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Exploring the Role of Industry 4.0 Technologies in Enhancing Cost Management Efficiency and Resource Optimization: Evidence from Botswana's Key Industries

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ABSTRACT

Incorporating Industry 4.0 technologies into Botswana's management accounting procedures has shown promise for efficiency and cost reduction. According to quantitative evaluations, technologies like cloud computing, artificial intelligence, machine learning, and data analytics greatly improve operational efficiency and allow for cost savings through streamlined procedures and data-driven decision-making. Newer technologies like the Internet of Things and 3D printing, however, have not yet produced quantifiable cost savings, indicating unrealized potential. Qualitative results also highlight operational improvements like automation and the ability to operate remotely, as well as environmental advantages like lower energy and paper usage. Even if certain technologies have limited immediate benefits and compatibility issues, firms are nevertheless hopeful about future efficiencies as usage grows. The study emphasizes the strategic significance of addressing personnel and regulatory issues, investing in infrastructure, and cultivating an innovative culture. These revelations open the door for future studies on the revolutionary potential of Industry 4.0 and well-informed adoption methods.

1. Introduction

Global corporate operations are entering a revolutionary era with the advent of Industry 4.0 technologies. Organizations are reinventing operational processes, improving cost management, and optimizing resources by using cutting-edge technologies like blockchain, cloud computing, big data analytics, artificial intelligence (AI), and machine learning (ML). Unmatched opportunities to improve decision-making accuracy, save waste, and streamline operations are presented by this paradigm change. Developing economies like Botswana are starting

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to realize the promise of these innovations as businesses throughout the world embrace them to overcome obstacles related to resource limitations and competitive pressures. But Botswana's use of Industry 4.0 technology is still relatively unexplored, especially when it comes to cost effectiveness in important sectors like manufacturing, mining, and services. By investigating how these technologies are being incorporated into Botswana's management accounting procedures to maximize resource use and attain cost reductions, this study aims to close this gap.

1.1 Current State of Botswana Regarding Industry 4.0 Technologies

The strong mining industry, especially the production of diamonds, has long been the mainstay of the economy of Botswana, a middle-income nation in Southern Africa. However, the nation has recently placed a high priority on technical innovation and digital transformation in recognition of the need for diversity and sustainable growth. The significance of implementing cutting-edge technologies to modernize industry and boost competitiveness is highlighted by government efforts like Vision 2036 and the National Fourth Industrial Revolution (4IR) Strategy (Mhlanga, 2020).

Despite these initiatives, there is still uneven adoption of Industry 4.0 technology throughout Botswana's major industries. While certain sectors have welcomed advances like automation and AI-driven analytics, including financial services and telecommunications, others, like conventional manufacturing and mining, have not yet fully benefited from new technologies. Widespread adoption has been hampered by issues like poor infrastructure, a lack of qualified workers, and change aversion. Furthermore, financial and technological obstacles prevent small and medium-sized businesses (SMEs), who make up a sizable section of Botswana's economy, from integrating cutting-edge solutions.

These technologies have a lot of potential to improve cost management procedures and address inefficiencies in the area of management accounting. Big data analytics and artificial intelligence (AI) have already shown promise in lowering operating expenses, enhancing decision-making, and reducing dependency on human procedures. However, because of their early adoption stages and lack of contextual adaptation, technologies like 3D printing and the Internet of Things (IoT) have not yet significantly improved cost efficiency in Botswana, according to the study's findings. Despite these drawbacks, businesses are becoming more optimistic about the long-term advantages of using Industry 4.0 technologies, especially as labor and infrastructural capacities advance.

1.2 Background

Industry 4.0, which was first introduced in Germany in the early 2010s, is defined by the incorporation of IoT, intelligent automation, and cyber-physical systems into industrial processes. The goal of this technological revolution is to build networked systems that maximize efficiency, minimize resource usage, and boost overall output. With the advancement of these technologies, their use has spread beyond manufacturing to a number of industries, such as healthcare, finance, and education.

Industry 4.0 technologies provide revolutionary advantages in the field of management accounting. Real-time data analysis is made possible by AI and ML, which improves the precision and promptness of financial reporting and decision-making. Automation streamlines repetitive tasks and minimizes errors by reducing manual effort. Blockchain guarantees safe and open record-keeping, while cloud computing makes collaboration and data

access easier. When taken as a whole, these technologies give businesses the means to improve cost control procedures and maximize resource use.

Industry 4.0 technology adoption in Botswana is still in its infancy. Traditional industries like mining and manufacturing continue to face difficulties, but early adopters in the financial and service sectors have shown promise for increased productivity and cost reductions. The government's commitment to using technology for sustainable development is shown in its strategic goal for adopting the 4IR (Mbizi, 2022). But in order to achieve this goal, important obstacles such a lack of digital infrastructure, a lack of skilled workers, and organizational change aversion must be addressed.

The results of this study highlight how Industry 4.0 technologies have the potential to revolutionize management accounting procedures in Botswana. In order to fully realize the potential of digital transformation in Botswana's major industries, policymakers, business executives, and researchers can benefit greatly from this research's examination of how these technologies can improve cost effectiveness and resource optimization.

1.3 Research Questions

1. What is the extent of Industry 4.0 technology adoption in Botswana's key industries?
2. How do Industry 4.0 technologies contribute to cost management efficiency in Botswana?
3. Which specific technologies (e.g., AI, machine learning, blockchain) have the most significant impact on resource optimization?
3. What is the future outlook for cost management and resource optimization through Industry 4.0 technologies in Botswana?
4. What strategies can be implemented to enhance the adoption and effectiveness of Industry 4.0 technologies in Botswana?

2.0 Literature Review

2.1 Industry 4.0 Technologies

Operational landscapes across sectors have changed with the introduction of Industry 4.0, which is defined by the integration of cyber-physical systems, the Internet of Things (IoT), and advanced analytics (Schwab, 2017). A framework for comprehending the adoption and application of Industry 4.0 technologies is offered by theoretical constructs including contingency models of leadership effectiveness (Fiedler, 1964) and diffusion of innovations (Rogers, 2003). Through digital transformation, sophisticated data analytics, and real-time process management, Industry 4.0 technologies provide substantial potential for resource efficiency and cost reduction (Frank, 2019) (Veile, 2020).

2.2 Role of Industry 4.0 in Cost Management

Cost management procedures have changed as a result of the incorporation of Industry 4.0 technologies like cloud computing, blockchain, and artificial intelligence (AI). (Bhimani, 2020) Emphasizes the need for management accounting procedures and digital data to change in order to accommodate the complexity brought about by Industry 4.0. By fostering real-time visibility into operations, digitalization helps businesses spot inefficiencies and allocate resources as efficiently as possible (Marsintauli, 2021) (Piosik, 2022). Under the Industry 4.0 paradigm, performance is frequently assessed using the balanced scorecard approach (Frederico, 2021).

(Ahmad, 2019) Emphasizes how sustainability, digitization, and organizational success are intertwined. Incorporating digital technology with eco-efficiency not only lowers expenses but also encourages environmental sustainability (Abdelhalim, 2023) (Pramono, 2023). These observations are especially pertinent to Botswana, where industries must improve operational efficiency due to growing input costs.

2.3 Resource Optimization and Sustainability

Industry 4.0 resource optimization is mostly dependent on IoT and advanced analytics, which enable waste reduction, predictive maintenance, and effective energy use (Bag, 2021) (Allioui, 2023). (Müller, 2018) (Moeuf, 2020) Highlight the significance of coordinating technology advancements with sustainability objectives in order to identify important success criteria for Industry 4.0 adoption. For instance, smart systems make it possible to track resource usage in real time, which encourages accountability and transparency (Azcarate-Aguerre, 2022).

Mining and agriculture, two of Botswana's most important industries, stand to gain a great deal from these developments. According to (Muchuchuti, 2021), improving digital skills and preparing the workers are essential to maximizing Industry 4.0's potential in emerging nations. This is consistent with research by (Mhlanga, 2020), who supports the use of digital education and skill development as the cornerstones of an effective Industry 4.0 deployment.

2.4 Challenges in Industry 4.0 Adoption

Adoption of Industry 4.0 is difficult despite its revolutionary potential, especially in developing nations. Barriers are often identified as managerial and organizational, including skill gaps and aversion to change (Agostini, 2019) (Singaram, 2022). The foundation of Botswana's economy, SMEs, frequently face difficulties implementing digital technologies due to a lack of financial and technical resources (Acquah, 2007) (Majama, 2017).
(Mbizi, 2022) (Hahm, 2018) Emphasize the necessity of customized interventions to address cultural hurdles and labor readiness in implementing Industry 4.0. These obstacles are more noticeable in Botswana, where small-scale and informal businesses are the norm. In order to facilitate digital transformation in both the public and private sectors, (Molokwane, 2019) emphasizes the necessity of policy-level initiatives.

2.5 Industry 4.0's Impact on Decision-Making and Management Accounting

Management accounting procedures need to be reassessed in light of the trend toward digitization. According to (Möller, 2020), digitization introduces new tools and methods for decision-making, transforming management control systems. Digital tools can facilitate data-driven decision-making in Botswana, increasing resource use accountability and openness.
Data integrity is enhanced and human error is decreased when blockchain and artificial intelligence are included into accounting procedures (Marsintauli, 2021) (Sokolenko, 2020). This is consistent with research by (Wijethilake, 2018), which shows that organizational success and environmental innovation initiatives are positively correlated.

2.6 Lessons from Global and Regional Perspectives

Strategic planning and stakeholder participation are crucial, according to lessons learned from the adoption of Industry 4.0 in developed nations like Germany (Veile, 2020). For Botswana, where industries are negotiating the challenges of digital change, these lessons are priceless. In order to attain long-term results, (Rutherford,

2020) emphasizes the significance of matching workforce development with technology investments.
(Mbizi, 2022) Highlight the changing role of accountants in the Fourth Industrial Revolution in the African setting. Their conclusions are consistent with the necessity for Botswana's industries to make investments in worker upskilling and the adoption of cutting-edge accounting standards. Furthermore, it is impossible to overestimate the importance of universities in developing digital skills and advancing sustainability education (Mian, 2020).

