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Innovating Through Integration: How Industry 4.0 Technologies Reshape Management Accounting Practices in Botswana

Kudzai Chuma[1*] and Mubanga Mpundu[2]

[1]Senior Lecturer, Faculty of Business & Accounting, Botho University, P.O Box 501564, Gaborone, Botswana
Email: kudzai.chuma@bothouiniversity.ac.bw

[2]University of the Western Cape, Faculty of Economics and Management Sciences, Department of Economics, P/Bag X17, Robert Sobukwe Road, Belville, 7535, Cape Town, South Africa.
Email: mmpundu@uwc.ac.za

*Corresponding e-mail: kudzai.chuma@bothouiniversity.ac.bw

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ABSTRACT

This study explores the transformational potential of Industry 4.0 technologies in driving management accounting innovation in Botswana. Key enablers, such as technological readiness, competitive pressure, and strategic leadership, significantly influence adoption. Technologies like process automation, artificial intelligence, and the Internet of Things enhance decision-making, cost efficiency, and innovation, while blockchain and big data have limited impact due to resource constraints and early adoption challenges. The findings highlight the importance of robust infrastructure, leadership support, and skill development in integrating these technologies. To fully leverage Industry 4.0, fostering a creative culture and strategically allocating resources are essential. Future research should address adoption barriers, economic impacts, and cross-sector comparisons. This study offers a strategic framework for harnessing technology to enhance organizational performance and competitiveness in Botswana.

1. Introduction

1.1 Background

The rapid emergence of Industry 4.0 technologies has redefined business practices across the globe, driving innovation and transforming traditional operational frameworks. These technologies encompassing artificial intelligence (AI), the Internet of Things (IoT), process automation, big data analytics, and distributed ledger systems are not merely tools for efficiency but serve as catalysts for strategic evolution in various fields, including management accounting. While much research has explored Industry 4.0's impact in developed economies, relatively little has been done to understand its influence in emerging markets, such as Botswana, where unique socio-economic and infrastructural factors shape the adoption and implementation of these technologies.

Management accounting, a discipline integral to organizational decision-making and strategic planning, is particularly poised for transformation through Industry 4.0. By enabling real-time data collection, advanced analytics, and enhanced process automation, these technologies promise to shift management accounting practices from transactional processes toward strategic value-adding functions. However, the adoption of such technologies in Botswana's context presents both opportunities and challenges, influenced by technological readiness, resource allocation, organizational culture, and leadership dynamics.

Botswana's economic landscape provides a unique lens through which to evaluate the transformative potential of Industry 4.0 technologies. As a middle-income country heavily reliant on mining and agriculture, Botswana faces the dual challenge of diversifying its economy and fostering innovation within its industries. In this environment, management accounting practices must evolve to not only support cost optimization and operational efficiency but also to drive innovation and competitiveness. Recognizing these imperatives, this study examines how Industry 4.0 technologies reshape management accounting practices in Botswana and identifies the enablers and barriers to their effective adoption.

Existing literature highlights that technological adoption in developing countries often lags due to infrastructural limitations, skill shortages, and cultural resistance to change. Yet, these challenges also present opportunities for innovation, particularly when organizations can leverage strategic leadership, robust infrastructure, and targeted skill development to overcome them. In Botswana, the adoption of technologies like Artificial Intelligence and Internet of Things has shown significant potential for enhancing decision-making accuracy, reducing costs, and fostering innovative accounting techniques. However, technologies such as blockchain and big data have exhibited limited impact, likely due to resource constraints and early-stage adoption hurdles.
This study builds on the foundation of prior research while addressing a critical gap, the need for a localized understanding of how Industry 4.0 technologies influence management accounting innovation in Botswana. It leverages both quantitative and qualitative methods to explore the interplay between technology adoption, organizational performance, and innovation. Key findings underscore the importance of leadership commitment, cultural adaptability, and resource prioritization in maximizing the benefits of Industry 4.0.

Furthermore, the study situates its findings within a broader strategic context, emphasizing the need for Botswana's organizations to cultivate a creative culture and align their technological initiatives with long-term economic goals. By offering a detailed analysis of adoption barriers, economic implications, and cross-sector comparisons, this research not only advances theoretical understanding but also provides actionable insights for practitioners and policymakers. It serves as a roadmap for leveraging Industry 4.0 technologies to enhance Botswana's competitiveness and drive sustainable economic development.

In summary, the integration of Industry 4.0 technologies into management accounting practices represents a transformative opportunity for Botswana. However, realizing this potential requires a multifaceted approach that addresses infrastructural gaps, develops requisite skills, and fosters leadership commitment. By focusing on these critical enablers, this study contributes to the growing body of knowledge on technology-driven innovation in emerging markets and underscores the vital role of management accounting in driving organizational and national competitiveness in the Industry 4.0 era.

1.2 Research Questions

Main Research Question

1. How does the adoption of Industry 4.0 technologies influence innovative practices within management accounting in Botswana?

Specific Research Questions

1. Which specific Industry 4.0 technologies (e.g., Internet of Thimgs, Artificial Intelligence, machine learning, data analytics, cloud computing) have the most significant impact on innovations in management accounting?
2. To what extent do organizational factors (e.g., leadership, culture, resources, employee skills) influence the adoption and effectiveness of Industry 4.0 technologies in driving management accounting innovations?
3. What are the barriers (e.g., resistance to change, resource limitations) and facilitators (e.g., top management support, innovation-oriented culture) affecting the integration of Industry 4.0 technologies into management accounting practices?
4. How do specific Industry 4.0 technologies enhance key management accounting processes such as decision-making, cost management, and performance reporting?
5. What is the relationship between adopting data-centric technologies (e.g., big data, data analytics, distributed ledger, cloud computing) and the improvement of real-time reporting and operational efficiency in management accounting?
6. To what extent does the adoption of advanced automation tools (e.g., process automation, Artificial Intelligence, machine learning) streamline traditional management accounting processes and reduce costs?
7. What role do leadership and strategic orientation play in shaping the adoption and innovative outcomes of Industry 4.0 technologies in management accounting in Botswana?
8. How do Industry 4.0 technologies contribute to a competitive advantage and improved decision-making for organizations in Botswana through innovations in management accounting?
9. What are the tangible innovative outcomes observed in management accounting practices following the adoption of Industry 4.0 technologies in Botswana (e.g., enhanced data visualization, efficiency, automation, and cost-effectiveness)?

2. Literature Review

2.1 Introduction

The advent of Industry 4.0, characterized by digital transformation technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, and Cyber-Physical Systems, has brought transformative changes across industries globally. Within the context of management accounting, Industry 4.0 technologies introduce opportunities for enhanced decision-making, real-time data analysis, and sustainability. This literature review explores the integration of these technologies within management accounting practices, with a focus on Botswana's unique socio-economic landscape.

2.2 Industry 4.0 and Management Accounting: Global Trends

Conceptual Foundations of Industry 4.0

Industry 4.0 represents the fourth industrial revolution, leveraging advanced digital technologies to integrate physical and virtual systems for enhanced productivity and efficiency (Schwab, 2017) (Ustundag, 2017). The conceptual underpinnings of Industry 4.0 emphasize interconnectivity, real-time data, and automation (Rojko,

2017). These developments create both opportunities and challenges for management accounting (Möller, 2020).

Integration of Digital Technologies in Accounting

Digitalization in management accounting enables real-time reporting, predictive analytics, and improved decision-making capabilities. (Bhimani, Digital data and management accounting: why we need to rethink research methods. , 2020) Argues for the need to rethink traditional research methods in light of digital transformation. Similarly, (Varaniūtė, 2022) emphasize that management accounting now plays a crucial role in fostering sustainability and circularity, enabled by digital tools.

Sustainability and Digital Environmental Management Accounting

(Abdelhalim, 2023) Highlights the moderating role of digital environmental management accounting in enhancing corporate sustainability. Integrating eco-efficiency and sustainability practices aligns with global calls for ethical business practices (Pramono, 2023).

2.3 Industry 4.0 in Botswana: Opportunities and Challenges

Economic and Technological Landscape

Botswana's economic environment, characterized by small and medium enterprises (SMEs), presents unique challenges and opportunities for Industry 4.0 adoption. (Acquah, 2007) Identifies factors influencing SME performance in Botswana, while (Majama, 2017) explores strategic planning practices in SMEs. Both studies underscore the critical role of technological adoption in enhancing competitiveness.

Readiness for Industry 4.0

(Muchuchuti, 2021) Examines the readiness of Botswana's workforce for Industry 4.0, identifying gaps in digital literacy and technological infrastructure. This is consistent with global findings on the challenges of digital transformation in developing economies (Rogers, 2003) (Moeuf, 2020).

Evolving Role of Accountants

(Mbizi, 2022) Emphasizes the evolving competencies required for accountants in the 4IR era. The integration of digital tools in management accounting necessitates re-skilling and up-skilling to address emerging challenges (Allioui, 2023).

2.4 Management Accounting Practices in the Industry 4.0 Era

Real-Time Data and Decision-Making

Digital technologies enable real-time data collection and analysis, transforming decision-making processes in management accounting. (Bag, 2021) Discusses the role of advanced manufacturing capabilities in fostering operational efficiency, while (Piosik, 2022) highlights the intensified use of management accounting systems under Industry 4.0 conditions.

Performance Measurement

(Frederico, 2021) Proposes a balanced scorecard approach tailored to Industry 4.0 environments. This framework integrates traditional performance metrics with sustainability and digitalization indicators, providing a holistic view of organizational performance.

Cyber-Physical Systems and Cloud-Based Accounting

Cloud-based accounting systems and cyber-physical systems have emerged as critical enablers of digital transformation in management accounting. (Sokolenko, 2020) (Marsintauli, 2021) Explores the implementation of cloud technologies in accounting processes, highlighting their potential for improving efficiency and security.

2.5 Challenges and Risks

Technological and Organizational Barriers

The adoption of Industry 4.0 technologies is often hindered by technological and organizational barriers. (Müller, 2018) Identifies key drivers and challenges for implementing Industry 4.0, including resource constraints and resistance to change.

Skills Gap

A significant challenge in leveraging Industry 4.0 technologies is the skills gap among accounting professionals. (Alsughayer, 2023) (Mian, 2020) Advocates for updated curricula and training programs to address this gap.

Ethical and Security Concerns

The digital transformation of management accounting raises ethical and security concerns. (Naciri, 2023) Highlights risks associated with digital technologies, including data breaches and privacy issues, necessitating robust governance frameworks.

2.6 Lessons Learned from Global Experiences

German Manufacturing Industry

(Veile, 2020) Provides insights into lessons learned from Industry 4.0 implementation in the German manufacturing sector. The study underscores the importance of aligning technological adoption with organizational strategy and culture.

South African Context

In South Africa, (Mhlanga, 2020) Examines the impact of digital transformation on education, emphasizing the need for skills development to leverage Industry 4.0 technologies effectively. These findings are relevant for Botswana, given similar socio-economic contexts.

2.7 Seminal Works Relevant to Industry 4.0 and Management Accounting

One seminal work in this field is by (Bhimani, Accounting disrupted: How digitalization is changing finance. , 2021). This book explores the profound impact of digital technologies, including AI and blockchain, on accounting practices, providing insights into the evolving role of management accountants in the digital age.

Justification for Relevance to the Journal Topic

i. Integration of Industry 4.0 Technologies in Management Accounting.

(Bhimani, Accounting disrupted: How digitalization is changing finance. , 2021) Argues that the growing complexity and demand for real-time data analysis have forced management accountants to adopt technologies that enhance decision-making processes. This is directly aligned with our journal topic, which focuses on how Industry 4.0 technologies reshape management accounting practices.

ii. The Technological Shift

The book delves into how new technologies are facilitating predictive analytics, performance measurement, and business intelligence in accounting. This directly addresses how Botswana's businesses, especially those in manufacturing and resource management sectors, could be impacted by such technological changes. Industry 4.0 brings about automated reporting, budgeting, and forecasting, which are transformative for management accounting.

iii. Local Context of Botswana

While the book itself may not directly cover Botswana, the principles can be extrapolated to the local context by analyzing how Botswana's industries (like mining and agriculture) can integrate advanced technologies in their management accounting systems to stay competitive globally. The increased adoption of technologies like Internet of Things for inventory management, cloud computing, and blockchain for financial transparency can be framed as innovative steps in the local context.

iv. Emerging Role of Accountants in the Digital Era

The study underlines the evolution of the accountant's role from being a mere number cruncher to a strategic partner in decision-making. The same dynamic could be examined in Botswana's case, where there is growing interest in how management accountants must reskill to operate in a technology-heavy environment.

