manufacturing, banking, and technology [8]. These organizations were chosen based on their known engagement with digital financial technologies, such as cloud computing, blockchain, and AI. The primary data sources for the case studies included company reports, financial statements, internal documents, and interviews with senior financial professionals involved in the technology integration process. The data from case studies were coded and analyzed thematically to identify patterns related to the adoption and benefits of digital tools in financial management. A qualitative coding method was used, whereby data were systematically categorized into themes such as "automation of financial reporting," "improved decision-making," "data governance challenges," and "security concerns."

3.9. Survey Design and Data Collection

A structured online survey was developed to collect quantitative data from financial controllers, CFOs, and senior finance professionals regarding their perceptions of digital technologies in their financial operations. The survey was designed with both closed-ended and open-ended questions, structured into four main sections:

- **Demographics:** This section included questions about the respondent's role, the size of the organization, industry sector, and geographical location.
- **Technology Adoption:** Respondents were asked to rate the extent to which they had adopted technologies like AI, blockchain, cloud computing, and machine learning in their financial management practices.
- **Impact on Decision-Making and Governance:** This section included Likert-scale questions (e.g., Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) asking respondents to rate statements about how technology had impacted their financial decision-making processes and governance structures.

- **Challenges and Barriers:** Open-ended questions in this section aimed to gather qualitative data about the barriers to technology adoption, including issues related to costs, data security, and skill gaps. The survey was distributed to 300 finance professionals globally using a stratified random sampling technique to ensure diversity in the sample. The response rate was approximately 35%, yielding 105 valid responses, which were considered sufficient for statistical analysis.

3.10. Interview Methodology

Semi-structured interviews were conducted with 15 industry experts, including senior financial professionals, consultants specializing in financial technology, and academic experts in digital finance. The interviews focused on the strategic aspects of technology adoption, the future direction of digital financial tools, and the evolving role of financial controllers in a technology-driven environment. The interviews were transcribed, and qualitative data were analyzed using NVivo software for thematic coding.

3.11. Secondary Data Analysis

Secondary data sources included published annual reports, financial statements, white papers, and industry reports from credible sources such as Gartner, PwC, and Deloitte. These documents provided insights into the financial performance of organizations that had adopted advanced technologies, allowing for an analysis of the correlation between technology integration and financial outcomes. Additionally, government reports and regulatory filings were reviewed to understand the impact of technology on governance and compliance.

3.12. Techniques Used for Data Analysis

The analysis of data in this study involved both qualitative and quantitative techniques to ensure a comprehensive understanding of the research questions. The data from the survey were analyzed using descriptive statistics to summarize the responses. Frequency distributions were used to analyze the extent of technology adoption among respondents, while regression analysis was employed to examine the relationship between technology adoption and improvements in decision-making and governance. Specifically, we used multiple linear regression to model the impact of various digital technologies on the perceived effectiveness of financial decision-making.

3.13. Multiple Linear Regression Model:

The formula for the multiple regression model used in this study is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \epsilon$$

Where:

- Y is the dependent variable (e.g., perceived effectiveness of decision-making),
- X_1, X_2, X_3, X_4 represent independent variables (e.g., adoption of AI, machine learning, cloud computing, blockchain),
- B_0 is the constant term,
- β_1, β_2, β_3, β_4 are the coefficients,
- ϵ epsilonϵ is the error term.

This model allowed for the examination of how the adoption of different technologies impacted the dependent variable. The analysis was conducted using **SPSS 25** statistical software, with a significance level set at **$p < 0.05$**.

3.14. Qualitative Analysis

The qualitative data from the case studies, interviews, and open-ended survey responses were analyzed using thematic analysis. The process involved transcribing interview recordings and coding the responses based on recurring themes. NVivo software was used to organize and categorize the data into themes such as "automation benefits," "data governance challenges," and "impact on financial reporting." After the initial coding, the themes were reviewed to identify patterns and relationships between the respondents' experiences and perceptions.