2.7 Theoretical Frameworks Relevant for this study

Theoretical frameworks play a pivotal role in grounding research by providing structured perspectives to explore complex phenomena. This study, which examines the role of Industry 4.0 technologies in enhancing cost management efficiency and resource optimization within Botswana's key industries, draws on three key theoretical foundations, the Technology-Organization-Environment (TOE) framework (Tomatzky, 1990), the Resource-Based View (RBV) (Barney J. , 1991), and the Diffusion of Innovation (DOI) theory (Rogers, 2003). Each of these frameworks offers unique insights into understanding the adoption, integration, and impact of Industry 4.0 technologies. Together, these theories form a robust foundation for exploring how Botswana's industries can optimize their operations and enhance cost efficiencies in the era of digital transformation.

i. Technology-Organization-Environment (TOE) Framework

(Tomatzky, 1990) Created the TOE framework, which describes the elements affecting an organization's adoption of technology. It highlights three crucial components and features of the technology, including relative advantage, compatibility, and complexity. External elements including competition, laws, and market dynamics, as well as internal factors like size, structure, and resource availability. This approach fits in nicely with the study's emphasis on how Industry 4.0 technologies are being used in Botswana's major industries. It makes it possible to examine how technological prowess, organizational preparedness, and outside influences influence how these technologies are implemented and optimized. The TOE framework is appropriate for comprehending the forces behind and obstacles to Industry 4.0 technologies since it offers a comprehensive perspective on technology adoption. Although thorough, the TOE framework may not adequately account for the efficiency and resource optimization elements because it concentrates on adoption.

ii. Resource-Based View (RBV)

According to the RBV framework (Barney J. , 1991), a company's distinct assets and competencies provide it a competitive edge. It places a strong emphasis on using internal resources such as technology and human capital to boost productivity and performance. This approach is especially pertinent for analyzing how Industry 4.0 technologies function as strategic assets to improve resource optimization and cost management effectiveness in Botswana's industries. RBV highlights the strategic value of resources like artificial intelligence (AI), big data, and process automation and establishes a direct link between technology adoption and organizational performance. RBV may ignore the larger environmental and technological effects that are essential to Industry 4.0 because it mostly concentrates on internal aspects.

iii. Diffusion of Innovation (DOI) Theory

The DOI hypothesis, which was created by (Rogers, 2003), describes how innovations are incorporated into a social system over time. It highlights important elements such as trial ability, observability, complexity, compatibility, and relative benefit. In order to investigate how Industry 4.0 technologies spread throughout Botswana's

businesses and how quickly they are embraced based on perceived advantages and difficulties, DOI theory is pertinent. It offers a thorough comprehension of the adoption procedure and variables affecting the uptake of new technology. The DOI hypothesis places less emphasis on post-adoption results like resource optimization and cost efficiency and more on adoption patterns.

Most Suitable Framework for this study is Technology Organization Environment (TOE) Framework

Because it offers a thorough lens through which to examine the adoption and application of Industry 4.0 technologies within the framework of Botswana's industries, the TOE framework is best suited for this research. Its focus on organizational, technological, and environmental aspects complements the study's emphasis on resource optimization and cost management effectiveness while also taking into account the particular opportunities and difficulties of the business environment in Botswana. The TOE framework can be modified for a multifaceted study by incorporating elements of the RBV (to emphasize the strategic value of resources) and DOI theory (to comprehend adoption trends), if necessary.

2.8 Conclusion

The literature emphasizes how Industry 4.0 technology might improve resource optimization and cost management effectiveness. But for adoption to be successful, important issues like business culture, worker preparedness, and budgetary limitations must be resolved. As long as there is a determined effort to match digital transformation with strategic investments, skills building, and policy interventions, utilizing Industry 4.0 technologies presents a route to sustainable development for Botswana.

3.0 Materials and Methods

3.1 Introduction

This section describes the methodology used to investigate how Industry 4.0 technologies can improve resource optimization and cost management effectiveness in Botswana's major industries. The adoption of digital technology and its effects on operational efficiency and financial management are thoroughly examined in this study using a strict mixed-methods methodology. The research design, population, sample protocols, data gathering tools, and analytical methodologies are important elements of this methodology.

3.2 Research Design and Methodology

The study employs a mixed-methods strategy, combining qualitative and quantitative techniques to offer a comprehensive evaluation of Industry 4.0's effects on resource usage and cost effectiveness. This strategy guarantees the gathering of statistical information as well as in-depth understanding of organizational adoption patterns, decision-making procedures, and the financial effects of technology change.

3.3 Quantitative Component

The goal of the quantitative phase is to measure how much Industry 4.0 technologies help with resource optimization and cost control. In order to attain statistical impartiality and rigor while assessing adoption trends and financial results, a systematic technique was applied (Bryman, 2016).

i. Sampling Strategy

The study utilized a stratified random sample technique to guarantee a representative selection of businesses from a range of industries and sizes. Company size (SMEs vs. large companies), Industry 4.0 adoption level, and

sector classification (public vs. private) were among the stratification variables. By using this method, selection bias was reduced and the findings were more broadly applicable to Botswana's economic environment (Creswell, 2017).

ii. Data Collection – Structured Questionnaires

Key stakeholders, such as corporate decision-makers, IT professionals, and finance managers, were given structured questionnaires. These tools were created to evaluate the efficiency improvements, technological adoption rates, and cost management strategies related to Industry 4.0 deployments (Fowler Jr, 2013). The questionnaire's standardization improved the results' comparability and dependability.

iii. Data Analysis – Statistical Evaluation

Using SPSS software, the study used Chi-Square tests to assess the connection between cost efficiency measures and Industry 4.0 adoption. Because of its ability to analyze categorical variables, this analytical approach was used to find statistically significant relationships between financial performance metrics and technology integration (Agresti, 2018).

iv. Rationale for Quantitative Approach

To find empirical connections between the adoption of Industry 4.0 and the effectiveness of cost management, a quantitative approach was chosen. The application of statistical analysis and standardized data collection methods guarantees unbiased, fact-based findings that support useful industry suggestions.

3.4 Qualitative Component

Organizational experiences, obstacles, and strategic approaches to Industry 4.0 adoption were examined in a qualitative study to support the quantitative results.

i. Participant Selection

In order to ensure that insights were obtained from people who have first-hand experience managing cost structures and resource utilization in technologically evolving environments, the study employed a purposive sampling strategy to recruit senior financial executives, operations managers, and digital transformation leaders from a variety of sectors.

ii. Data Collection – Semi-Structured Interviews and Focus Groups

It was possible to have in-depth conversations about the anticipated advantages and obstacles to Industry 4.0 adoption through semi-structured interviews. This method's adaptability made it possible to investigate financial plans, resource allocation, and cost optimization initiatives in greater detail (Patton, 2014). The finance and IT departments of a few chosen companies also participated in focus groups to study the dynamics of cooperative decision-making over technology-driven cost reductions.

iii. Thematic Analysis for Qualitative Data

Thematic analysis was used to examine qualitative data in order to find important insights into the strategic implementation of Industry 4.0 as well as recurrent trends. Based on important topics like cost-cutting tactics, efficiency enhancements, and technological investment choices, thematic divisions were created (Braun, 2006).

iv. Justification for Qualitative Methods

In order to completely capture contextual nuances that could not be fully addressed by quantitative data alone, qualitative methodologies were employed. A better comprehension of managerial viewpoints, decision-making frameworks, and industry-specific limitations pertaining to digital transformation was made possible by the inclusion of focus groups and interviews.

3.5 Study Population and Sampling Framework

Stratified random sampling was used to ensure representation across industry sectors, with specific allocation as follows: The study focused on important industry sectors in Botswana, including both private and public organizations, with an estimated total population of 20,000 professionals working in financial management and digital transformation roles.

- **Public Sector Organizations:** 126 participants
- **Private Sector Organizations:** 126 SMEs and 126 large corporations

3.6 Ethical Considerations

The Botswana Ministry of Trade and the University of Zambia Institutional Review Board provided their ethical approval. All participants gave their informed consent, and confidentiality procedures were closely followed to guarantee participant anonymity and data security.

This approach maintains scientific rigor and practical relevance for industry stakeholders while guaranteeing a fair and methodical investigation of Industry 4.0's contribution to resource management and cost efficiency.