Further Supporting Works

1. How Accountants Can Drive Digital Transformation. In Digital Transformation in Accounting and Auditing: Navigating Technological Changes by (Goh, 2024)

This work discusses the proactive roles accountants can play in digital transformation initiatives, emphasizing the integration of new technologies into accounting systems. This work can serve as a complementary resource to provide insights into how Botswana's accounting systems might evolve under the influence of similar technological disruptions.

2. Advancement of cloud-based accounting effectiveness, decision-making quality, and firm performance through digital transformation and digital leadership: Empirical evidence from Vietnam. By (Hung, 2023)

This study highlights the benefits of cloud-based accounting systems in enhancing decision-making and organizational performance, underscoring the importance of digital leadership in the accounting field.

3. Fintech Accounting and Industry 4.0: Future-Proofing or Threats to the Accounting Profession? By (Fülöp, 2022)

This research delves into the intersection of fintech innovations and accounting, discussing potential opportunities and challenges posed by Industry 4.0 technologies to the accounting profession. This study can be used to contextualize Botswana's position within the broader African technological landscape.

2.8 Theoretical Frameworks Underpinning this study

Dynamic Capabilities Framework

The dynamic capabilities framework, introduced by (Teece, 1997), focuses on an organization's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments.

Justification

i. Integration and Innovation

The framework aligns well with the journal's focus on integration and innovation, as it emphasizes the need for organizations to continuously adapt to technological advancements.

ii. Technological Adaptability

Industry 4.0 technologies demand that organizations in Botswana develop capabilities to leverage real-time data, enhance predictive analytics, and integrate cross-functional systems.

iii. Strategic Advantage

Management accountants must evolve from traditional roles to strategic partners, requiring the development of dynamic capabilities to use Industry 4.0 technologies effectively.

Relevance to Botswana

Botswana's industries, particularly in resource-dependent sectors, must adapt dynamically to the global shift toward technology-driven processes. This framework can help explain how organizations in Botswana can build capabilities to harness these technologies for strategic decision-making.

Technology Organization Environment (TOE) Framework

The TOE framework, developed by (Tornatzky, 1990), explains how technological, organizational, and environmental factors influence the adoption and implementation of new technologies.

Justification

i. Technological Context

Industry 4.0 technologies (e.g., Internet of Things, big data analytics, Artificial Intelligence, blockchain) are at the core of this research. The TOE framework allows the study to analyze the technological readiness and compatibility of these tools with Botswana's management accounting practices.

ii. Organizational Context

Management accounting practices are deeply embedded in organizational structures. The framework facilitates an exploration of how organizational factors, such as leadership, size, culture, and resource availability, impact the integration of these advanced technologies.

iii. Environmental Context

The framework addresses external environmental factors, such as government regulations, market pressures, and technological infrastructure, which are particularly relevant in the Botswana context. For instance, Botswana's regulatory and technological environment can be examined as a factor influencing the adoption of Industry 4.0.

Relevance to Botswana

Botswana's unique socioeconomic and technological context makes the TOE framework valuable for assessing barriers and enablers in adopting these innovations in local industries, such as mining and agriculture.

3. Institutional Theory

Institutional theory, as developed by (DiMaggio, 1983), examines how institutional pressures (coercive, normative, and mimetic) influence organizational practices and decision-making.

Justification

i. Coercive Pressures

Regulatory requirements and governmental incentives in Botswana for technological advancement could drive the adoption of Industry 4.0 in management accounting.

ii. Normative Pressures

The influence of professional bodies, international accounting standards, and industry best practices on reshaping accounting practices can be explored.

iii. Mimetic Pressures

Organizations in Botswana may imitate global leaders in adopting Industry 4.0 technologies to stay competitive, which institutional theory can help analyze.

Relevance to Botswana

The theory provides insights into how local industries are influenced by international norms and regional competitors, particularly in a developing economy context where benchmarking global practices is crucial for economic growth.

Recommended Theoretical Framework for the study Dynamic Capabilities Framework

While all the three above frameworks are highly relevant, the Dynamic Capabilities Framework is the most suitable for this research. This is because the journal topic emphasizes innovation through integration and how Industry 4.0 technologies reshape practices, which requires a focus on organizational adaptability and strategic decision-making. This framework provides a robust foundation to analyze how organizations in Botswana can develop the capabilities to integrate Industry 4.0 technologies into their management accounting systems effectively.

2.9 Research Gaps and Future Directions

Despite significant advancements, several research gaps remain. There is limited empirical evidence on the impact of Industry 4.0 technologies on management accounting practices in Botswana. Future research should focus on:

i. Identifying critical success factors for Industry 4.0 adoption in Botswana.
ii. Exploring the role of cultural and organizational factors in shaping digital transformation.
iii. Developing frameworks to address ethical and security concerns in digital accounting.

2.10 Summary

Industry 4.0 technologies hold transformative potential for management accounting practices, offering opportunities for enhanced decision-making, sustainability, and efficiency. However, their successful integration requires addressing challenges such as technological barriers, skills gaps, and ethical concerns. For Botswana, leveraging Industry 4.0 technologies in management accounting presents an opportunity to foster economic growth and sustainability, provided the unique socio-economic and cultural contexts are considered.

3. Materials and Methods

3.1 Introduction

This section outlines the methodological approach adopted to investigate the integration of Industry 4.0 technologies into management accounting practices in Botswana. It details the study design, population, sampling strategies, data collection methods, and analytical techniques to provide a robust empirical basis for addressing the research objectives.

3.2 Study Design/Methodology

The study adopted a mixed-methods approach, combining both quantitative and qualitative methods. This approach was chosen to capture a comprehensive understanding of how Industry 4.0 technologies are reshaping management accounting practices in Botswana. The quantitative component provided measurable insights into adoption rates and key factors influencing integration, while the qualitative component explored deeper organizational, cultural, and contextual influences.

3.3 Quantitative Phase

Sampling Methodology

A stratified random sampling technique was employed to ensure that the sample was representative of Botswana's diverse organizational landscape. Stratification was based on organization type (public and private sector) and organization size (small and medium-sized enterprises (SMEs) and large enterprises). This method was chosen to reflect variations in the adoption and implementation of Industry 4.0 technologies across different organizational contexts, ensuring findings were generalizable (Creswell, 2017).

Data Collection using Structured Questionnaires

Data was collected using structured questionnaires distributed to management accountants, IT professionals, and senior managers. These stakeholders were identified as having direct knowledge of the integration of Industry 4.0 technologies in management accounting processes. The questionnaire included both closed-ended questions to gather quantifiable data and scaled questions to measure the extent of integration across core accounting functions (e.g., financial reporting, budgeting, and performance management) (Bryman, 2016).

Data Analysis using the Chi-Square Test

The Chi-Square Test was employed using SPSS to analyze relationships between the degree of Industry 4.0 technology adoption and management accounting practices (Agresti, 2018). This test is ideal for evaluating categorical variables and identifying significant associations, such as the influence of organizational type or size on adoption levels.

Justification of Methods

The quantitative approach, structured questionnaires, and statistical analysis tools (e.g., Chi-Square Test) were selected for their ability to provide robust and generalizable insights (Field, 2013). This approach aligns with the study's objective to empirically assess the impact of Industry 4.0 technologies on management accounting across various organizational contexts in Botswana (Fowler Jr, 2013).

3.4 Qualitative Phase

Sampling Strategy

The stratified purposive sampling method was applied to select participants with relevant expertise, such as management accountants, IT specialists, and senior executives. Participants were chosen to ensure a diversity of perspectives on the integration of Industry 4.0 technologies into management accounting.

Data Collection Methods using Semi-Structured Interviews and Focus Groups

Semi-Structured Interviews

These were conducted with key stakeholders to gain insights into organizational experiences, challenges, and strategies for integrating Industry 4.0 into management accounting (Kvale, 2009). The interviews allowed for flexibility while ensuring that critical topics, such as technological adoption, leadership roles, and cultural influences, were explored systematically (Patton, 2014).

Focus Groups

Focus group discussions were held with cross-functional teams, including management accountants and IT professionals. This method provided insights into team dynamics and collaboration during digital transformation initiatives (Morgan, 1996).

Data Analysis using Thematic Analysis

The qualitative data was analyzed using thematic analysis, following the framework by (Braun, 2006). Key themes related to adoption drivers, barriers, and the transformation of management accounting practices were identified and analyzed.

Justification for Qualitative Methods

The qualitative approach was crucial for uncovering contextual factors and organizational dynamics that cannot be captured through quantitative methods (Creswell, 2017). Semi-structured interviews and focus groups allowed for an in-depth exploration of the complex interplay between technology and accounting practices (King, 2018).

3.5 Population/Study Frame

The study focused on organizations across Botswana, including public sector institutions, SMEs, and large corporations. The target population included management accountants, IT professionals, and senior executives. Based on the BICA 2022 report, there are approximately 20,000 relevant professionals within the country, including chartered accountants, certified public accountants, and accounting technicians.

3.6 Sample Size Determination

Using the Raosoft sample size calculator, a sample size of 377 participants was determined based on a 50% response distribution, 95% confidence level, and 5% margin of error. The stratified random sampling ensured proportional representation across the population.

3.7 Stratification Criteria

Public vs. Private Sector

Public Sector

Public organizations were included to examine how governmental structures and policies influence the integration of Industry 4.0 technologies.

Private Sector

Private enterprises, driven by competitive pressures, were analyzed to understand their innovative approaches to integrating digital technologies into accounting functions.

SMEs vs. Large Enterprises

SMEs

SMEs were included to explore challenges like limited resources and capacity in adopting Industry 4.0 technologies.

Large Enterprises
Large firms were analyzed to assess advanced integration strategies and their impact on management accounting innovation.

3.8 Ethical Considerations
Ethical approval was obtained from relevant authorities, including the University of Zambia Institutional Review Board and Botswana's Ministry of Trade. Participants provided informed consent, ensuring they understood the study's purpose and confidentiality protocols. Anonymity was maintained through the use of pseudonyms, and data was securely stored to protect participant information.

4. Results and Discussion
This section presents the findings of the study on how Industry 4.0 technologies are reshaping management accounting practices in Botswana. The discussion aligns with the study's primary objectives, which include analyzing adoption patterns, understanding influencing factors, and evaluating the impact of these technologies on management accounting innovative practices. The results are presented using descriptive statistics, reliability measures, and visual data representations for a holistic understanding of the topic.

4.1 Demographic Insights on Industry 4.0 Technology Adoption
Study Response Rate and Representativeness
The study achieved a response rate of 72.9%, with 275 completed surveys from the total sample of 377 distributed questionnaires. This high response rate compares favorably with similar studies on technology adoption in developing economies, such as those by (Mian, 2020) (Nankervis, 2021), which reported response rates of 65% and 68%, respectively. This level of participation indicates strong engagement with the study topic, though it remains critical to consider potential biases, such as self-selection, which could skew the representativeness of the results.

Addressing Non-Response and Selection Bias
While the response rate is commendable, non-response bias remains a concern, as non-respondents may differ significantly in their perspectives or adoption levels. Future studies could address this limitation by collecting demographic data on non-respondents or implementing follow-up surveys. Additionally, the risk of self-selection bias where organizations already invested in Industry 4.0 technologies may have been more inclined to participate which suggests caution in generalizing the findings.

Sectoral and Geographic Distribution
The study included participants from both public and private sectors, with 31% representing government organizations and 69% from private enterprises. Public sector respondents primarily consisted of representatives from ministries and regulatory bodies, while private sector participants spanned industries such as manufacturing, mining, and financial services. Geographically, 57% of respondents were based in Gaborone, the economic hub of Botswana, followed by Francistown (24%) and other regional centers. This distribution aligns with Botswana's economic activity patterns but indicates a potential underrepresentation of rural enterprises.

Organizational Size and Financial Characteristics

The majority of participating organizations were large enterprises, reflecting Botswana's industry composition, particularly in sectors like mining and manufacturing. Over 65% of surveyed organizations reported annual revenues exceeding five million pula, and 60% reported total assets valued above ten million pula. These financial profiles suggest that larger organizations, with greater resource availability, are better positioned to adopt and benefit from Industry 4.0 technologies.

Professional Roles and Expertise of Respondents

The study drew insights from a diverse pool of respondents, including CEOs and directors (28%), finance managers and directors (17%), accountants (38%), IT professionals (10%), and business owners (7%). This diversity provided a multidimensional understanding of how Industry 4.0 technologies intersect with management accounting. Notably, over 85% of respondents held professional accounting qualifications (e.g., CIMA, ACCA, CIPFA), underscoring the high level of expertise in the sample.