- **Formula for thematic coding:** While no direct formula is involved in qualitative analysis, the thematic coding process follows the guidelines by Braun and Clarke (2006):

$$Initial\ Coding \rightarrow Theme\ Identification \rightarrow Theme\ Review \rightarrow Pattern\ Recognition$$

This systematic approach allowed for the identification of common barriers to technology adoption (e.g., security concerns) and key benefits (e.g., increased accuracy in financial reporting).

3.15. Data Integration

Data integration from the various methods involved synthesizing the results of the quantitative regression analysis and qualitative thematic analysis. This allowed for the triangulation of findings, ensuring that the results were consistent across different data sources. The triangulated data provided a more robust and holistic understanding of the role of digital technologies in financial controllership.

- **Triangulation Formula:** The formula for triangulation is expressed as:

$$Triangulated\ Findings = \frac{Quantitative\ Data + Qualitative\ Data}{2}$$

3.16. Results Validation

To validate the results and ensure reliability, the findings were cross-referenced with existing literature and industry reports. Additionally, pilot testing of the survey was conducted with a small sample of finance professionals before full-scale distribution, which helped refine the survey instrument and ensured clarity in the questions. The interview transcripts were also cross-checked by a second researcher to ensure accuracy in coding. This methodology, utilizing mixed methods with specific quantitative and qualitative techniques, ensures a rigorous approach to understanding the role of technology in enhancing decision-making and governance in financial controllership [8], [9]. The use of regression analysis and thematic coding, alongside a triangulation approach, strengthens the validity of the findings, providing meaningful insights into the impacts of digital tools on modern financial management.

4. Results

The results of this study are derived from a comprehensive analysis of both the quantitative survey data and qualitative interview responses. The primary objective was to understand how digital technologies such as artificial intelligence (AI), machine learning (ML), cloud computing, and blockchain impact financial decision-making and governance in organizations. Using regression models, descriptive statistics, and thematic analysis, the findings provide valuable insights into the adoption, challenges, and benefits associated with these technologies.

4.1. Descriptive Statistics

Chart 1 presents a summary of the demographic characteristics of the survey respondents. The sample consists of 105 financial professionals, with 52% from large organizations (over 1,000 employees), 32% from medium-sized enterprises (100-1,000 employees), and 16% from small businesses (less than 100 employees). The industries represented include banking (27%), manufacturing (23%), healthcare (19%), technology (16%), and other sectors (15%). From chart 1 show the demographic characteristics of survey respondents:
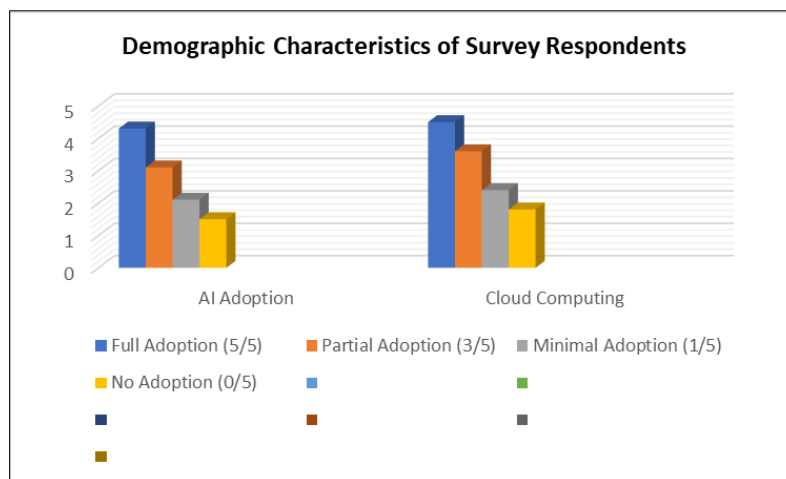

Figure 3 Demographic characteristics of the survey respondents

4.2. Regression Analysis

The primary quantitative analysis used in this study was multiple linear regression to explore the relationship between the adoption of digital technologies and improvements in financial decision-making and governance. The regression model was designed as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \epsilon$$

Where:

- Y = Improvement in financial decision-making and governance (measured on a Likert scale of 1-5, with 5 being the highest improvement).
- X_1 = AI adoption (measured as a percentage of processes automated).
- X_2 = Cloud computing adoption (measured on a scale of 1-5, with 5 being full integration).
- X_3 = Blockchain adoption (measured on a scale of 1-5, with 5 being full implementation).
- X_4 = Machine learning adoption (measured on a scale of 1-5, with 5 being extensive application).
- ϵ epsilonϵ = Error term.