4.1 Discussion on Demographic Results of Industry 4.0 Technologies Adoption

i. Study Response Rate Overview

This study achieved a response rate of 72.9%, which is notably higher than the typical response rates reported in similar research on Industry 4.0 technology adoption and management accounting in developing economies. Studies such as those by (Mian, 2020)and (Nankervis, 2021) documented response rates of 65% and 68%, respectively, demonstrating that the present study's response rate is within an expected range and slightly exceeds standard benchmarks. The robust response rate suggests a high level of engagement from the target population; however, it is important to consider potential biases, such as voluntary response bias, which may have influenced participation patterns.

ii. Calculation of Response Rate

The response rate was determined using a conventional formula: the number of completed responses divided by the total number of distributed questionnaires, multiplied by 100 to yield a percentage. Specifically, 275 responses were obtained from a total of 377 distributed surveys, resulting in a response rate of 72.9%. This method aligns with established research standards, as outlined by (Singaram, 2022).

iii. Addressing Non-Response Bias

While the response rate is relatively high, non-response bias remains a concern, as individuals who opted not to participate might differ in meaningful ways from those who did. Studies such as (Anshari, 2022) emphasize the need to account for such discrepancies, although in this study, no data were collected on non-respondents. Future research should consider non-response follow-ups to assess potential differences in demographic or organizational characteristics, as suggested by (Mbizi, 2022). This would improve the validity of findings by identifying whether factors such as business sector, company size, or technological readiness influenced response patterns.

iv. Self-Selection Bias and Sample Representativeness

Despite the satisfactory response rate, self-selection bias may have played a role, as organizations more invested in Industry 4.0 adoption may have been more likely to respond. This could result in an overrepresentation of businesses with a strong digital transformation focus, thereby influencing findings. The study sought to mitigate this concern by comparing respondent demographics against national business statistics (Acquah, 2007). The analysis showed a close match in terms of sector representation, company size, and geographical distribution. However, micro-enterprises and rural businesses were somewhat underrepresented, highlighting an area for improvement in future studies.

v. Use of Incentives

No monetary incentives were provided to participants; however, respondents were informed that they would receive access to the research findings upon completion. This transparency likely contributed to the strong response rate. Future research may explore the effectiveness of non-financial incentives, such as certificates of participation or networking opportunities, as proposed by (Rojko, 2017), to encourage participation among hard-to-reach groups.

vi. Reliability of Findings and Future Research Considerations

The high response rate enhances the credibility of the findings, particularly in relation to inferential statistical analyses such as Chi-Square Tests. Nevertheless, future studies should aim to improve representativeness by incorporating strategies to reduce non-response and self-selection biases. Strategies such as targeted outreach to underrepresented business categories, weighting adjustments in data analysis, and larger sample sizes could enhance the robustness of future results (Bag, 2021).

vii. Distribution of Participating Organizations: Public vs. Private Sectors

The study encompassed both public and private sector organizations, with 31% of participants representing government agencies, primarily within the Ministry of Trade and Finance, and 69% representing private businesses. This distribution ensures a balanced examination of the topic, given the differing priorities of public institutions (regulatory compliance and service efficiency) and private firms (profit maximization and competitive advantage).

viii. Geographical Location of Respondent Organizations

A significant proportion (57%) of respondents were based in Gaborone, Botswana's economic and administrative hub, followed by Francistown. This distribution reflects the concentration of businesses and digital transformation initiatives in major urban centers. As noted by previous studies, firms in metropolitan areas are often more exposed to Industry 4.0 innovations, highlighting potential regional disparities in adoption levels.

ix. Organization Size and Workforce Composition

The majority of respondents were from large organizations with over 100 employees, given that management accounting functions were a key inclusion criterion. Larger enterprises tend to have greater financial and human capital resources, making them more capable of adopting Industry 4.0 technologies compared to smaller firms.

x. Annual Revenue and Financial Strength

Approximately 65% of surveyed organizations reported annual revenues exceeding five million pula, indicating substantial financial capacity to invest in digital transformation. The correlation between financial stability and technological adoption underscores the importance of resource availability in driving Industry 4.0 implementation.

xi. Asset Base and Investment Potential

Most participating organizations reported total asset values above ten million pula, reflecting their ability to finance substantial investments in digital infrastructure. The scale of available resources is a critical determinant

of Industry 4.0 readiness, as businesses with stronger asset bases can more easily implement transformative technologies.

xii. Participant Roles within Organizations

Respondents occupied diverse roles, including business owners (7%), CEOs and directors (28%), finance managers (17%), accountants (38%), and IT specialists (10%). This diversity ensures a multi-perspective analysis of Industry 4.0 adoption, incorporating insights from executive leadership, financial management, and technology experts.

xiii. Experience Levels of Participants

A significant proportion of respondents had over five years of experience in their current roles, enhancing the credibility of the insights provided. Industry experience is particularly valuable in assessing long-term trends in technological adoption and management accounting practices.

xiv. Educational Qualifications and Professional Expertise

Most participants held professional accounting certifications such as CIMA, ACCA, CIPFA, and AAT, indicating a high level of expertise in financial management and decision-making. This professional background strengthens the study's analysis of the efficiency and strategic benefits associated with Industry 4.0 adoption.

xv. In-House vs. Outsourced Management Accounting Functions

The study found that 75.27% of organizations performed management accounting in-house, reflecting a preference for maintaining direct oversight of financial functions. The remaining firms outsourced these services, often leveraging specialized expertise and cost efficiencies associated with external providers.

xvi. Frequency of Feedback from Outsourced Accounting Services

Among organizations that outsourced management accounting functions, the frequency of feedback varied, with the highest proportion receiving updates twice a year (8%), followed by quarterly, monthly, weekly, and annual updates (7.64%). Timely and consistent financial reporting is essential for strategic decision-making, a process that Industry 4.0 technologies aim to enhance.

4.2 Quantitative Analysis of Impact on Cost Efficiency

4.2i. Impact on Traditional Cost Management Strategies

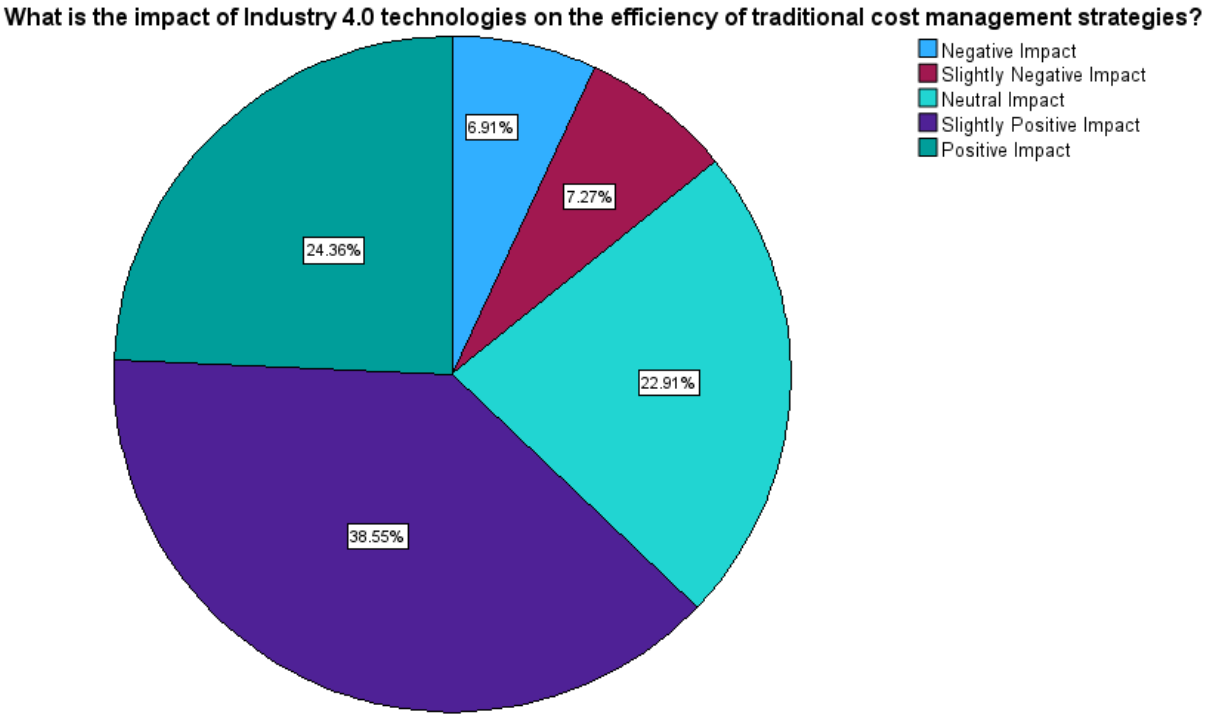

Figure 104a Impact of industry 4.0 adoption on traditional cost management strategies.

The effect of Industry 4.0 technologies on the effectiveness of conventional cost management techniques is seen in the pie chart. Five categories comprise the responses: Positive Impact, Neutral Impact, Slightly Positive Impact, Negative Impact, and Slightly Negative Impact. The majority of respondents (38.55%) indicate that Industry 4.0 technologies have a marginally favorable effect on the effectiveness of cost management. A close second is represented by 24.36% of respondents who see a positive impact. While a lower percentage of respondents experienced slightly unfavorable (7.27%) and negative impacts (6.91%), a considerable portion (22.91%) reported a neutral influence. These findings show that, overall, people's perceptions of Industry 4.0 technology as improving cost management efficiency are generally positive, with most respondents citing at least some improvement.

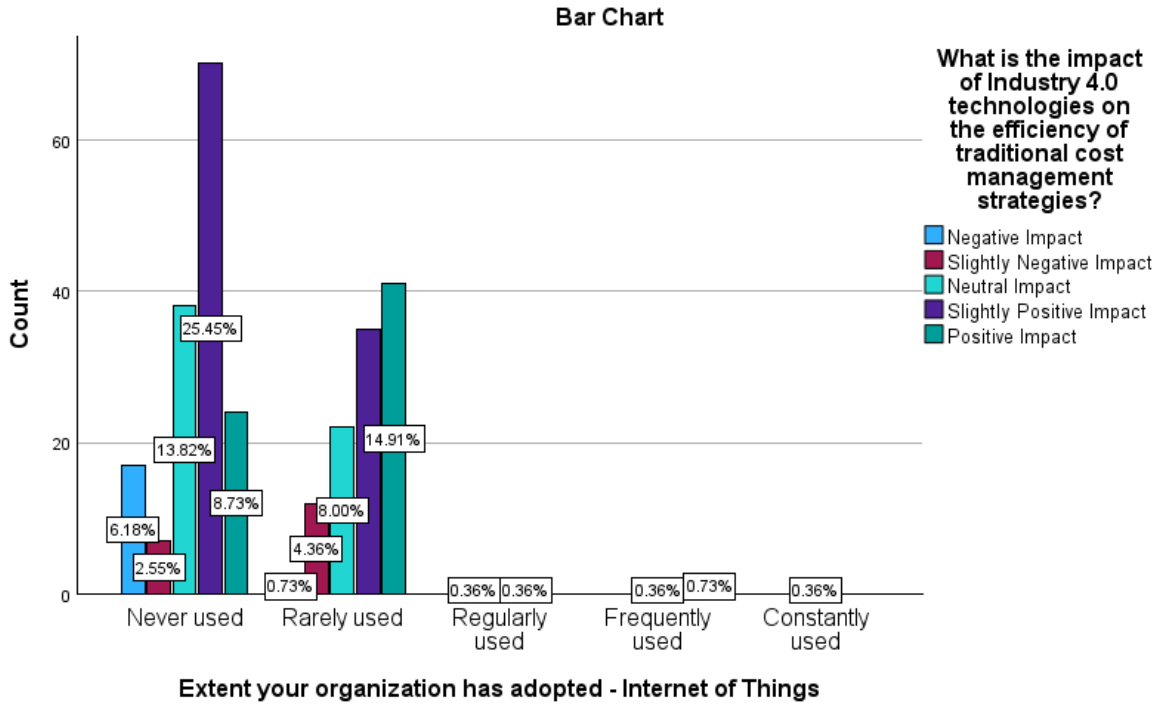

Figure 119. Extent of Internet of Things influence on the efficiency of traditional cost management strategies.