Experience and Management Accounting Practices

Participants were generally experienced, with 72% reporting over five years of tenure in their current roles. Regarding management accounting practices, 75.27% of organizations managed these functions in-house, reflecting a preference for retaining strategic control. The remaining 24.73% outsourced these functions, often citing cost savings and access to specialized expertise enabled by digital tools.

4.2 Insights into Industry 4.0 Technology Adoption

Adoption Levels and Factors Influencing Integration

The findings revealed varying degrees of Industry 4.0 technology adoption across organizations. Adoption was most prevalent in larger firms and industries where automation, data analytics, and digital tools offered immediate operational benefits (e.g., manufacturing and mining). Key factors influencing adoption included,

a. Financial Capacity

Organizations with robust revenues and asset bases were more likely to invest in these technologies.

b. Leadership Support

Firms with proactive leadership exhibited faster adoption rates.

c. Sectoral Characteristics

Private sector enterprises demonstrated higher adoption rates due to competitive pressures, while public sector adoption was slower, hindered by bureaucratic constraints.

Barriers to Adoption

Participants identified several challenges impeding the adoption of Industry 4.0 technologies,

a. High Initial Investment Costs

SMEs, in particular, struggled with limited budgets to finance advanced technologies.

b. Skills Gap

A shortage of skilled professionals proficient in digital tools was a recurring theme.

c. Infrastructure Deficiencies

Limited access to high-speed internet and reliable power in rural areas hampered widespread adoption.

Impact on Management Accounting Practices

Industry 4.0 technologies have transformed management accounting practices by automating repetitive tasks, enhancing data analysis capabilities, and enabling real-time decision-making. Key impacts include,

a. Improved Data Accuracy and Timeliness - Digital systems facilitated precise, timely financial reporting.

b. Strategic Insights - Advanced analytics tools empowered accountants to focus on value-added tasks, such as scenario analysis and strategic planning.

c. Collaborative Decision-Making - Integration of IT and accounting functions fostered cross-departmental collaboration, especially in large enterprises.

Broader Implications and Future Directions

The findings underscore the transformative potential of Industry 4.0 technologies in reshaping management accounting practices. However, to fully harness this potential, organizations in Botswana must address adoption barriers through,

a. Capacity Building - Training initiatives to upskill accounting and IT professionals.

b. Policy Support - Government incentives to offset high adoption costs, particularly for SMEs.

c. Infrastructure Investments - Expanding internet access and improving energy reliability to support digital transformations across the country.

Quantitative Analysis of Innovations in Management Accounting

1. Has Adoption of Industry 4.0 Resulted in Innovative Practices

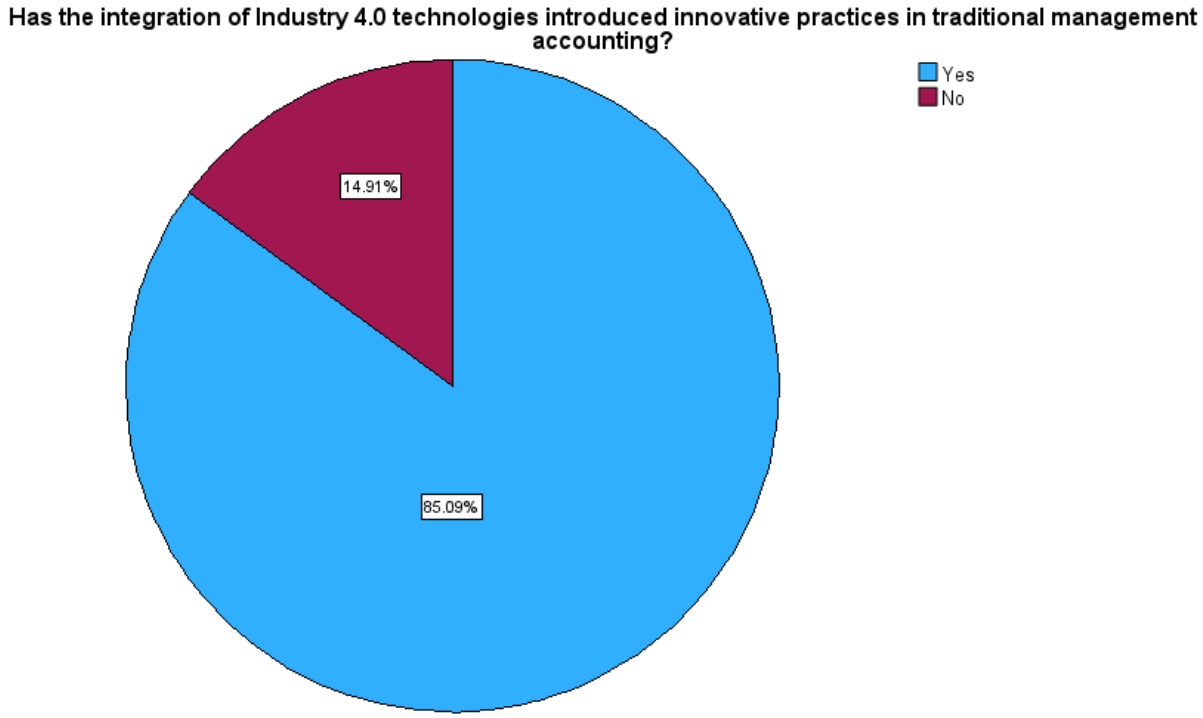

Figure 1: Has Integration of Industry 4.0 technologies influenced innovative practices within management accounting

The figure 1 above indicates, that 86% of the respondents state that adopting industry 4.0 technologies in management accounting, positively influences innovative practices in management accounting, whereas the remaining 15% do not think so. Below we shall break down the most commonly used and known industry 4.0 technologies and seek to identify the specific ones that the participants acknowledge as having a significant influence on the innovative practices in management practices. The open ended questions plus the interview questions below will further add more light on this, including examples of what is happening on the ground.

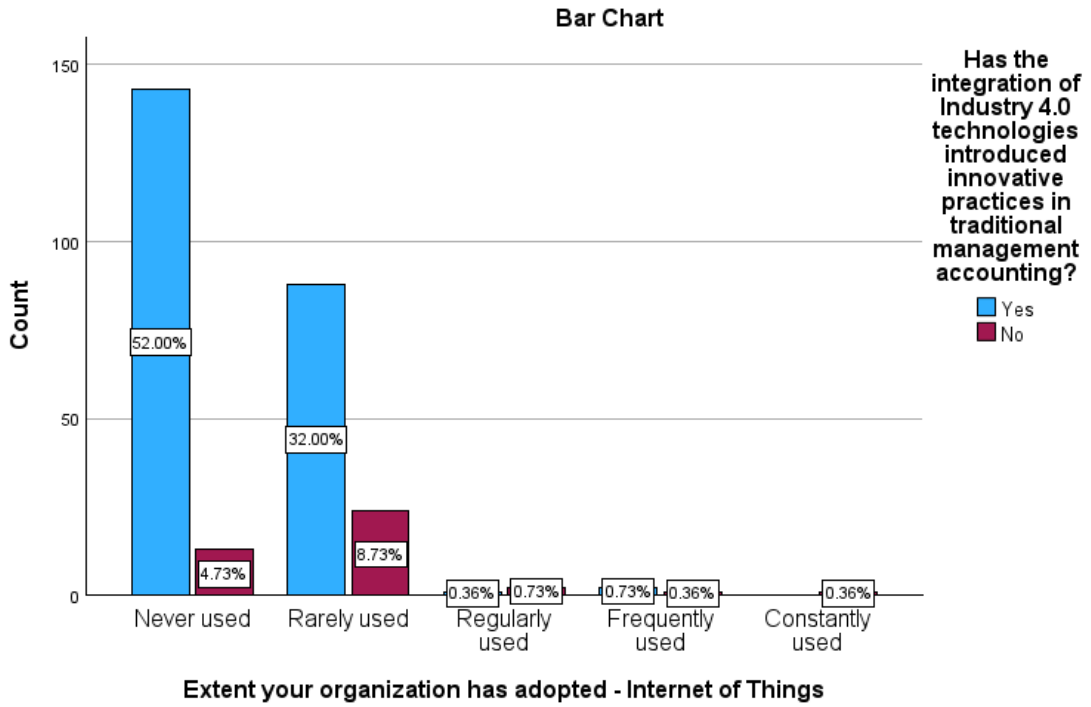

Figure 2: Extent of Internet of Things adoption influence on innovative practices in traditional management accounting

The figure 2 above shows, that adopting Internet of Things, positively influences innovative practices within management accounting fairly.

Table 1: Figure 161 Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	21.914[a]	4	<.001
Likelihood Ratio	18.104	4	.001
Linear-by-Linear Association	17.968	1	<.001
N of Valid Cases	275		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .15.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoption of Internet of Things influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 1 above.

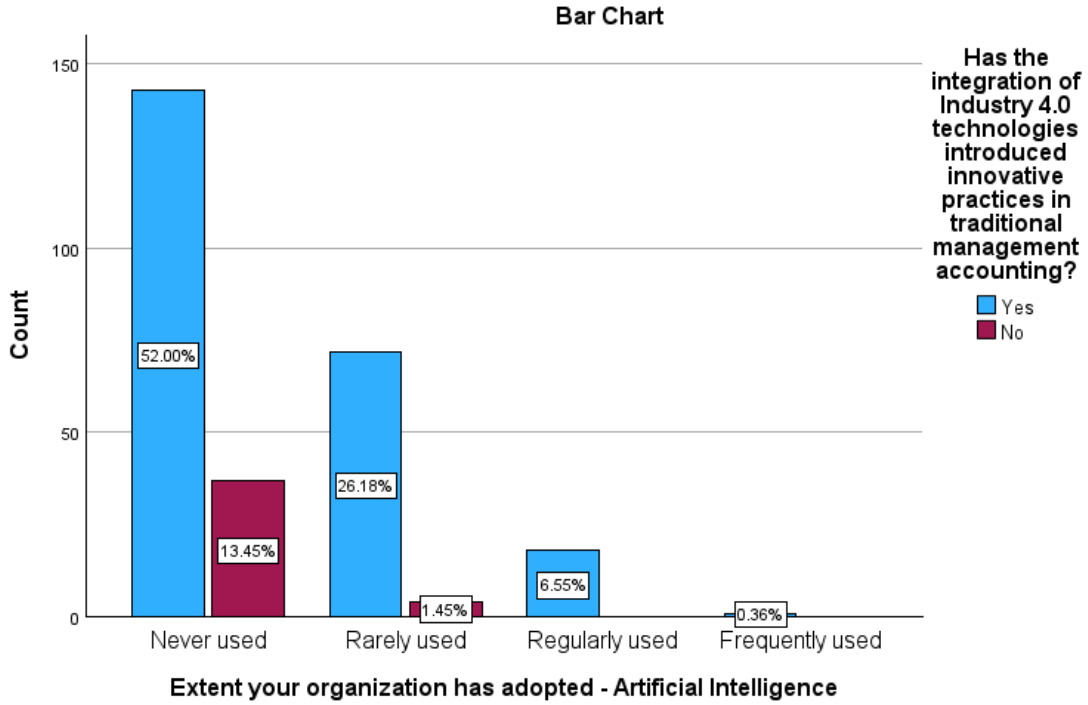

Figure 3: Extent of artificial intelligence adoption influence on innovative practices in traditional management accounting

The figure 3 above shows, that adopting artificial intelligence, positively influences innovative practices within management accounting fairly.

Table 2: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.427[a]	3	.004
Likelihood Ratio	17.397	3	<.001
Linear-by-Linear Association	12.462	1	<.001
N of Valid Cases	275		

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is .15.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoption of artificial intelligence influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 2 above.