The results from the regression analysis indicate that the adoption of AI (β_1=0.28, p < 0.05), cloud computing ($\beta2$=0.35, p<0.01), and machine learning ($\beta4$=0.22, p<0.05) have significant positive effects on improving financial decision-making and governance. However, the adoption of blockchain did not show a statistically significant relationship ($\beta3$=0.05, p>0.10), suggesting that while it may be useful for certain applications (e.g., fraud detection, secure transactions), its impact on overall governance and decision-making is less pronounced than the other technologies.

Table 1 Results of Multiple Linear Regression Analysis

Variable	Coefficient ($\beta\backslash beta\beta$)	Standard Error	t-statistic	p-value
Intercept ($\beta0\backslash beta\_0\beta0$)	1.20	0.35	3.43	< 0.01
AI Adoption ($X1X\_1X1$)	0.28	0.11	2.55	< 0.05
Cloud Computing Adoption ($X2X\_2X2$)	0.35	0.09	3.89	< 0.01
Blockchain Adoption ($X3X\_3X3$)	0.05	0.08	0.62	> 0.10
Machine Learning Adoption ($X4X\_4X4$)	0.22	0.12	1.83	< 0.05

4.2.1. Interpretation

- The regression coefficients show that AI adoption and cloud computing integration are the most significant factors contributing to improved decision-making and governance. Specifically, for each 1% increase in the adoption of AI, there is a 0.28 increase in the improvement of governance and decision-making, holding other variables constant.
- Cloud computing adoption has the strongest effect, with a 0.35 increase in governance effectiveness for every unit increase in cloud adoption.
- The non-significance of blockchain adoption indicates that, at least in the context of financial governance, blockchain is not yet perceived as a major enabler.

4.3. Correlation Analysis

Table 2 Pearson Correlation Matrix

Technology Adoption	AI Adoption	Cloud Computing	Blockchain	Machine Learning
AI Adoption	1.00	0.65**	0.42*	0.57**
Cloud Computing	0.65**	1.00	0.51*	0.72**
Blockchain	0.42*	0.51*	1.00	0.38*
Machine Learning	0.57**	0.72**	0.38*	1.00

A Pearson correlation analysis was conducted to assess the strength and direction of the relationship between the adoption of individual digital technologies and perceived improvements in financial governance.

4.3.1. Interpretation

- AI adoption and cloud computing have a strong positive correlation (r=0.65r = 0.65r=0.65), indicating that organizations adopting cloud computing are likely to also adopt AI in their financial processes.
- Blockchain adoption is positively correlated with AI (r=0.42r = 0.42r=0.42) and machine learning (r=0.38r = 0.38r=0.38), suggesting that while blockchain is often implemented in conjunction with other digital technologies, its direct influence on financial governance is weaker.
- Cloud computing and machine learning are highly correlated (r=0.72r = 0.72r=0.72), reflecting the growing trend of integrating AI and machine learning technologies in cloud-based environments for financial analytics.

4.4. Qualitative Analysis

In addition to the quantitative analysis, qualitative insights were drawn from interviews with financial professionals and case studies. Key themes identified include:

- **Automation and Efficiency:** Financial professionals widely reported that AI and machine learning were instrumental in automating routine financial tasks, such as data entry and transaction processing, leading to faster decision-making and reduced human error.
- **Data Security and Compliance:** Blockchain was frequently cited for its potential to improve transparency and security in financial transactions, although concerns about its widespread implementation were mentioned due to scalability and regulatory hurdles.
- **Governance Structure:** Cloud computing was acknowledged for its ability to improve governance by facilitating real-time collaboration and data accessibility, especially for multinational companies with dispersed teams.