The figure 119 above shows, that adopting Internet of Things, positively impacts traditional cost management strategies fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	38.415[a]	16	.001
Likelihood Ratio	39.652	16	<.001
Linear-by-Linear Association	5.184	1	.023
N of Valid Cases	275		

a. 15 cells (60.0%) have expected count less than 5. The minimum expected count is .07.

Table 106. Figure 119 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of Internet of Things and the efficiency of traditional cost management strategies as per table 106 above.

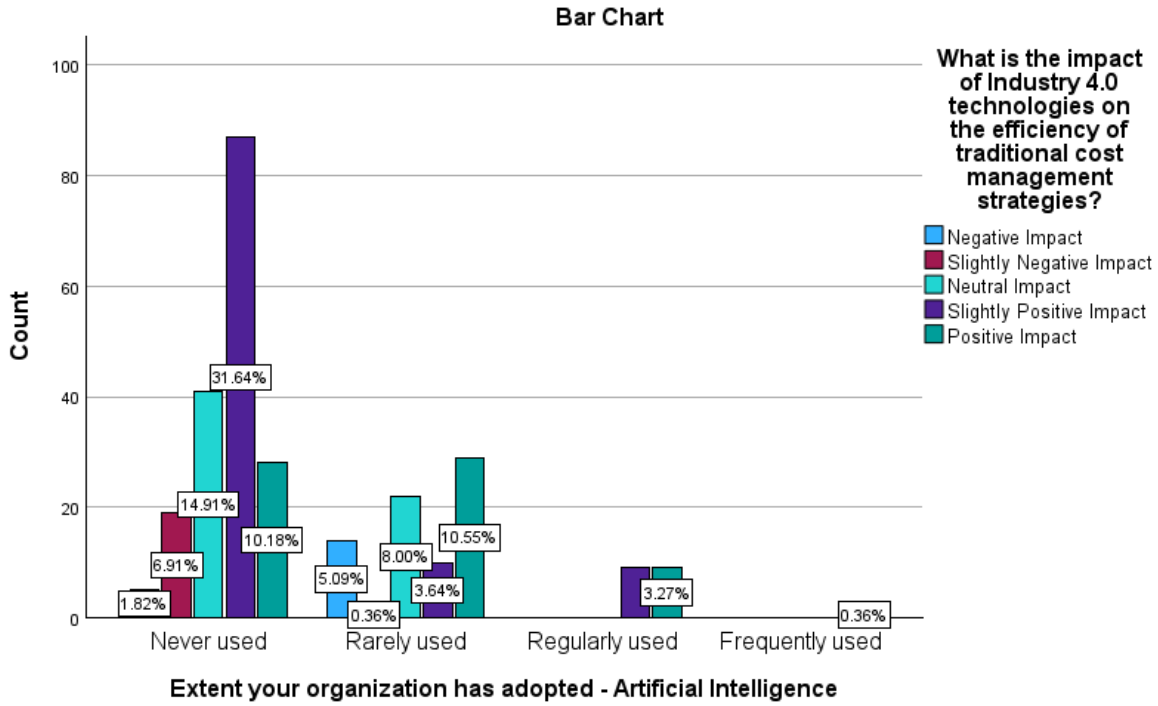

Figure 120. Extent of artificial intelligence influence on the efficiency of traditional cost management strategies.

The figure 120 above shows, that adopting artificial intelligence, positively impacts traditional cost management strategies fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	70.709[a]	12	<.001
Likelihood Ratio	78.126	12	<.001
Linear-by-Linear Association	3.771	1	.052
N of Valid Cases	275		

a. 9 cells (45.0%) have expected count less than 5. The minimum expected count is .07.

Table 107. Figure 120 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of artificial intelligence and the efficiency of traditional cost management strategies as per table 107 above.

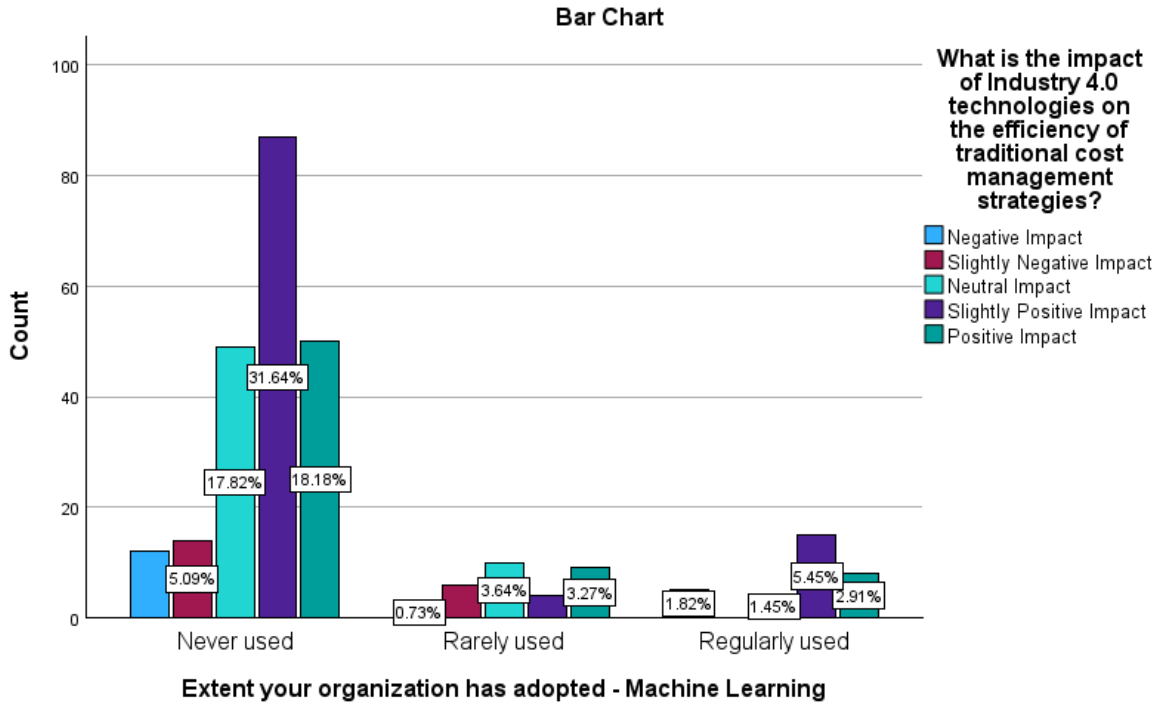

Figure 121. Extent of machine learning influence on the efficiency of traditional cost management strategies.

The figure 121 above shows, that adopting machine learning, positively impacts traditional cost management strategies fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	21.927[a]	8	.005
Likelihood Ratio	23.350	8	.003
Linear-by-Linear Association	.489	1	.484
N of Valid Cases	275		

a. 4 cells (26.7%) have expected count less than 5. The minimum expected count is 2.14.

Table 108. Figure 121 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of machine learning and the efficiency of traditional cost management strategies as per table 108 above.

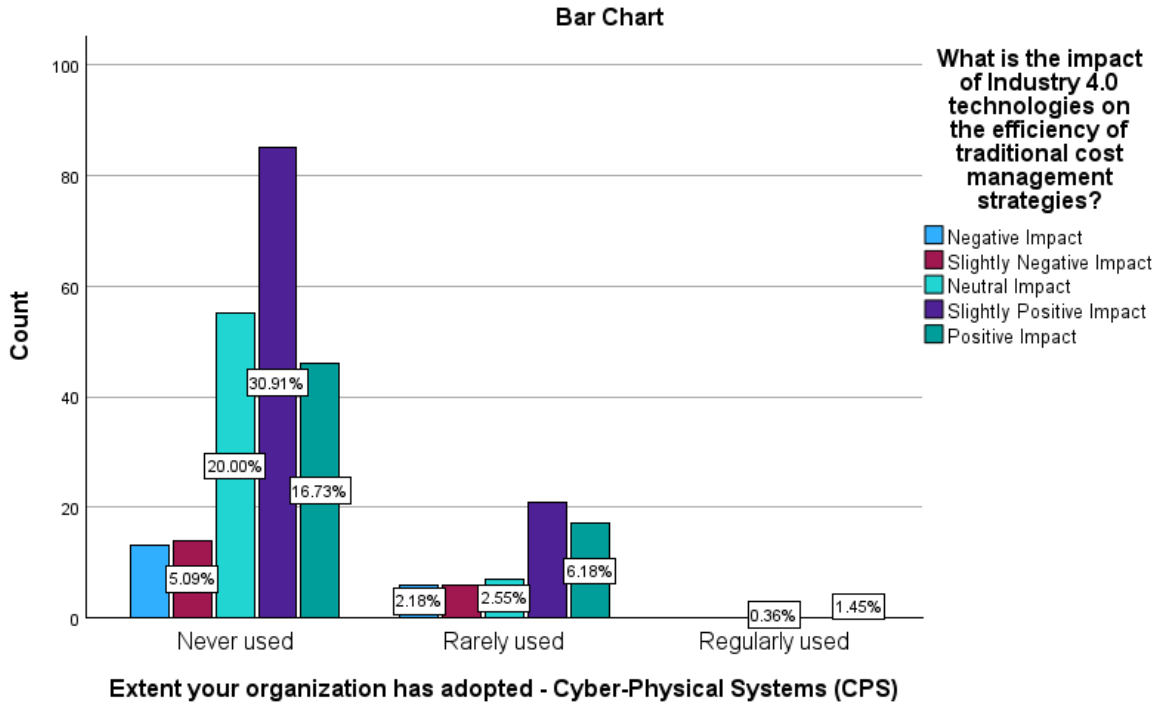

Figure 122. Extent of cyber physical systems influence on the efficiency of traditional cost management strategies.