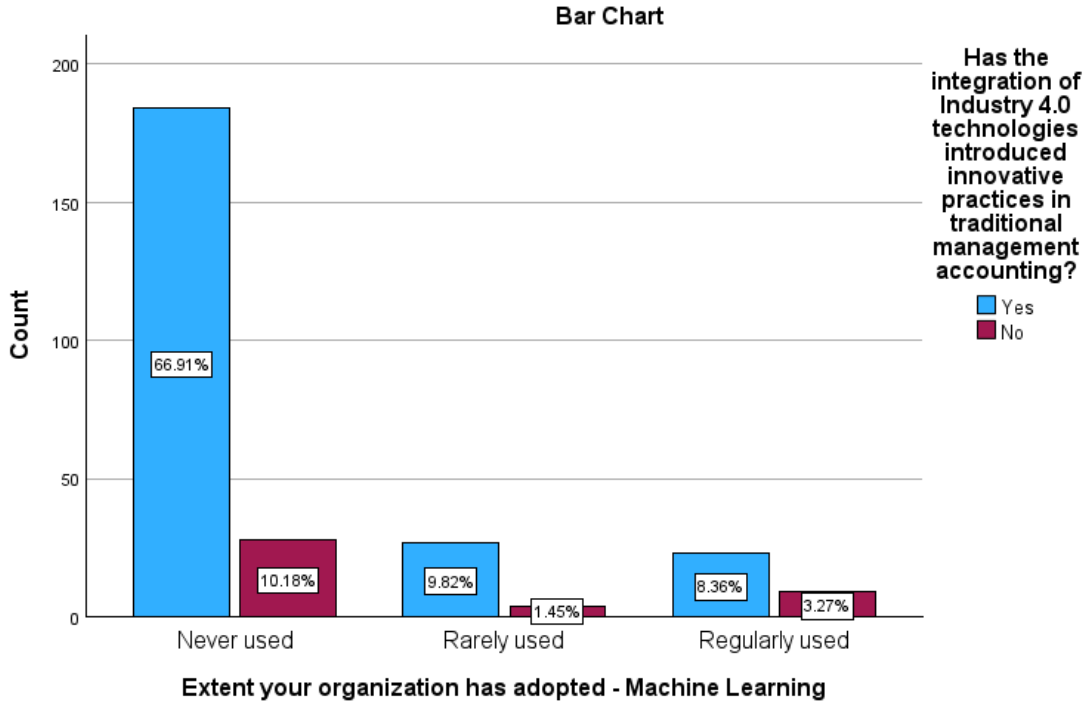

Figure 4: Extent of machine learning adoption influence on innovative practices in traditional management accounting

The figure 4 above shows, that adopting machine learning, positively influences innovative practices within management accounting fairly.

Table 3: Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.988[a]	2	.083
Likelihood Ratio	4.262	2	.119
Linear-by-Linear Association	3.822	1	.051
N of Valid Cases	275		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 4.62.

There appears to be no statistically significant correlation between adoption of machine learning influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 3 above.

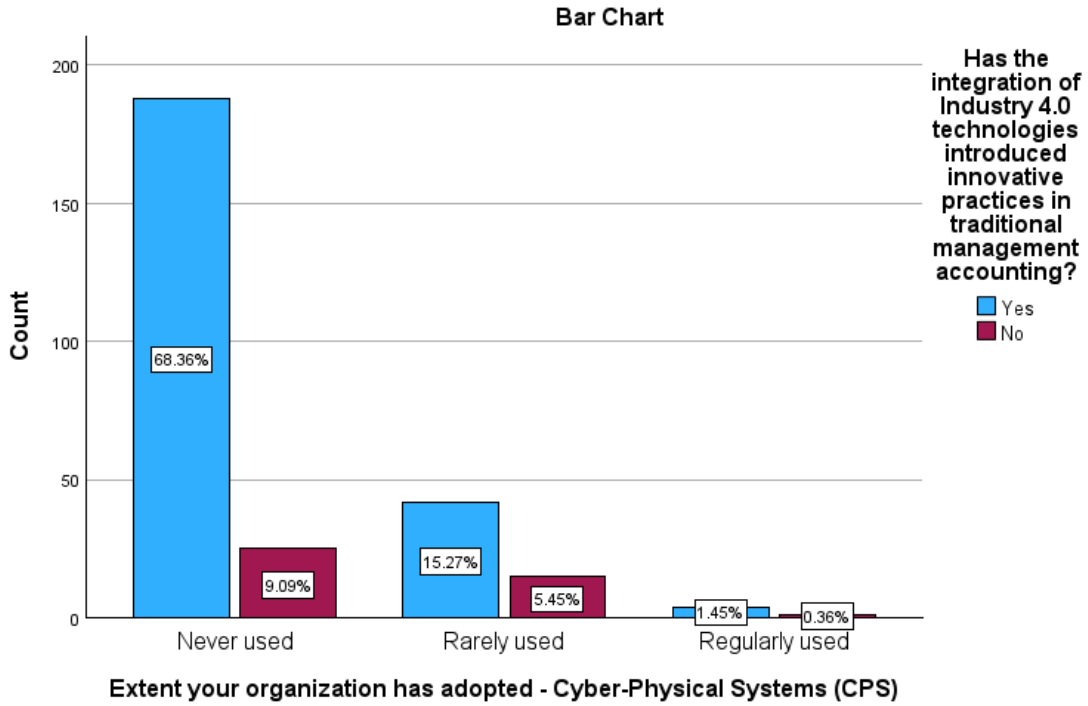

Figure 5: Extent of cyber physical systems adoption influence on innovative practices in traditional management accounting

The figure 5 above shows, that adopting cyber physical systems, positively influences innovative practices within management accounting fairly.

Table 4: Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.637[a]	2	.022
Likelihood Ratio	6.850	2	.033
Linear-by-Linear Association	6.362	1	.012
N of Valid Cases	275		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .75.

There appears to be no statistically significant correlation between adoption of cyber physical systems influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 4 above.

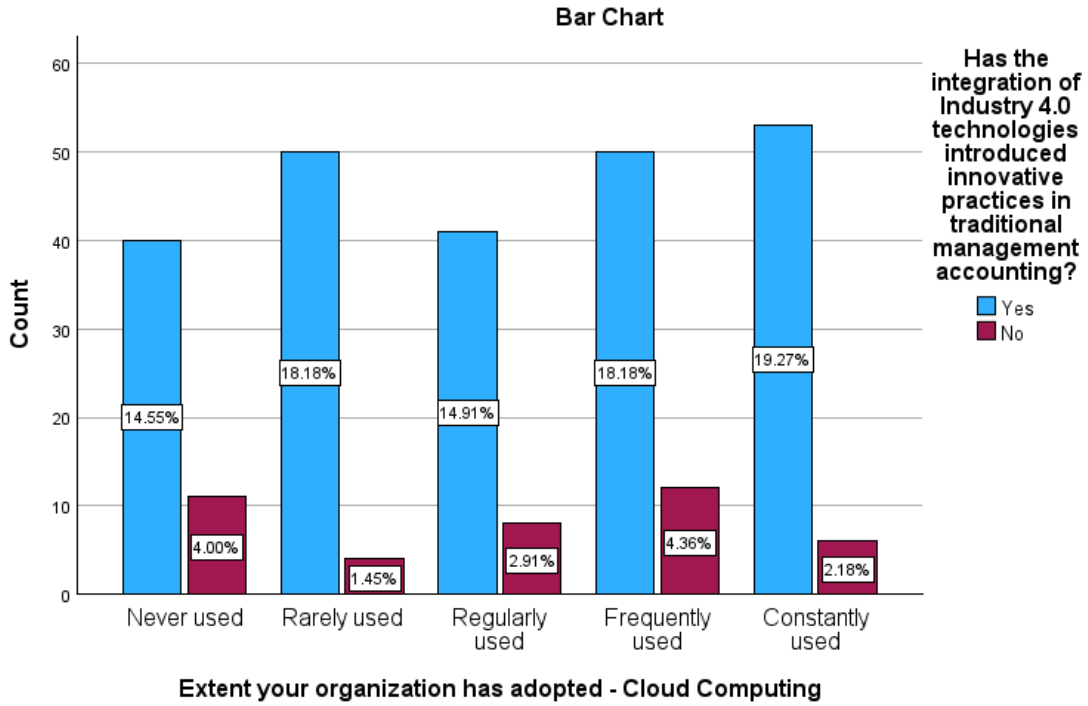

Figure 6: Extent of cloud computing adoption influence on innovative practices in traditional management accounting

The figure 6 above shows, that adopting cloud computing, positively influences innovative practices within management accounting significantly.

Table 5: Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.267[a]	4	.180
Likelihood Ratio	6.585	4	.160
Linear-by-Linear Association	.441	1	.507
N of Valid Cases	275		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.31.

There appears to be no statistically significant correlation between adoption of cloud computing influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 5 above.

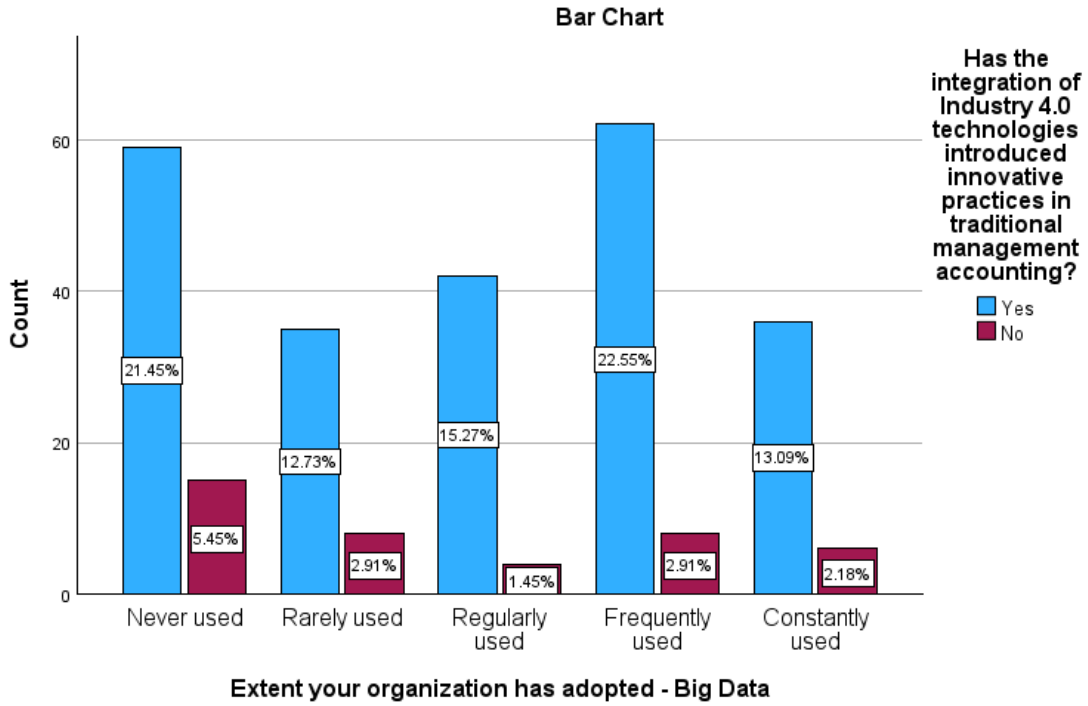

Figure 7: Extent of big data adoption influence on innovative practices in traditional management accounting

The figure 7 above shows, that adopting big data, positively influences innovative practices within management accounting significantly.

Table 6: Figure 166 Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.221[a]	4	.377
Likelihood Ratio	4.309	4	.366
Linear-by-Linear Association	2.140	1	.144
N of Valid Cases	275		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.26.

There appears to be no statistically significant correlation between adoption of big data influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 6 above.

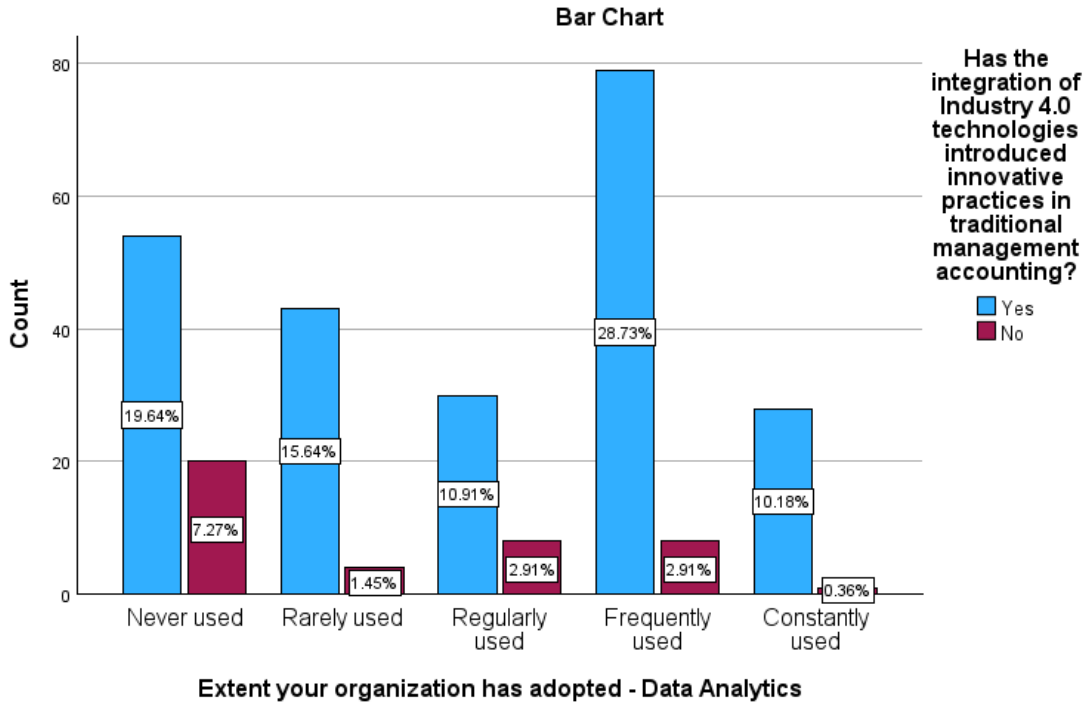

Figure 8: Extent of data analytics adoption influence on innovative practices in traditional management accounting

The figure 8 above shows, that adopting data analytics, positively influences innovative practices within management accounting significantly.