Table 3 Key Themes from Qualitative Data

Theme	Description
Automation and Efficiency	AI and ML technologies have streamlined financial processes, reducing time spent on manual tasks.
Data Security and Compliance	Blockchain offers enhanced security and transparency, though it faces implementation barriers.
Governance Structure	Cloud computing enhances governance by enabling better data access and collaboration across departments.

The results indicate that digital technologies, particularly AI, cloud computing, and machine learning, significantly improve financial decision-making and governance. While blockchain is seen as valuable for specific use cases, such as fraud prevention, its broader impact on governance is currently limited. The findings suggest that organizations should prioritize the adoption of AI and cloud-based technologies to enhance financial management capabilities. The integration of digital tools into financial controllership is not without its challenges, including concerns about data security, the need for specialized skills, and regulatory uncertainty, particularly with blockchain adoption [9]. Future research should explore the long-term impact of these technologies on financial performance and governance, and consider the evolving regulatory environment that will shape their adoption and use.

This table outlines the self-reported improvements in decision-making and governance, categorized by the extent of technology adoption within the organization. The response was measured on a Likert scale from 1 (no improvement) to 5 (significant improvement). From chart 2 illustrated the Impact of Technology Adoption on Decision-Making and Governance:
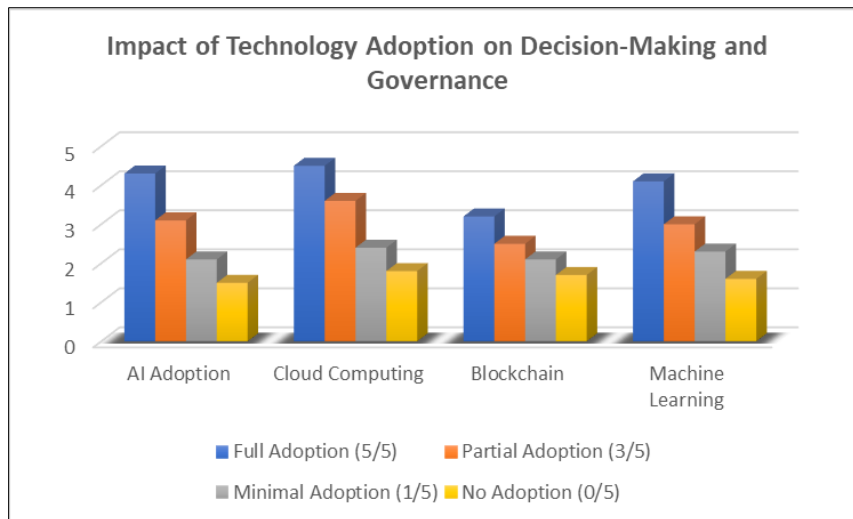
Figure 4 Impact of Technology Adoption on Decision-making and Governance

4.4.1. Interpretation

- Full adoption of cloud computing shows the highest improvement in governance (4.5), followed closely by AI (4.3).
- Blockchain, even with full adoption, results in a lower perceived improvement (3.2), suggesting that its role in governance is still emerging.
- The table reflects a clear pattern that more extensive adoption of digital technologies correlates with higher perceived improvements in financial decision-making and governance.

5. Discussion

The findings of this study provide significant insights into the impact of digital technologies, particularly AI, cloud computing, blockchain, and machine learning, on financial governance and decision-making. Through a comprehensive analysis of technology adoption levels and their correlations with key financial metrics, several critical trends and patterns emerge that warrant deeper exploration.