The figure 122 above shows, that adopting cyber physical systems, positively impacts traditional cost management strategies fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.372[a]	8	.037
Likelihood Ratio	16.890	8	.031
Linear-by-Linear Association	.968	1	.325
N of Valid Cases	275		

a. 7 cells (46.7%) have expected count less than 5. The minimum expected count is .35.

Table 109. Figure 122 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of cyber physical systems and the efficiency of traditional cost management strategies as per table 109 above.

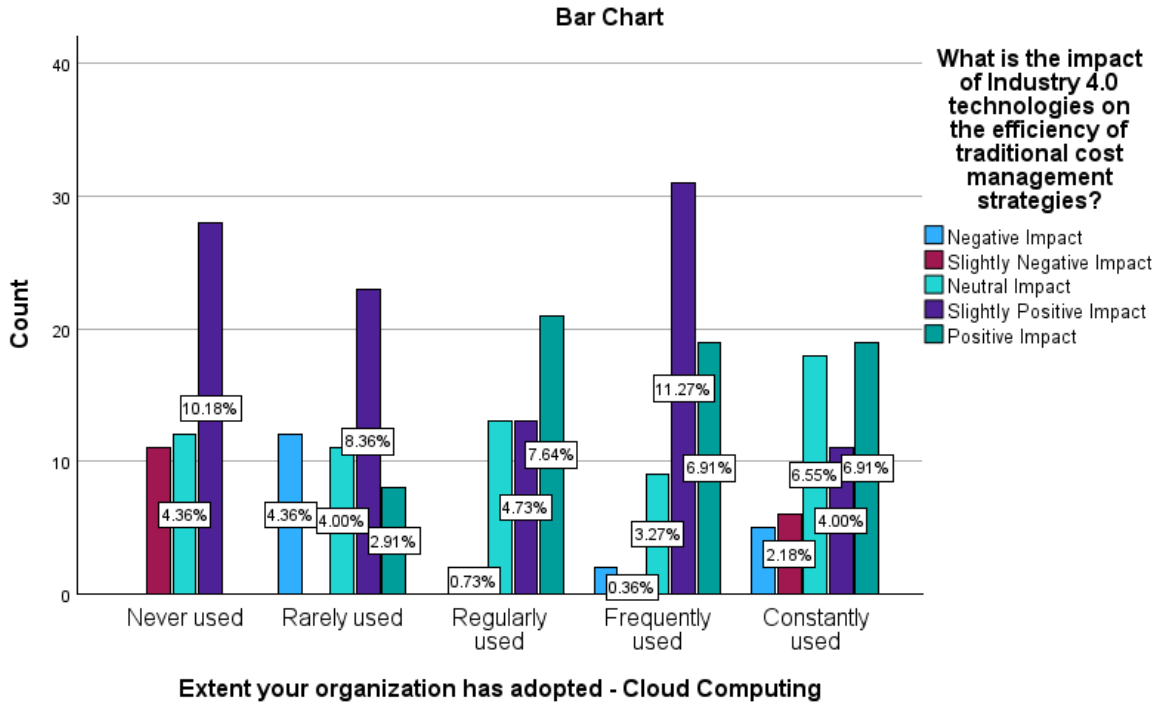

Figure 123. Extent of cloud computing influence on the efficiency of traditional cost management strategies.

The figure 123 above shows, that adopting cloud computing, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	90.449[a]	16	<.001
Likelihood Ratio	103.544	16	<.001
Linear-by-Linear Association	6.000	1	.014
N of Valid Cases	275		

a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is 3.39.

Table 110. Figure 123 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of cloud computing and the efficiency of traditional cost management strategies as per table 110 above.

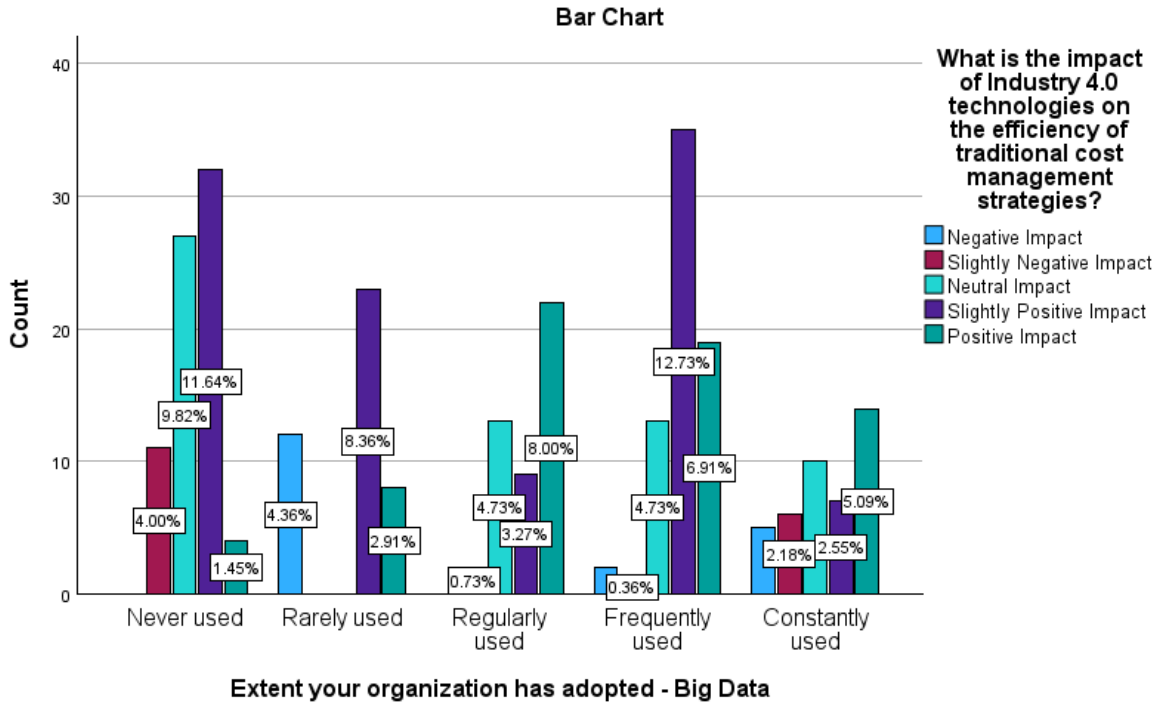

Figure 124. Extent of big data influence on the efficiency of traditional cost management strategies.

The figure 124 above shows, that adopting big data, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	109.860[a]	16	<.001
Likelihood Ratio	122.733	16	<.001
Linear-by-Linear Association	4.529	1	.033
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.90.

Table 111. Figure 124 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of big data and the efficiency of traditional cost management strategies as per table 111 above.

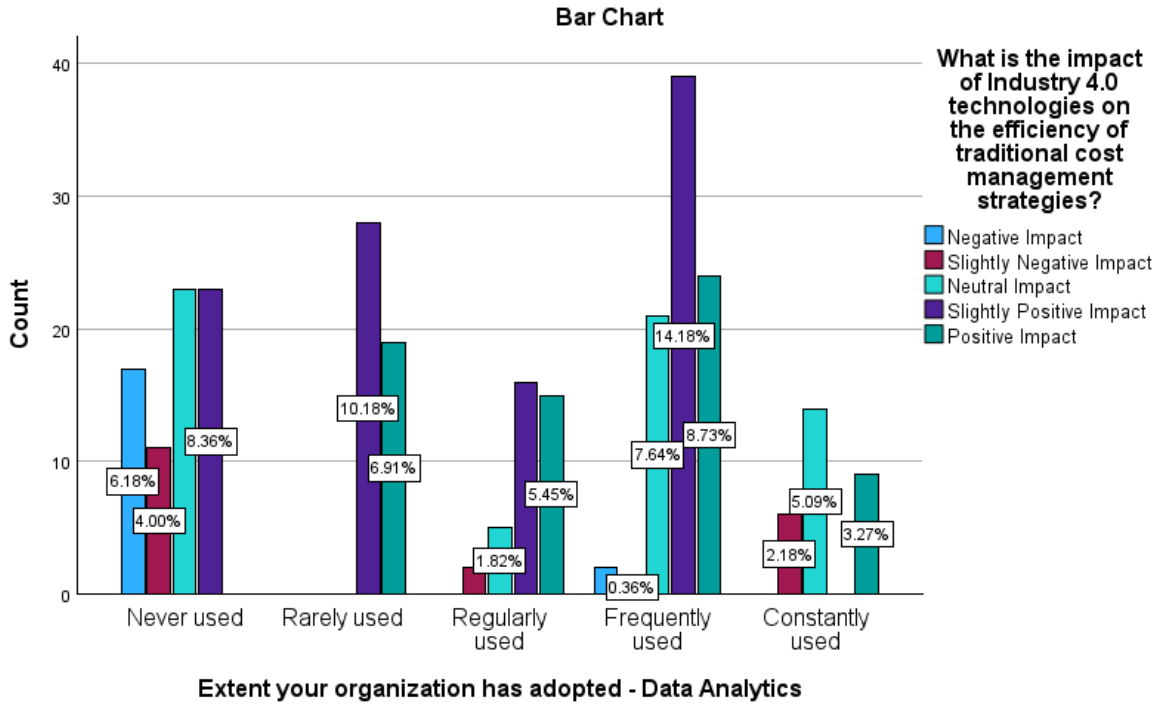

Figure 125. Extent of data analytics influence on the efficiency of traditional cost management strategies.