Table 7: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.454[a]	4	.002
Likelihood Ratio	16.661	4	.002
Linear-by-Linear Association	10.308	1	.001
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.32.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoptions of data analytics influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 7 above.

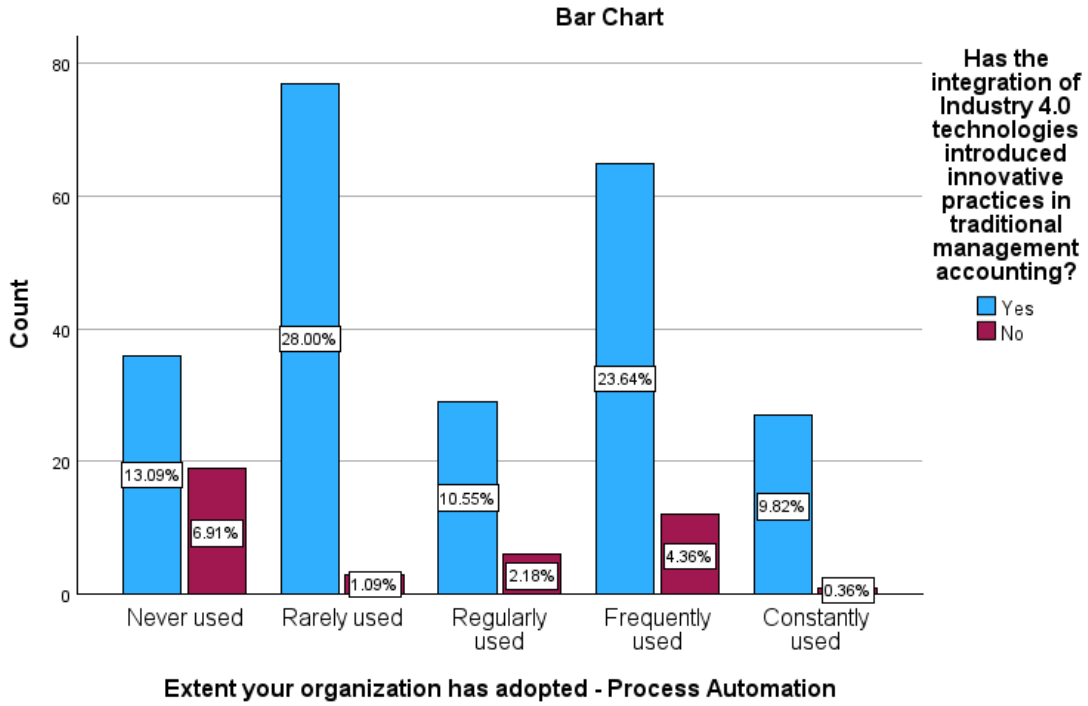

Figure 9: Extent of process automation adoption influence on innovative practices in traditional management accounting

The figure 9 above shows, that adopting process automation, positively influences innovative practices within management accounting significantly.

Table 8: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.572[a]	4	<.001
Likelihood Ratio	27.793	4	<.001
Linear-by-Linear Association	5.634	1	.018
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.17.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoption of process automation influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 8 above.

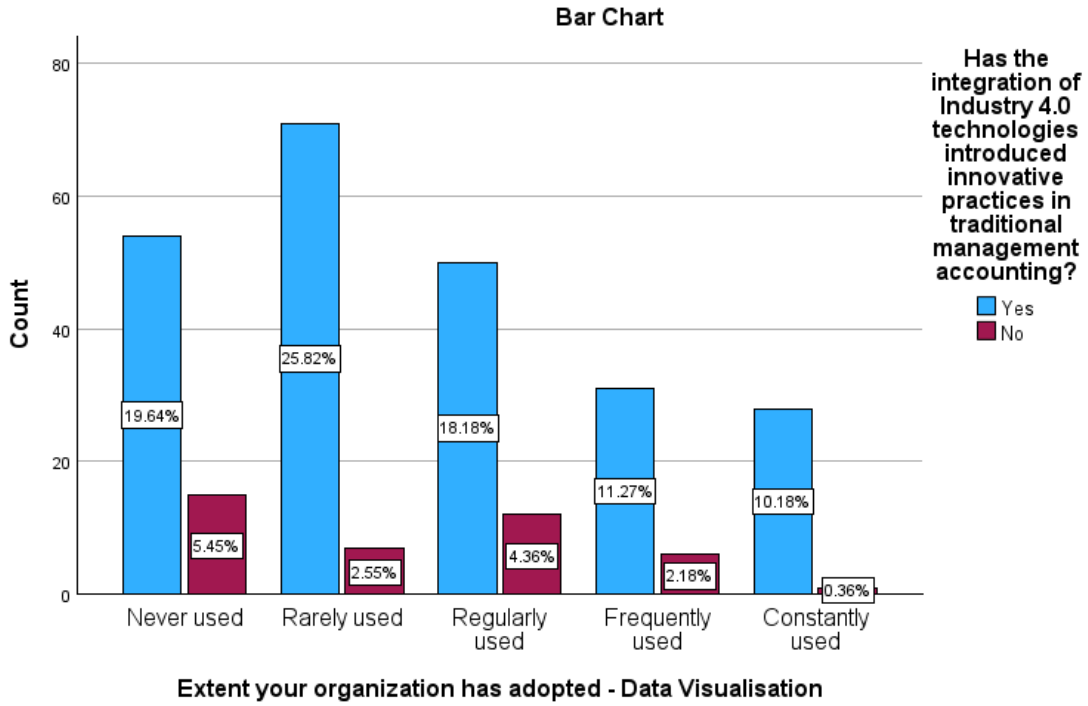

Figure 10: Extent of data visualisation adoption influence on innovative practices in traditional management accounting

The figure 10 above shows, that adopting data visualisation, positively influences innovative practices within management accounting fairly.

Table 9: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.721[a]	4	.068
Likelihood Ratio	9.839	4	.043
Linear-by-Linear Association	2.079	1	.149
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.32.

There appears to be no statistically significant correlation between adoption of data visualisation influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 9 above.

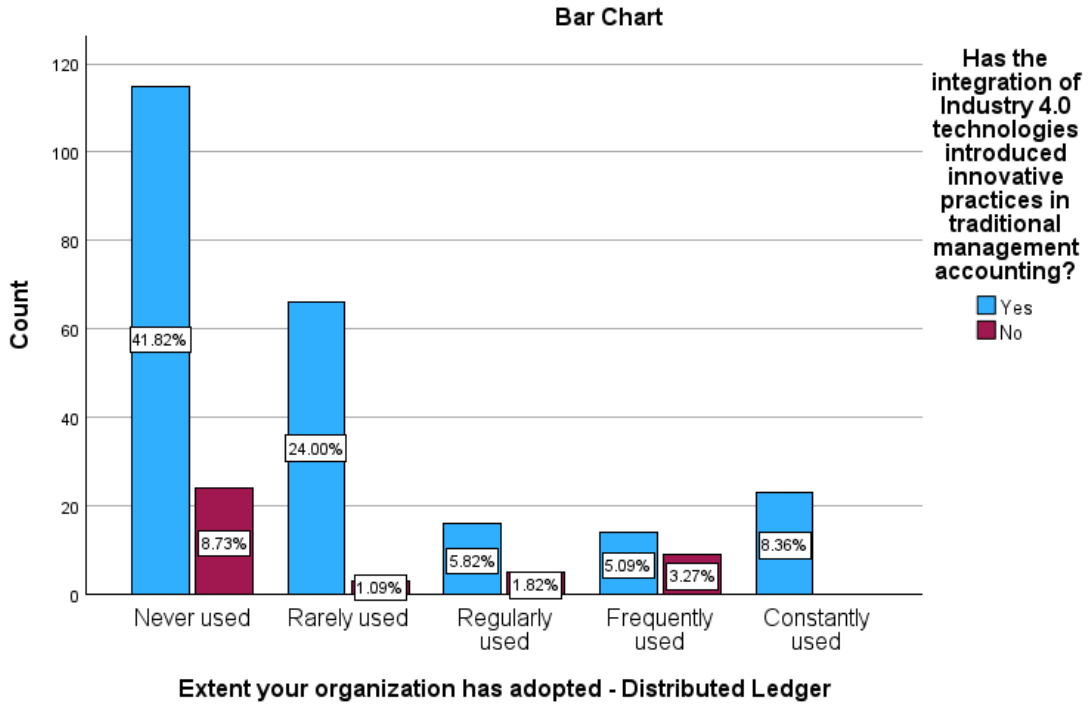

Figure 11: Extent of distributed ledger adoption influence on innovative practices in traditional management accounting

The figure 11 above shows, that adopting distributed ledger, positively influences innovative practices within management accounting significantly.

Table 10: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	22.653[a]	4	<.001
Likelihood Ratio	25.196	4	<.001
Linear-by-Linear Association	.005	1	.942
N of Valid Cases	275		

a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is 3.13.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoptions of distributed ledger influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 10 above.

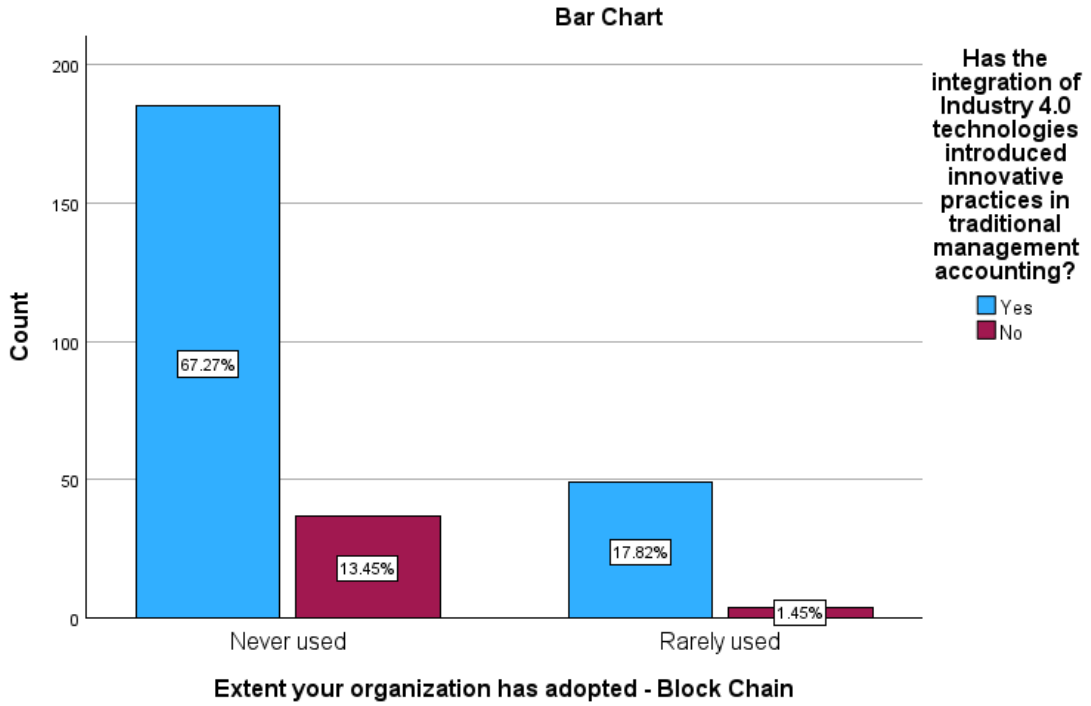

Figure 12: Extent of block chain adoption influence on innovative practices in traditional management accounting

The figure 12 above shows, that adopting block chain, does positively influences innovative practices within management accounting.