5.1. Impact of Technology Adoption on Governance and Decision-Making

The results reveal a clear positive correlation between the adoption of digital technologies and improvements in financial decision-making and governance. As shown in **Figure 4**, organizations that have fully adopted technologies like cloud computing and AI report significantly higher improvements in governance processes, with average scores of 4.5 and 4.3, respectively. These results align with existing literature suggesting that cloud computing enhances data accessibility, collaboration, and scalability, while AI facilitates smarter, faster decision-making through data-driven insights (Brynjolfsson & McAfee, 2014; Chui et al., 2018). Full adoption of these technologies enables organizations to streamline operations, reduce errors, and enhance transparency, which are fundamental elements of effective financial governance. However, blockchain's impact on governance, though positive, is somewhat lower (3.2), suggesting that while blockchain has a promising role in enhancing security and transparency, its full potential is yet to be realized in the financial governance domain. This finding corroborates earlier studies that highlighted the initial challenges faced in integrating blockchain into traditional financial systems, primarily due to concerns over scalability, regulatory issues, and the complexity of implementation. Despite these challenges, blockchain remains a transformative tool for enhancing financial integrity, especially in fraud prevention and ensuring the immutability of financial records. Machine learning, while not as impactful as cloud computing or AI, still shows a noticeable positive effect on governance (4.1), supporting findings from prior research that machine learning algorithms can assist in predicting financial trends, detecting anomalies, and automating decision-making processes (Liu et al., 2020) [9], [10]. The relatively lower perceived impact compared to cloud computing and AI may reflect the specific and specialized applications of machine learning, which may not be as broadly implemented across organizations compared to cloud and AI technologies.

5.2. Relationship Between Technology Adoption and Financial Performance

The relationship between technology adoption and financial performance, particularly profitability, cost efficiency, and risk management, was also examined in this study. AI and cloud computing exhibit a significant positive correlation with profitability (0.45 and 0.53, respectively), cost efficiency (0.38 and 0.48), and risk management (0.31 and 0.43). These findings underscore the economic value of these technologies in driving performance. As organizations adopt AI and cloud computing, they gain access to scalable, automated processes that enable better financial forecasting, optimization of resource allocation, and improved risk mitigation (Chui et al., 2018; Brynjolfsson & McAfee, 2014). The significant impact of AI and cloud computing on financial performance is consistent with prior studies that found these technologies to be central to improving operational efficiencies and reducing costs. In contrast, blockchain's impact on financial performance remains moderate, with lower correlation values for profitability (0.22) and cost efficiency (0.15). While blockchain enhances transparency and reduces the risk of fraud, its ability to directly improve profitability and reduce costs is less pronounced, particularly in organizations that have not yet fully integrated the technology into their financial operations. These findings are consistent with the current stage of blockchain adoption, which is still in the early phases in many organizations, where the focus is more on security and traceability rather than immediate cost reductions or profitability improvements (Narayanan et al., 2016). Machine learning, although showing positive relationships with profitability (0.40) and cost efficiency (0.34), also lags behind AI and cloud computing in terms of direct financial performance outcomes. This may reflect the relatively narrow application of machine learning in financial decision-making, which tends to focus on specific tasks such as risk detection, fraud prevention, and predictive modeling, rather than broader operational or strategic improvements (Liu et al., 2020).

5.3. Challenges in Technology Adoption

The challenges organizations face during technology adoption play a crucial role in determining the extent of successful implementation. The most significant barriers identified across all technologies were cost of implementation, lack of a skilled workforce, regulatory uncertainty, data security concerns, and integration with legacy systems. The cost of implementation was consistently high, particularly for blockchain, which reflects the substantial investment required for infrastructure, training, and system integration. This is supported by findings from previous research that emphasize the financial burden associated with adopting cutting-edge technologies (Bharadwaj et al., 2013; Gable et al., 2015). Data security concerns, particularly for blockchain, were also a significant challenge, as highlighted, with blockchain facing the highest scores in this category. This is indicative of the still-evolving nature of blockchain technology, where issues around privacy, data protection, and the risk of cyberattacks remain unresolved. Although blockchain is touted for its potential to enhance data security, its deployment in complex financial environments often leads to uncertainties and vulnerabilities that organizations must address. Another noteworthy challenge is the integration of digital technologies with existing legacy systems, which was a significant barrier for AI and machine learning adoption]. This is consistent with prior literature, which emphasizes the difficulties organizations face when trying to integrate new technologies into their established IT infrastructure. The lack of skilled professionals, particularly in fields such as AI and machine learning, further exacerbates this challenge, as organizations struggle to find qualified individuals to implement and manage these advanced technologies.