The figure 125 above shows, that adopting data analytics, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	128.176[a]	16	<.001
Likelihood Ratio	164.414	16	<.001
Linear-by-Linear Association	20.016	1	<.001
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 2.00.

Table 112. Figure 125 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of data analytics and the efficiency of traditional cost management strategies as per table 112 above.

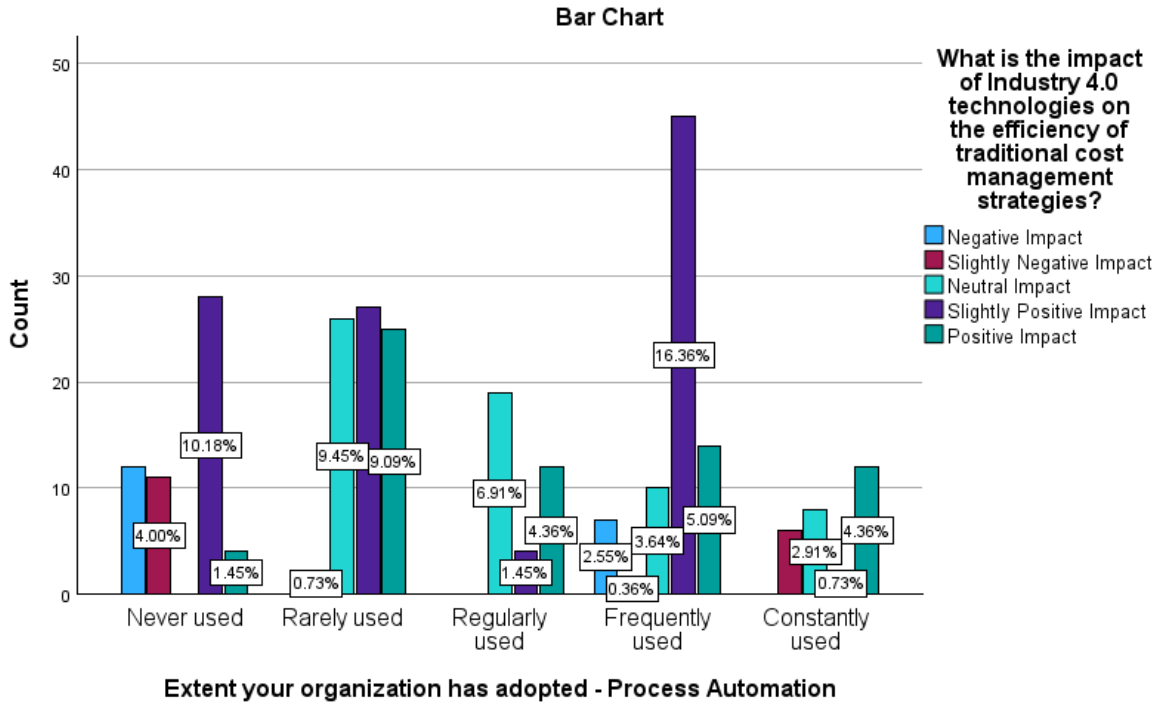

Figure 126. Extent of process automation influence on the efficiency of traditional cost management strategies.

The figure 126 above shows, that adopting process automation, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	130.564[a]	16	<.001
Likelihood Ratio	147.823	16	<.001
Linear-by-Linear Association	5.665	1	.017
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 1.93.

Table 113. Figure 126 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of process automation and the efficiency of traditional cost management strategies as per table 113 above.

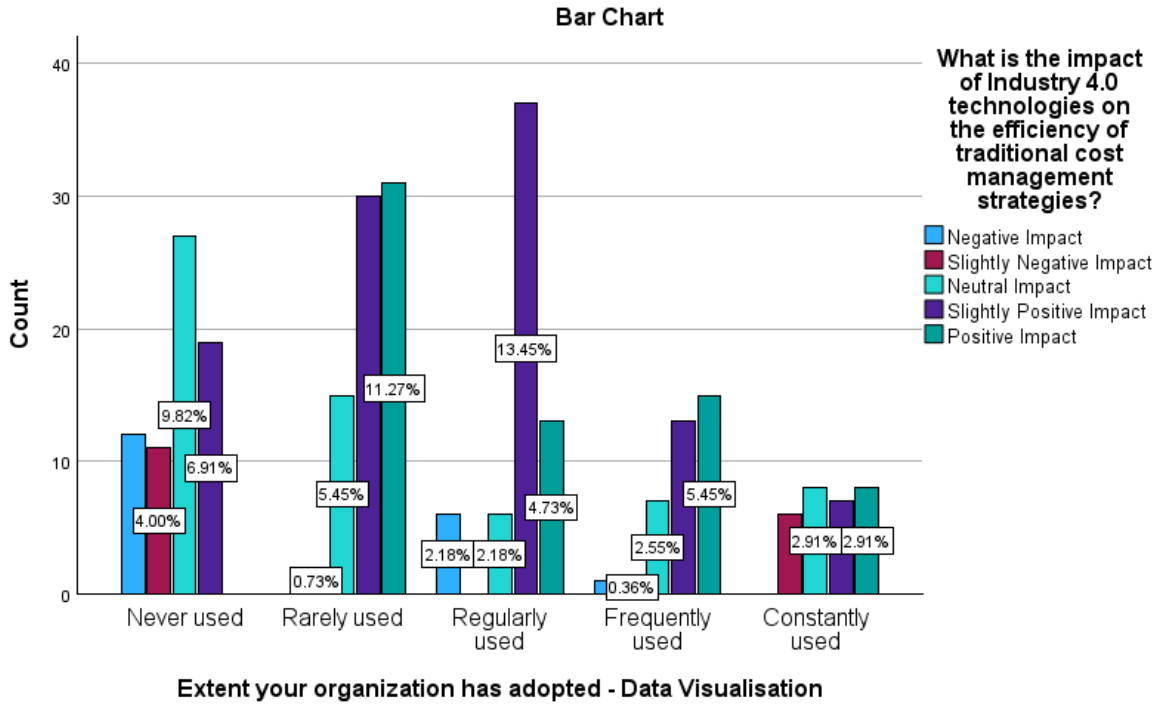

Figure 127. Extent of data visualisation influence on the efficiency of traditional cost management strategies.

The figure 127 above shows, that adopting data visualisation, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	95.719[a]	16	<.001
Likelihood Ratio	115.770	16	<.001
Linear-by-Linear Association	15.947	1	<.001
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.00.

Table 114. Figure 127 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of data visualisation and the efficiency of traditional cost management strategies as per table 114 above.

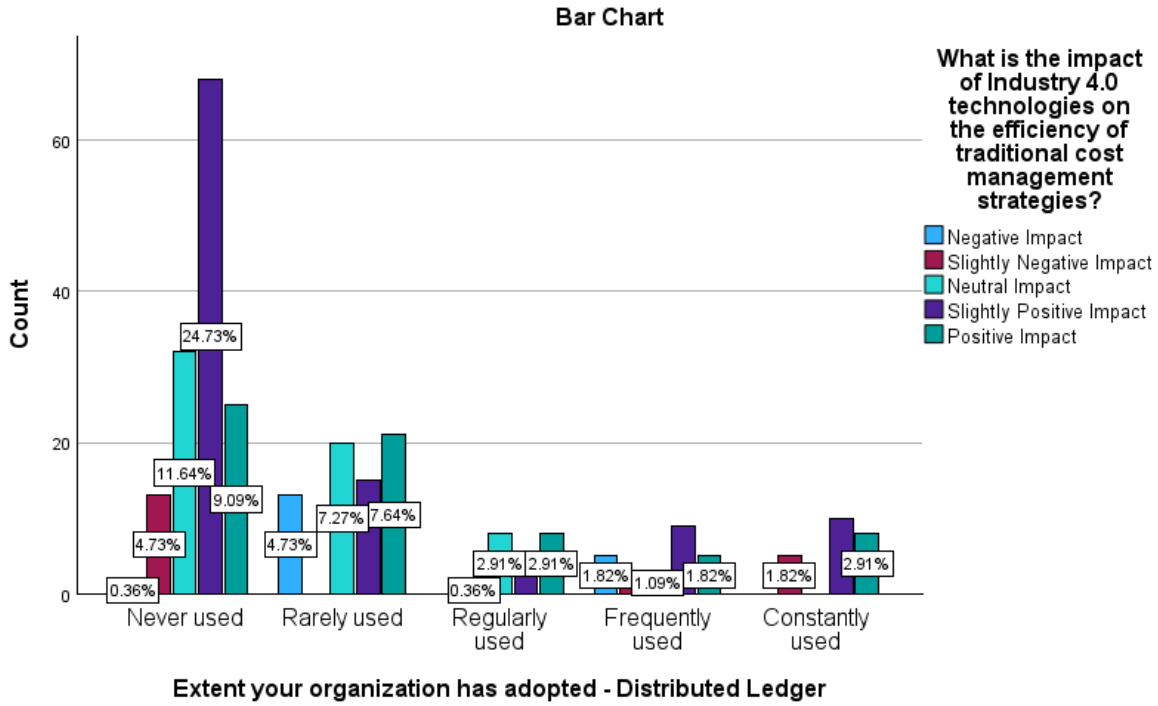

Figure 128. Extent of distributed ledger influence on the efficiency of traditional cost management strategies.