Table 11: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.805[a]	1	.094		
Continuity Correction[b]	2.132	1	.144		
Likelihood Ratio	3.210	1	.073		
Fisher's Exact Test				.131	.066
Linear-by-Linear Association	2.795	1	.095		
N of Valid Cases	275				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.90.

b. Computed only for a 2x2 table

There appears to be no statistically significant correlation between adoption of block chain influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 11 above.

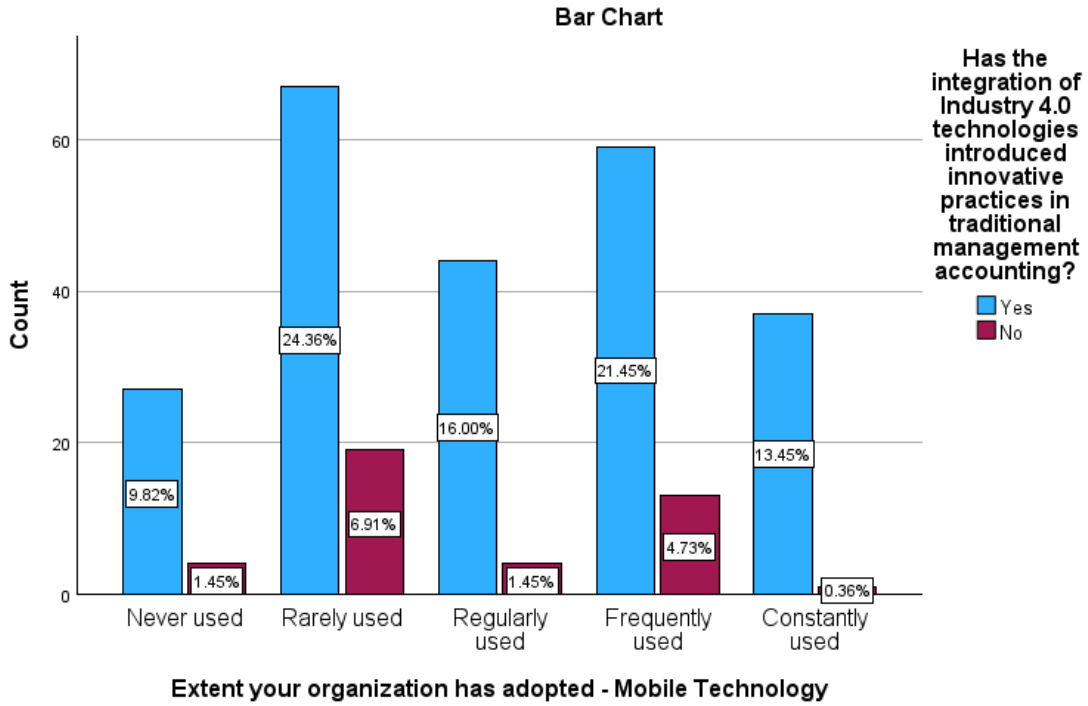

Figure 13: Extent of mobile technology adoption influence on innovative practices in traditional management accounting

The figure 13 above shows, that adopting mobile technology, positively influences innovative practices within management accounting.

Table 12: Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.310[a]	4	.036
Likelihood Ratio	12.162	4	.016
Linear-by-Linear Association	2.606	1	.106
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.62.

There appears to be no statistically significant correlation between adoption of mobile technology influencing innovation within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 12 above.

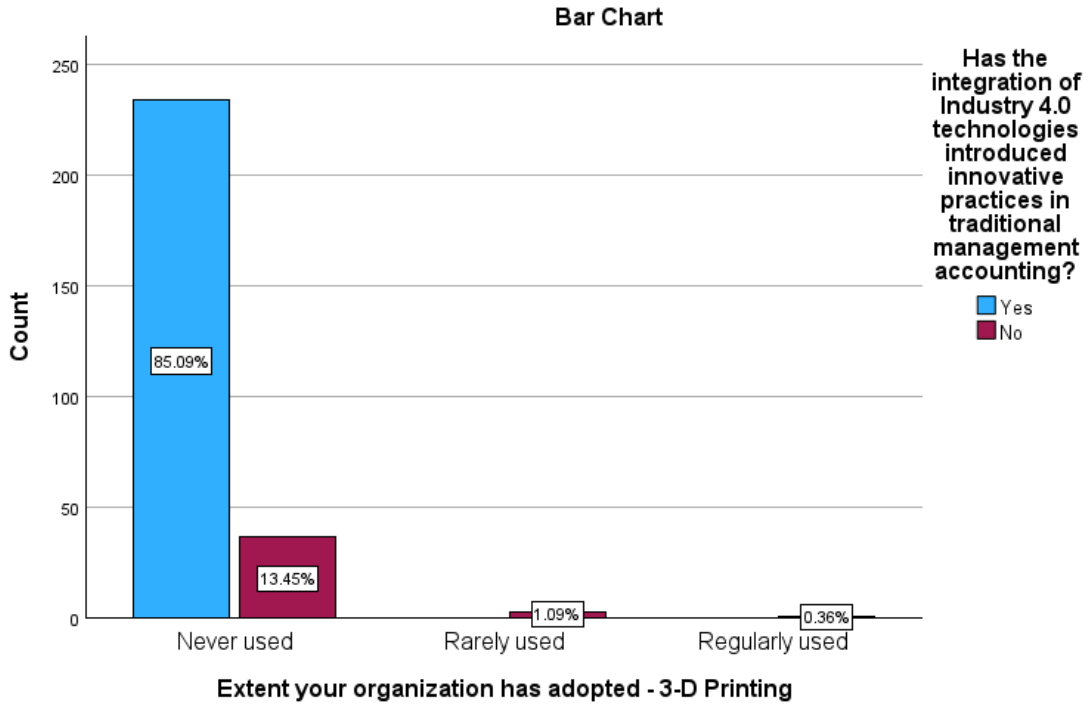

Figure 14: Extent of 3-D printing adoption influence on innovative practices in traditional management accounting

The figure 14 above shows, that adopting 3-D printing, does not positively influences innovative practices within management accounting.

Table 13: Figure 173 Chi-Square Tests

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	23.166[a]	2	<.001
Likelihood Ratio	15.571	2	<.001
Linear-by-Linear Association	20.576	1	<.001
N of Valid Cases	275		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .15.

The results from the Pearson Chi-Square test, Likelihood Ratio test, and Linear-by-Linear Association all strongly indicate a statistically significant association between adoptions of 3-D printing influencing innovation within management accounting, with p-values well below the 0.05 threshold as per table 13 above.

4.5 Qualitative Analysis of Innovations in Management Accounting

How do organizational factors influence the innovative outcomes resulting from the adoption of Industry 4.0 technologies in management accounting?

Table 13: Thematic Analysis of organisational factors influencing Innovations in Management Accounting

Theme	Codes	Description
Leadership and Support	- Top Management Support	The role of top management in supporting the adoption of Industry 4.0 technologies is crucial. Their backing can enhance the organization's capability to implement and benefit from these technologies.
	- Enhanced adoption	Active support from top management facilitates the faster and more effective adoption of new technologies.
	- Visionary Leadership	Leadership that is forward-thinking and visionary is vital for guiding the organization towards successful technology integration.
	- Supportive leadership	Leaders who actively promote and support innovation help drive successful technology adoption and utilization.
	- Influence of leadership	The overall impact of leadership on the organization's innovative outcomes is significant, especially in technology adoption.
Organizational Culture	- Innovation-Oriented Culture	A culture that encourages and nurtures innovation is essential for leveraging the benefits of Industry 4.0 technologies.
	- Culture of innovation	Organizations that foster a culture of innovation see more noticeable impacts from technology adoption.
	- Supportive culture	A supportive cultural environment facilitates the smooth integration of new technologies and processes.
	- Resistance to Change	Resistance to change within an organization can be a major barrier to successful technology adoption.
	- Resistance	Organizational resistance can significantly hinder the implementation and effective use of new technologies.
	- Intimidation and fear	Fear and lack of knowledge about new technologies can prevent employees from fully embracing innovations.
Resource Allocation and Infrastructure	- Financial Resources	Adequate financial resources are necessary to support the acquisition and implementation of Industry 4.0 technologies.
	- Resource allocation issues	Limited financial resources can restrict access to the necessary tools and technologies for innovation.
	- Budget allocation	Proper budgeting and allocation of funds are critical for supporting technological advancements.
	- Technological Infrastructure	The presence of a robust technological infrastructure is essential for effectively implementing and utilizing new technologies.
	- Infrastructure role	A strong infrastructure base plays a crucial role in the successful integration of Industry 4.0 technologies.
	- IT infrastructure availability	The availability of advanced IT systems and infrastructure supports the use and benefits of technologies like IoT and AI.

Employee Skills and Development	- Skilled Workforce	A workforce with the necessary skills and expertise is vital for the effective adoption and use of new technologies.
	- Employee skills	The skills and competencies of employees significantly impact the organization's ability to leverage new technologies.
	- Recruiting expertise	Hiring individuals with expertise in relevant technological fields supports the organization's innovative capabilities.
	- Training and Professional Development	Continuous training and development programs keep the workforce updated with the latest technological advancements.
	- Continuous development	Ongoing professional development helps employees adapt to and excel with new technologies.
	- Ongoing training	Regular training ensures that staff are well-equipped to handle and benefit from new technological tools and systems.
Organizational Structure and Processes	- Flexible and Agile Structures	Organizations with flexible and agile structures are better positioned to adopt and benefit from new technologies.
	- Agile and collaborative culture	A culture that promotes agility and collaboration facilitates more effective technology adoption.
	- Flat structure benefits	Flat organizational structures enable easier communication and quicker decision-making, aiding in technology implementation.
	- Change Management	Effective change management strategies are critical for easing transitions and maximizing the benefits of new technologies.
	- Effective change management	Strong change management practices help in smoothly integrating new technologies into the organization.
	- Change management strategies	Planned and structured change management approaches ensure successful technology adoption and utilization.
Strategic Orientation	- Strategy and Decision-Making	Strategic planning and decision-making processes influence how effectively an organization can adopt and benefit from new technologies.
	- Company strategy	A clear and supportive company strategy can drive the adoption of Industry 4.0 technologies.
	- Decision-making processes	Effective decision-making processes are crucial for the successful implementation of new technologies.
	- Competitive Advantage	Adopting new technologies can provide organizations with a competitive edge in the market.
	- Market competition	Technology adoption is often driven by the need to stay competitive in the market.
	- Industry demands	Meeting the demands of the industry may necessitate the use of advanced Industry 4.0 technologies.

Innovative Outcomes and Benefits	- Enhanced Capabilities	The adoption of Industry 4.0 technologies often leads to enhanced capabilities and improved operational performance.
	- Improved data analytics	Advanced data analytics and real-time reporting capabilities allow for more informed and timely decision-making.
	- Cloud-based systems	Cloud-based solutions improve scalability, data accessibility, and collaboration across departments.
	- Efficiency and Cost Reduction	New technologies contribute to increased efficiency and cost reduction within the organization.
	- Increased efficiency	Technology adoption often results in streamlined processes and operational efficiencies.
	- Making processes easier	Implementing new technologies can simplify processes, making them faster and more efficient.

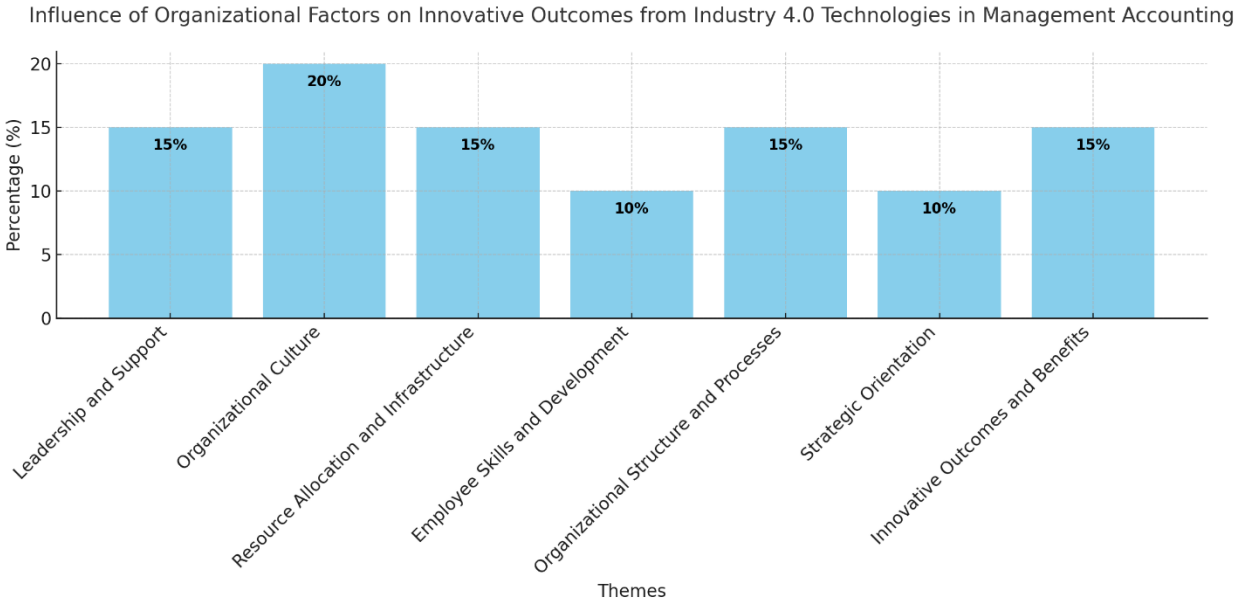

Figure 15: Extent of industry 4.0 technology adoption influence on innovations within management accounting

The figure 15 above shows, that adopting industry 4.0 technologies, positively impacts innovations within management accounting significantly.