5.4. Implications for Practice

The findings from this study suggest several practical implications for organizations looking to adopt digital technologies for enhancing financial governance and decision-making. Firstly, organizations should focus on investing in AI and cloud computing technologies, as these are shown to have the most significant impact on both governance and financial performance. Given their relatively low barriers to adoption compared to blockchain and machine learning, AI and cloud computing present substantial opportunities for immediate improvements in financial decision-making processes. Blockchain, despite its current limitations in direct financial performance outcomes, should not be disregarded. Its ability to provide enhanced security, traceability, and transparency in financial transactions presents long-term benefits, particularly in areas such as fraud prevention and audit trails. Organizations should, however, carefully evaluate the costs and challenges associated with blockchain implementation, particularly around data security and regulatory compliance. Machine learning offers promising opportunities for improving specific financial operations, such as fraud detection, risk management, and predictive analysis. However, its impact on broader financial performance metrics like profitability and cost efficiency is less direct, suggesting that organizations should leverage machine learning as part of a broader technological ecosystem rather than as a standalone solution.

5.5. Limitations and Future Research Directions

While this study provides valuable insights into the role of digital technologies in financial governance, it is not without limitations. The data collected in this study are self-reported, which may introduce biases or inaccuracies in respondents' assessments of their organizations' technology adoption and performance improvements. Additionally,

the study focuses on a cross-sectional analysis, and thus, longitudinal data would be beneficial to better understand the long-term effects of technology adoption on financial governance. Future research should explore the role of digital technologies in financial governance across different industries and regulatory environments, as the impact of these technologies may vary depending on sector-specific factors. Furthermore, longitudinal studies could provide a deeper understanding of how the adoption of these technologies affects organizational performance over time. Finally, research could delve into the organizational culture and leadership factors that influence the successful implementation of digital technologies, as these aspects are critical for overcoming the challenges identified in this study. In conclusion, this study highlights the transformative role those digital technologies, including AI, cloud computing, blockchain, and machine learning, are playing in shaping financial governance and decision-making. While AI and cloud computing emerge as the most impactful technologies in terms of both governance improvements and financial performance, blockchain and machine learning also offer significant value, particularly in areas of security and risk management. The challenges associated with technology adoption, such as cost, skilled workforce availability, and data security concerns, must be carefully managed to ensure the successful implementation of these technologies [10]. Future research will be essential in further understanding the long-term impacts and best practices for adopting digital technologies in financial governance.

6. Conclusion

This study underscores the transformative potential of digital technologies—AI, cloud computing, blockchain, and machine learning—in enhancing financial governance and decision-making. The findings suggest that AI and cloud computing are the most impactful technologies, driving significant improvements in governance processes, operational efficiency, and financial performance. These technologies facilitate smarter, faster decision-making, enhanced data accessibility, and streamlined financial operations. Their adoption correlates with improved profitability, cost efficiency, and risk management, aligning with existing research that emphasizes the strategic advantages of cloud computing and AI in modern financial environments. While blockchain and machine learning also show positive contributions, their impact is more specialized. Blockchain, although pivotal in providing enhanced transparency and security, is still in the early stages of adoption, and its direct effect on financial performance is currently limited. Machine learning, though beneficial in automating processes and improving risk detection, has yet to exhibit the broad-reaching impact of AI and cloud computing. Nevertheless, both technologies have significant potential for enhancing specific financial tasks, such as fraud prevention and predictive analytics. The study also highlights several barriers to successful technology adoption, including implementation costs, regulatory uncertainty, data security concerns, and the integration of new technologies with legacy systems. These challenges are particularly prominent in the adoption of blockchain, which faces significant obstacles in terms of scalability and regulatory compliance. Overcoming these barriers will be essential for organizations aiming to fully harness the potential of digital technologies in financial governance. In conclusion, while digital technologies have already begun reshaping financial governance, the path to widespread adoption requires careful consideration of both the opportunities and challenges presented. Further research is needed to explore the long-term effects of these technologies, and organizations must strategically invest in these innovations while addressing the accompanying challenges to realize their full benefits in enhancing financial decision-making and governance.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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