The figure 128 above shows, that adopting distributed ledger, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	71.912[a]	16	<.001
Likelihood Ratio	81.270	16	<.001
Linear-by-Linear Association	.016	1	.901
N of Valid Cases	275		

a. 8 cells (32.0%) have expected count less than 5. The minimum expected count is 1.45.

Table 115. Figure 128 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of distributed ledger and the efficiency of traditional cost management strategies as per table 115 above.

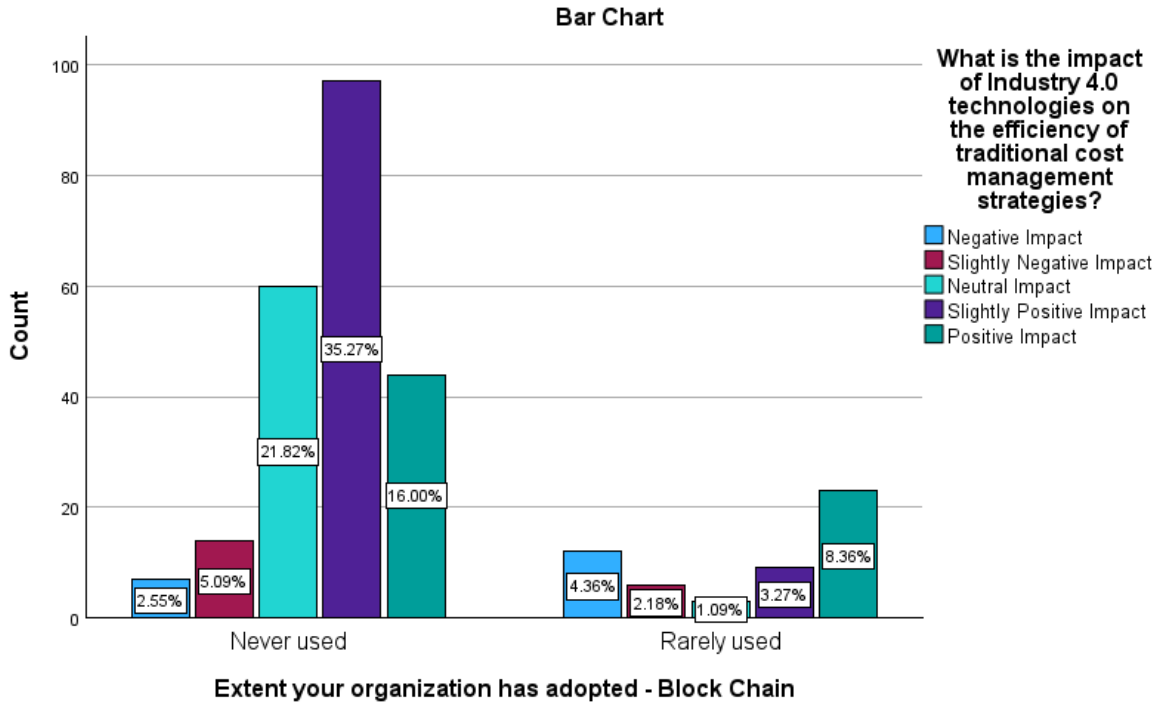

Figure 129. Extent of block chain influence on the efficiency of traditional cost management strategies.

The figure 129 above shows, that adopting block chain, positively impacts traditional cost management strategies fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	51.207[a]	4	<.001
Likelihood Ratio	48.227	4	<.001
Linear-by-Linear Association	1.860	1	.173
N of Valid Cases	275		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 3.66.

Table 116. Figure 129 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of block chain and the efficiency of traditional cost management strategies as per table 116 above.

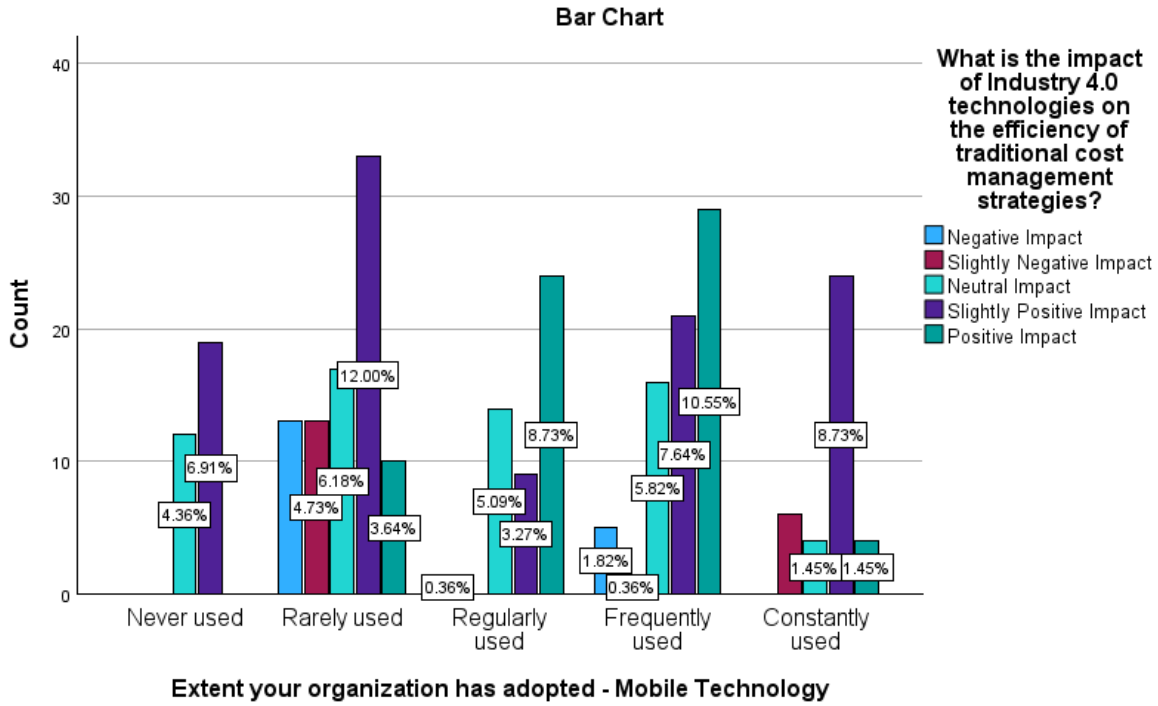

Figure 130. Extent of mobile technology influence on the efficiency of traditional cost management strategies.

The figure 130 above shows, that adopting mobile technology, positively impacts traditional cost management strategies significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	95.488[a]	16	<.001
Likelihood Ratio	108.670	16	<.001
Linear-by-Linear Association	8.352	1	.004
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.14.

Table 117. Figure 130 Chi-Square Tests

With p-values significantly below the 0.05 cut off, the findings of the Likelihood Ratio test, Pearson Chi-Square test, and Linear-by-Linear Association all clearly show a statistically significant association between adoption of mobile technology and the efficiency of traditional cost management strategies as per table 117 above.

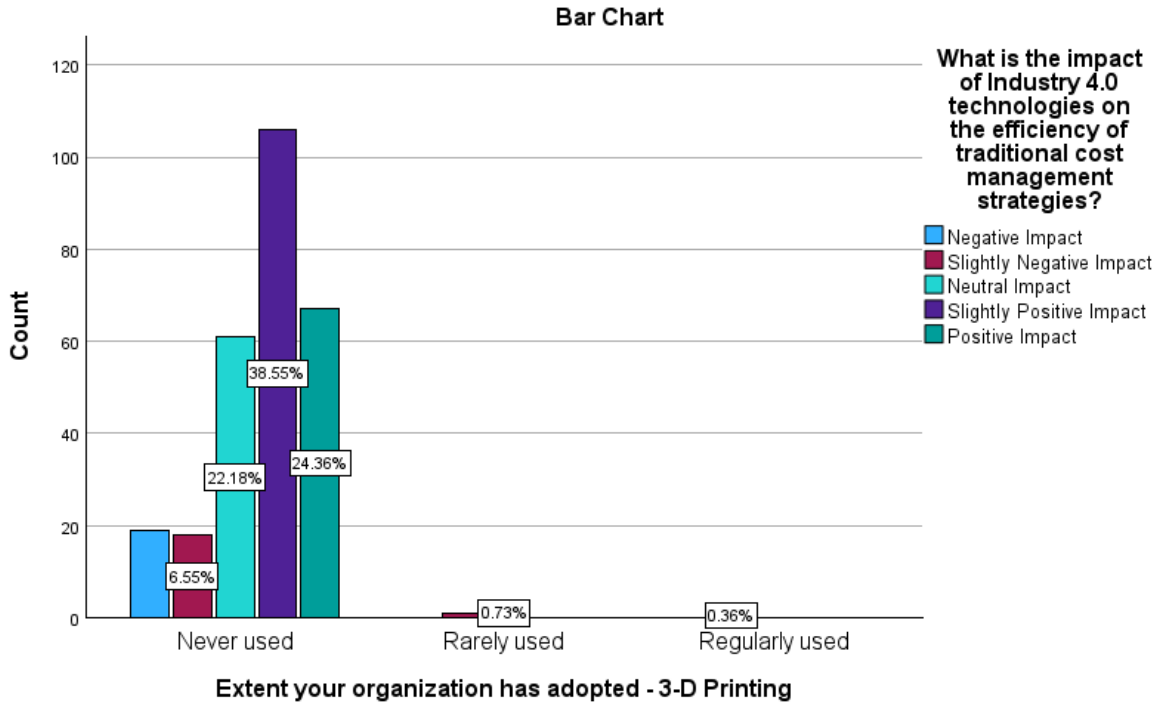

Figure 131. Extent of 3-D printing influence on the efficiency of traditional cost management strategies.

The figure 131 above shows, that adopting 3-D printing, does not positively impacts traditional cost management strategies at all.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.362[a]	8	.009
Likelihood Ratio	12.772	8	.120
Linear-by-Linear Association	4.516	1	.034
N of Valid Cases	275		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .07.