Examples of innovations in management accounting due to industry 4.0 adoption

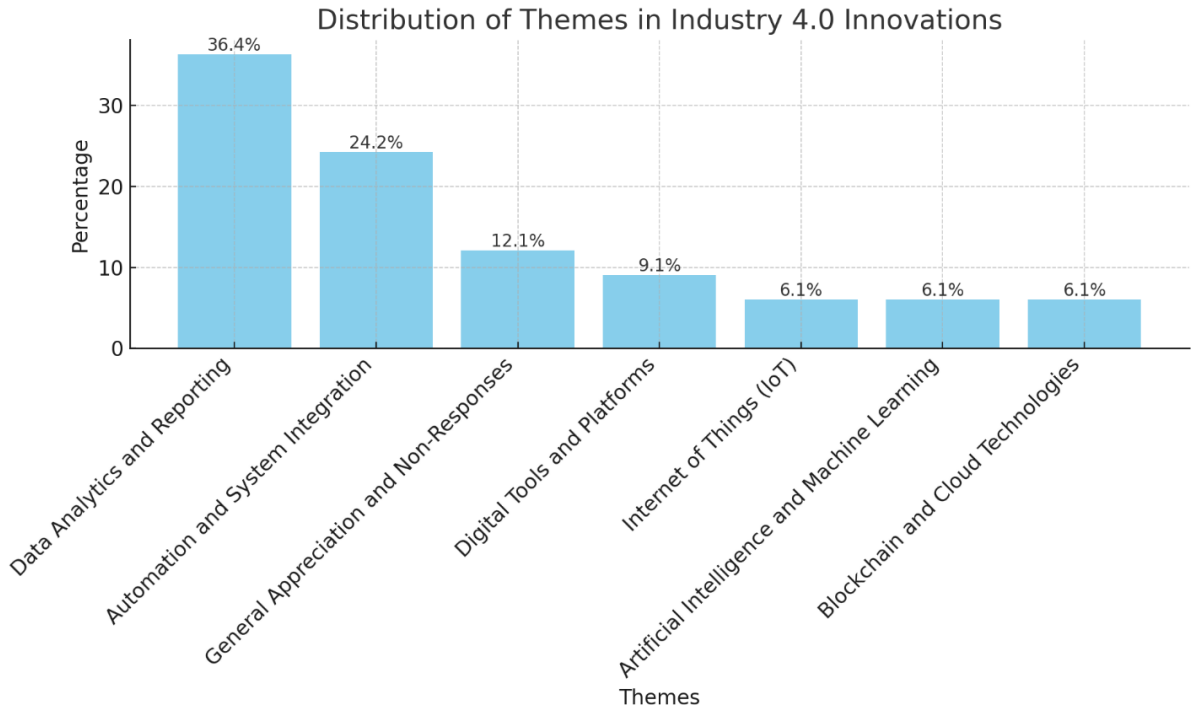

Figure 16: Extent of innovation after the adoption of industry 4.0 technologies within management accounting

The figure 16 above shows, that adopting industry 4.0 technologies, positively impacts innovations within management accounting significantly.

4.6 Summary

The study's findings, taken together, demonstrate the crucial significance that Industry 4.0 technologies will play in determining how management accounting develops in Botswana. Organizational behavior is greatly influenced by competitive pressure, technical preparedness, and leadership decisions, all of which play a major role in the strategic adoption of modern technologies. It has a significant effect on decision-making procedures, improving, automation, timeliness and accuracy. Furthermore, the enhancement of cost effectiveness and promotion of inventive methodologies highlight the revolutionary possibilities of Industry 4.0. These results offer a framework for Botswana-based companies to take advantage of technology breakthroughs, enhancing their competitive advantage and overall company performance.

5. Discussion, Industry 4.0 technology Adoption Impact on Innovation

5.1 How does the strategic adoption of Industry 4.0 technologies foster innovation within management accounting in the Botswana business context?

Discussion on Quantitative Innovation Effect

Innovative management accounting techniques are positively impacted by the Internet of Things in a statistically meaningful way. Strong correlations between Internet of Things adoption and innovation are found in the Pearson Chi-Square test (χ^2 = 21.914, p <.001), Likelihood Ratio (p =.001), and Linear-by-Linear Association (p <.001) (Figure 161, Table 146). This shows that Internet of Things technologies support creative management accounting practices by enabling firms to collect data in real-time, automate data collection, and give more accurate and timely information.

According to Figure 162, Table 147, the Likelihood Ratio (p <.001), the Linear-by-Linear Association (p <.001), and the Pearson Chi-Square test (χ^2 = 13.427, p =.004), the effect of artificial intelligence on innovation in management accounting is also statistically significant. Accountants are better equipped to recognize patterns and reach strategic judgments when artificial intelligence supports data analysis, predictive analytics, and decision-making procedures.

The results indicate that there is no statistically significant impact of machine learning adoption on innovative practices in management accounting. The significance threshold was not met by Pearson Chi-Square (χ^2 = 4.988, p =.083), Likelihood Ratio (p =.119), or Linear-by-Linear Association (p =.051) (Figure 163, Table 148). This suggests that although machine learning has potential, the way it is now implemented does not greatly increase the level of innovation in management accounting procedures.
According to Figure 164, Table 149, there is a statistically significant correlation between cyber-physical systems and innovation in management accounting. This is supported by the results of the Likelihood Ratio (p =.033), Pearson Chi-Square test (χ^2 = 7.637, p =.022), and Linear-by-Linear Association (p =.012). These systems increase the precision and effectiveness of accounting procedures by fusing digital monitoring and control with physical processes.

In contrast to predictions, the results of the Likelihood Ratio (p =.160), the Linear-by-Linear Association (p =.507), and the Pearson Chi-Square (χ^2 = 6.267, p =.180) do not indicate that cloud computing has a statistically significant impact on innovation within management accounting (Figure 165, Table 150). This shows that even if cloud computing is flexible and scalable, it does not currently have a significant impact on creative accounting procedures.

Similar results are obtained for the adoption of big data technologies and creative practices in management accounting (Figure 166, Table 151): Pearson Chi-Square (χ^2 = 4.221, p =.377), Likelihood Ratio (p =.366), and Linear-by-Linear Association (p =.144) all do not indicate a statistically significant impact on these practices. The potential of big data to enhance decision-making and yield profound insights may not have been completely utilized in management accounting as of yet.

Data analytics seems to have a major beneficial impact on management accounting innovation. This is confirmed by the Likelihood Ratio (p =.002), Linear-by-Linear Association (p =.001), and Pearson Chi-Square (χ^2 = 16.454, p =.002) tests (Figure 167, Table 152). Accounting professionals may improve strategic planning, expedite processes, and derive meaningful insights from data with the aid of data analytics solutions.
According to Figure 168, Table 153, Pearson Chi-Square (χ^2 = 27.572, p <.001), Likelihood Ratio (p <.001), and Linear-by-Linear Association (p =.018), process automation has a significant impact on innovative practices in management accounting. Automation speeds up accounting procedures, minimizes errors, and replaces manual work, resulting in more creative and effective accounting procedures.

Based on Pearson Chi-Square (χ^2 = 8.721, p =.068), Likelihood Ratio (p =.043), and Linear-by-Linear Association (p =.149), adoption of data visualization technologies does not appear to have a statistically significant impact on innovation in management accounting (Figure 169, Table 154). Although data visualization can improve comprehension and communication of data, it currently has little effect on creativity.

According to Figure 170, Table 155, the Likelihood Ratio (p <.001), Pearson Chi-Square (χ^2 = 22.653, p <.001), and Linear-by-Linear Association (p =.942), distributed ledger technology has a considerable impact on management accounting innovation. The efficiency, security, and transparency of financial transactions and record-keeping are improved by this technology.
The results of various tests (Figure 171, Table 156), including the Likelihood Ratio (p =.073) and Pearson Chi-Square (χ^2 = 2.805, p =.094), show that the adoption of blockchain does not significantly impact innovation in management accounting. Even while it has the potential to improve security and transparency, current usage does not stimulate innovation very much.
The adoption of mobile technology has a statistically significant effect on management accounting innovation, as demonstrated by the Likelihood Ratio (p =.016) and Pearson Chi-Square (χ^2 = 10.310, p =.036) (Figure 172, Table 157). Increased flexibility and accessibility to accounting data are made possible by mobile technology, which boosts productivity and creative thinking.

According to Figure 173, Table 158, the Likelihood Ratio (p <.001), Pearson Chi-Square (χ^2 = 23.166, p <.001), and Linear-by-Linear Association (p <.001), the use of 3D printing has a statistically significant but unfavorable impact on innovation in management accounting. This implies that although 3D printing is revolutionizing the production industry, novel techniques in management accounting are not directly translated by it.
The findings show that different Industry 4.0 technologies have different effects on creative management accounting techniques. This can be explained by a number of elements unique to Botswana's environment and the characteristics of these technologies. Compared to other technologies like machine learning and blockchain, the infrastructure and readiness for implementing cutting-edge technologies like artificial intelligence, the Internet of Things, and process automation may be more advanced. This has an impact on how well these technologies may be incorporated and applied in management accounting procedures.

A key factor is having the knowledge and experience necessary to manage and apply these technologies. Compared to new technologies like blockchain and big data, Botswana may have a greater number of people with training in data analytics and artificial intelligence, which could have an impact on innovation. Certain technologies may be adopted more easily or more slowly in Botswana depending on the country's economic climate and legal system. For example, laws that protect cybersecurity and data privacy may encourage the use of distributed ledger technologies, but laws that are too onerous may prevent blockchain from being used.
The way that cultures see technology adoption and change management can have a big impact on how effective these technologies are. Businesses in Botswana that embrace innovation and digital transformation stand to gain more from implementing Industry 4.0 technologies. Another factor is the type of the industry. In comparison to other industries, some (such manufacturing and logistics) may find it easier to adopt and more relevant to use technologies like Internet of Things and process automation, which could have a greater influence on creative behaviors in those sectors.

One potential obstacle to the adoption of these technologies is their initial cost and required investment, a good point here well supported by (Alsughayer, 2023). Technologies with higher entry costs (like data analytics and cloud computing) may experience faster uptake and influence than those that need larger upfront investments (like 3D printing). All things considered, Botswana's complex mix of preparation, skills, regulatory environment, cultural variables, industry uniqueness, cost considerations, and many other aspects is reflected in the various implications of Industry 4.0 technologies on innovation in management accounting.

Discussion on innovation themes coming from interviews and open ended questions

The following five major aspects are highlighted by the research data regarding how Industry 4.0 technologies encourage innovation in management accounting,

i. Leadership and Organizational Culture

The importance of organizational culture and leadership in fostering innovation is emphasized by this theme. Among the factors are a culture that welcomes innovation and new technologies. Visionary leadership that encourages the use of technology, good change management is necessary to provide a seamless transition and to foster departmental cooperation and open communication. (Joshi, 2023), (Yu, 2020) emphasises the role that organisational culture and more importantly leadership plays in the adoption and use of industry 4.0 technologies.

ii. Skills Development and Human Resources

Innovation in management accounting subject emphasizes how crucial it is to spend money on human resources in order to effectively manage Industry 4.0. This includes employing people with experience in artificial intelligence, big data, and other related sectors, creating a strong internal team, or outsourcing to qualified companies. Training and development programs are also important in equipping personnel with the appropriate skills (data analytics, cybersecurity).

iii. Infrastructure Technological and Allocation of Resources

Emphasis of this theme (innovation) is on how Industry 4.0 adoption requires a strong technology foundation. This entails having access to the tools and technologies (cloud computing, cutting-edge software) that are required, having a robust IT infrastructure to support big data, artificial intelligence, and the Internet of Things, and allocating enough funds for the adoption and upkeep of new technologies.

iv. Analytics and Data Management

Significance of efficient data management and analytics for management accounting innovation is emphasized by this theme. This entails putting strong data management procedures in place to guarantee the accuracy and quality of the data, applying data analytics for budgeting, variance analysis, and informed decision-making, and automating tasks with the help of artificial intelligence and machine learning technologies.

v. Scalability and Process Integration

This theme emphasizes the necessity of guaranteeing scalability for future expansion and integrating new technology with current systems. This entails putting in place scalable systems and processes that can expand with the company, integrating new technologies seamlessly with current workflows, and switching to cloud-based accounting systems for more accessibility and cooperation.

In summary

According to the research, certain firms are still in the early phases of adoption and are confronted with difficulties including resource limitations and change resistance, this point is supported by (Henderson, 1999), (Rutherford, 2020)and (Yaqub, 2023). Depending on the organization's type and industry, Industry 4.0's precise effects on innovation will differ. The data indicates that there is a great deal of room for innovation in management accounting using Industry 4.0 technologies. However, a comprehensive strategy that encompasses infrastructure, data management, leadership, skill development, and process integration is needed for successful deployment.

5.3 Examples of Innovation Themes from Interviews and Open Ended Questions

Discussion on themes of Innovation Example emanating from interviews and open ended questions

The following five categories can be used to organize the innovation examples based on the responses that were submitted for the open-ended questions and interviews. These groups aid in the classification of the innovations according to their main focus and underlying technology, offering a structured summary of the ways in which Industry 4.0 technologies are stimulating innovation across a range of management accounting and operational process domains.

A. Automation and Process Efficiency

i. Route fee calculation and automated invoicing

Many firms in Botswana are still in the process of switching from manual to automated methods. Time savings, error reduction, and process streamlining are all possible with automated invoicing. A nation where there are great distances between metropolitan areas needs to maximize logistics and transportation, which is why route fare calculation is important.

ii. Soil analysis and automatic irrigation

In Botswana, agriculture plays a big role in the economy. In Botswana's semi-arid climate, automatic watering systems and soil analysis can improve agricultural output by guaranteeing effective water usage and higher crop yields.

iii. Automated notification and alerting systems

The socioeconomic development of Botswana depends on the promptness and efficiency of industries like banking and healthcare, which can be enhanced by using automated alerts.

iv. Automated cash flow forecasting and consumer deposits

Automation in banking can improve operational effectiveness and customer service, which is important for Botswana's expanding financial sector.

B. Data Analytics and Real-time Reporting

i. Using Power Business Intelligence for budget tracking

Power Business Intelligence can offer real-time budget tracking and reporting to Botswana's public and private sectors, promoting openness and well-informed decision-making.

ii. Big data-driven real-time financial reporting and auditing

Businesses in Botswana can improve financial management and compliance by using real-time data to help them respond swiftly to changes in the market and financial abnormalities.

iii. Digital dashboards that are interactive

For Botswana's enterprises and government agencies, these dashboards can offer vital data that facilitate more effective resource allocation and strategic planning.

C. Internet of Things and Connected Devices

i. Internet of Things in the industrial and agricultural industries

The ability of Internet of Things devices to track and improve farming operations is essential for Botswana's agricultural growth. Internet of Things can decrease downtime and improve operational efficiency in industrial industries.

ii. Software meters and networked systems

Botswana's manufacturing and utility industries may monitor consumption and performance more efficiently and economically by switching to software meters and networked systems.

D. Integration and Interconnectivity

i. Microsoft Business Central's debut

This can improve overall efficiency and competitiveness by assisting Botswana's firms in integrating different activities such as finance, supply chain, and operations.

ii. Cloud backup and system integration

Businesses in Botswana need to make sure that data is secure and that information can be accessed easily in order to remain competitive in the global market.

iii. Financial data apps for mobile devices

Mobile apps can give managers on-the-go access to financial data in a nation where the rate of mobile adoption is rising, improving decision-making and operational flexibility.

E. Predictive Maintenance and Artificial Intelligence

i. Systems for predictive maintenance

Predictive maintenance can lower maintenance costs and downtime for Botswana's mining and industrial sectors, enhancing output and security.

ii. Virtual assistants and chatbots with artificial intelligence

These can improve client satisfaction and offer round-the-clock support in a variety of industries, such as banking and retail.

iii. Blockchain technology for safe and secure transactions

The success of Botswana's financial system depends on the security and transparency of financial transactions, which blockchain technology can improve.

5.4 Conclusion: Industry 4.0 Technologies Fostering Innovation

Botswana's management accounting sector's adoption of Industry 4.0 technology has a mixed but encouraging effect on innovation. While machine learning and cloud computing have less obvious effects, quantitative analysis, including Chi-Square tests, reveals statistically significant positive influences from technologies like Internet of Things, artificial intelligence, data analytics, and process automation on innovative practices. Critical issues including the necessity of top management support, appropriate resource allocation, a strong IT infrastructure, ongoing talent development, and an innovative culture are highlighted by qualitative insights. Taken together, these elements provide enhanced data analytics, instantaneous reporting, and heightened productivity, ultimately cultivating a competitive advantage in the marketplace. The degree of innovation arising from these technological adoptions in Botswana is significantly influenced by factors such as economic conditions, leadership, and organizational preparedness. Finally, (Chesbrough, 2003) and (Kriz, 2018), who emphasize the transformative potential of these technologies in promoting innovative behaviors, support the role of Industry 4.0 in supporting innovation.

5.5 Conclusion on the Hypothesis

The alternate hypothesis, which holds that Botswana's intentional use of Industry 4.0 technology significantly fosters innovation in management accounting, is supported by the results of the theme analysis and chi-square tests. With p-values considerably below the 0.05 cut off, chi-square results for technologies such as Internet of Things, artificial intelligence, data analytics, and process automation demonstrate strong positive correlations with creative management accounting techniques. This is further supported by the thematic analysis, which emphasizes the vital roles of IT infrastructure, innovation-friendly culture, resource allocation, and top-level

management support. The effective implementation of Industry 4.0 technologies is fuelled by these elements taken together, which result in improved data analytics, real-time reporting, and increased efficiency, all of which are important markers of innovation. As a result, the evidence clearly supports the alternative hypothesis, showing that Industry 4.0 technologies do in fact encourage management accounting innovation in Botswana's economic environment.

5.6 Summary Results Discussion

The study's findings offer a thorough understanding of the variables impacting the adoption of Industry 4.0 technologies in management accounting, as well as how they affect decision-making procedures, optimize cost efficiency, and promote innovation in Botswana's organizational structures. With Cronbach's Alpha values ranging from.755 to.930, the reliability statistics show a strong degree of internal consistency and robust reliability of the constructs assessed. In particular, the competitive pressure (.756), organizational culture (.723), technological preparedness (.774), and leadership decisions (.872) all have a substantial impact on the strategic adoption of Industry 4.0 technologies. Additionally, the use of these technologies improves decision-making speed (.798), accuracy (.814), and effectiveness (39.64% of respondents rated it as highly effective) in terms of cost savings. It's also clear that the favorable impact is having a good effect on traditional cost management measures; with the majority perceive positive effects. The tools also support creative activities and resource optimization, which improve organizational performance even further.

The chi-square tests, which summarize the hypothesis tests, show a statistically significant correlation between enhanced decision-making procedures, cost effectiveness, and innovation with the use of Industry 4.0 technology. The idea that Industry 4.0 technologies are crucial to Botswana's transformation of management accounting procedures is supported by statistical evidence. The noteworthy enhancement in decision-making precision and promptness, expense minimization, and inventiveness implies that these technologies play a crucial role in augmenting firm performance. Thus, in order to fully utilize Industry 4.0 technologies and gain a competitive edge as well as operational excellence, firms are urged to invest in and incorporate them. The results highlight the significance of technological preparedness, supportive organizational culture, and strategic leadership in enabling the effective adoption and deployment of these cutting-edge technologies.

5.7 Recommendations Cost Optimization with Industry 4.0

5.7.1 Use cutting-edge data analytics

To get real-time insights into operational effectiveness and financial performance, use modern data analytics. This will support the process of finding ways to save costs and allocating resources as efficiently as possible.

Make Use of Automation

Data input and reconciliation are two common accounting processes that can be automated with robotic process automation (RPA). This lowers personnel expenses, cuts down on mistakes, and frees up accountant time for more strategic endeavours.

Cloud-Related Products

Make the switch to cloud-based accounting systems to save money on IT infrastructure, boost departmental cooperation, and increase data accessibility. Because cloud solutions are scalable, companies can only pay for the resources they really use.

Use Internet of Things to Connect Asset Management

Make better use of Internet of Things technology to monitor and manage physical assets. In the end, this can result in lower operating costs through improved maintenance schedules, decreased downtime, and optimum asset use.

Put Lean Accounting Principles into Practice

Adopt lean accounting concepts to increase efficiency, cut waste, and streamline financial procedures. This strategy emphasizes ongoing development and value-added activities.

Negotiation and Management of Vendors

Utilize industry 4.0 technologies to improve the negotiation and vendor management procedures. Organizations can negotiate better terms and save costs by examining market trends and previous purchasing data.

5.8 Fostering Innovation with Industry 4.0

5.8.1 Boost the Support of Top Management

Urge senior management to embrace Industry 4.0 technology with initiative and dedication. Programs for leadership development that emphasize digital transformation and the advantages of creative management accounting techniques can help achieve this.

Provide Enough Resources.

Make sure there is enough funding set up for the adoption of Industry 4.0 technology. This entails making the continuous maintenance, software, and infrastructure investments required to support these systems.

Establish Sturdy IT Infrastructure

Create a solid IT foundation that can handle cutting-edge technologies like big data analytics, Artificial Intelligence, and the Internet of Things. This entails establishing cybersecurity safeguards, maintaining high-speed internet connectivity, and updating current systems.

Encourage an Innovative Culture

Create an environment in your company where change is welcomed and creativity is encouraged. This can be accomplished through encouraging a collaborative work atmosphere, honouring and rewarding creative solutions, and giving staff members access to platforms where they can test out cutting-edge technology.

Make an Employee Training Investment

Offer staff ongoing professional development opportunities with an emphasis on cybersecurity, innovative financial technologies, and data analytics. This guarantees that the labor force is adequately prepared to utilize Industry 4.0 technology.

Put Change Management Techniques into Practice

Create and implement efficient change management plans to facilitate the adoption of new technology. This entails outlining the advantages in detail, holding training sessions, and setting up support networks to deal with opposition and worries from staff members.

5.9 Future Research Areas

5.9.1 Assessment of Economic Impact

Examine the wider economic implications of Botswana's adoption of Industry 4.0, taking into account the effects on GDP growth, job levels, and industry competitiveness.

*Data privacy and cybersecurity***.**

Examine the issues around data privacy and cybersecurity in relation to the implementation of Industry 4.0. Create plans to defend against online attacks and preserve private financial information.

5.10 Conclusion

The study offers in-depth insights into Botswana's organizations' strategic adoption of Industry 4.0 technologies in management accounting, emphasizing the factors driving this adoption, its effects on decision-making procedures, cost efficiency optimization, and innovation promotion. The findings demonstrate how using these technologies significantly increases the timeliness and accuracy of decisions. Furthermore, a sizable portion of respondents rated cost reduction in management accounting as extremely effective, demonstrating its efficacy. There's also a big positive impact on conventional cost management techniques. These technologies also aid in the introduction of novel practices and the optimization of resource usage, which improves the general performance of the company.

Several recommendations are made for Botswana-based organizations looking to use Industry 4.0 technologies in light of the findings. To ensure successful adoption, businesses should first place a high priority on developing their leadership and cultivating a culture that welcomes technological innovation. For these technologies to work to their full potential, investments in technological infrastructure and preparedness are essential. Adoption and integration might be further accelerated by resolving regulatory implications and competitive constraints. Subsequent research endeavors ought to delve into the enduring consequences of Industry 4.0 technologies on management accounting methodologies and their wider influence on the performance of organizations. Deeper insights can be obtained by looking into adoption hurdles and solutions. Furthermore, comparative research between other industries and geographical areas can provide a more comprehensive understanding of the uptake and effects of Industry 4.0 technology. Future research may continue to inform and direct the strategic application of Industry 4.0 technologies by concentrating on these areas, ensuring that businesses in Botswana and elsewhere can fully utilize these technologies for improved business performance.

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