Table 118. Figure 131 Chi-Square Tests

There appears to be no statistically significant correlation between adoption of 3-D printing influencing efficiency of traditional cost management strategies, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 118 above.

4.2ii Impact on Resource Optimisation

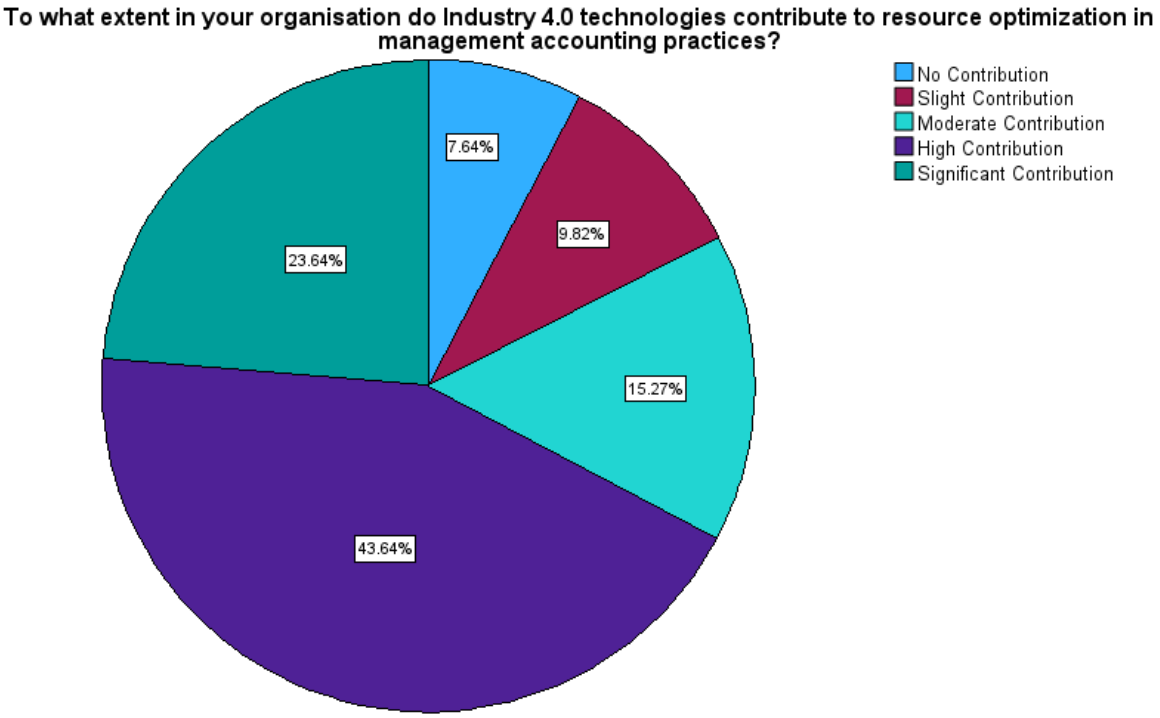

Figure 132. Extent of participating organisations adopted industry 4.0 technologies contribution to resource optimisation in management accounting

Adoption of industry 4.0 technologies contributes significantly to resource optimisation in management accounting practices as follows, 24% state it contributes significantly, 44% say it contributes highly, 15% say the contribution is moderate, 10% say they have noticed slight improvements, whereas only 8% claim that they have not seen any contribution to resource optimisation as a result of industry 4.0 adoption. We can safely conclude that the adoption of industry 4.0 technologies results in resource optimisation in the management accounting function.

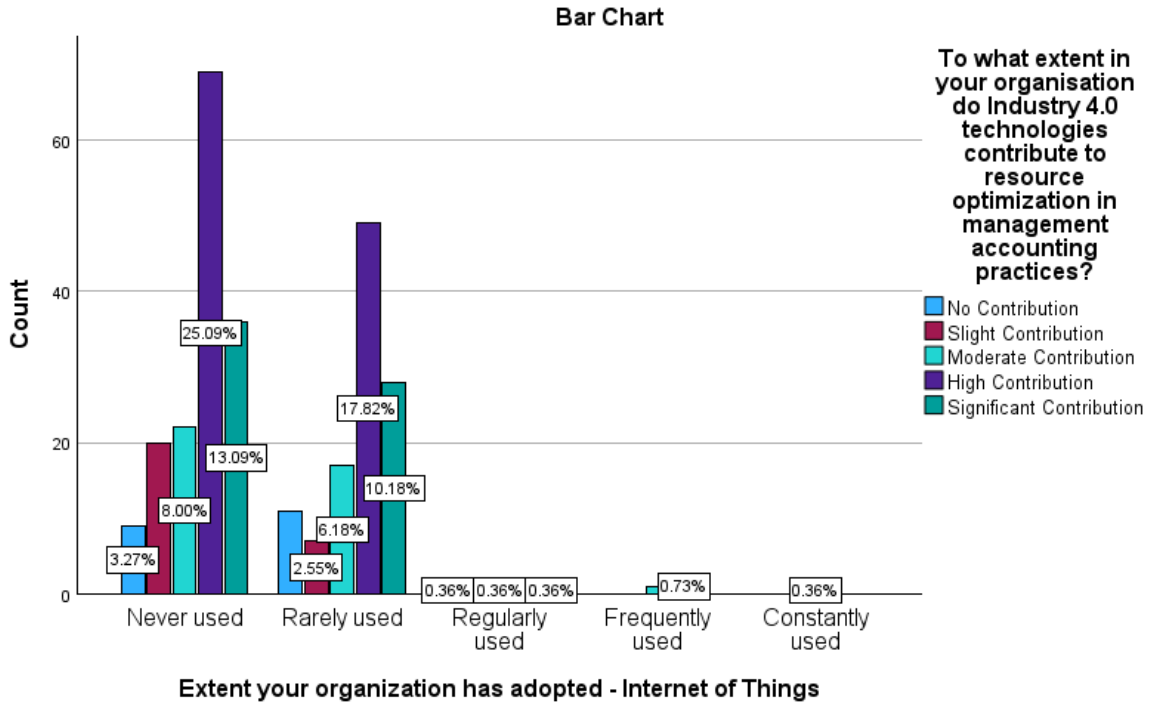

Figure 133. Extent of Internet of Things adoption influence on resource optimisation in management accounting practices.

The figure 133 above shows, that adopting Internet of Things, positively impacts resource optimisation fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.303[a]	16	.366
Likelihood Ratio	16.870	16	.394
Linear-by-Linear Association	.126	1	.723
N of Valid Cases	275		

a. 15 cells (60.0%) have expected count less than 5. The minimum expected count is .08.

Table 119. Figure 133 Chi-Square Tests

There appears to be no statistically significant correlation between adoption of Internet of Things influencing resource optimisation in management practices, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 119 above.

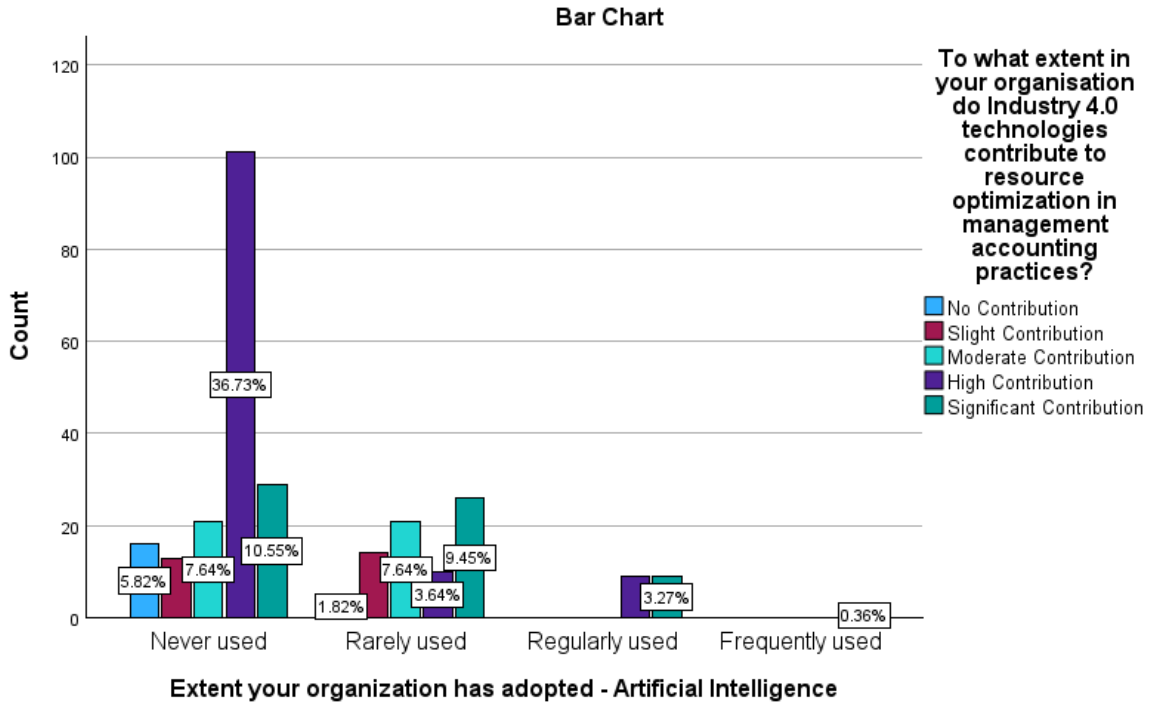

Figure 134. Extent of artificial intelligence adoption influence on resource optimisation in management accounting practices.

The figure 134 above shows, that adopting artificial intelligence, positively impacts resource optimisation fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	61.666[a]	12	<.001
Likelihood Ratio	69.227	12	<.001
Linear-by-Linear Association	3.367	1	.067
N of Valid Cases	275		

a. 9 cells (45.0%) have expected count less than 5. The minimum expected count is .08.

Table 120. Figure 134 Chi-Square Tests

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 as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 120 above.

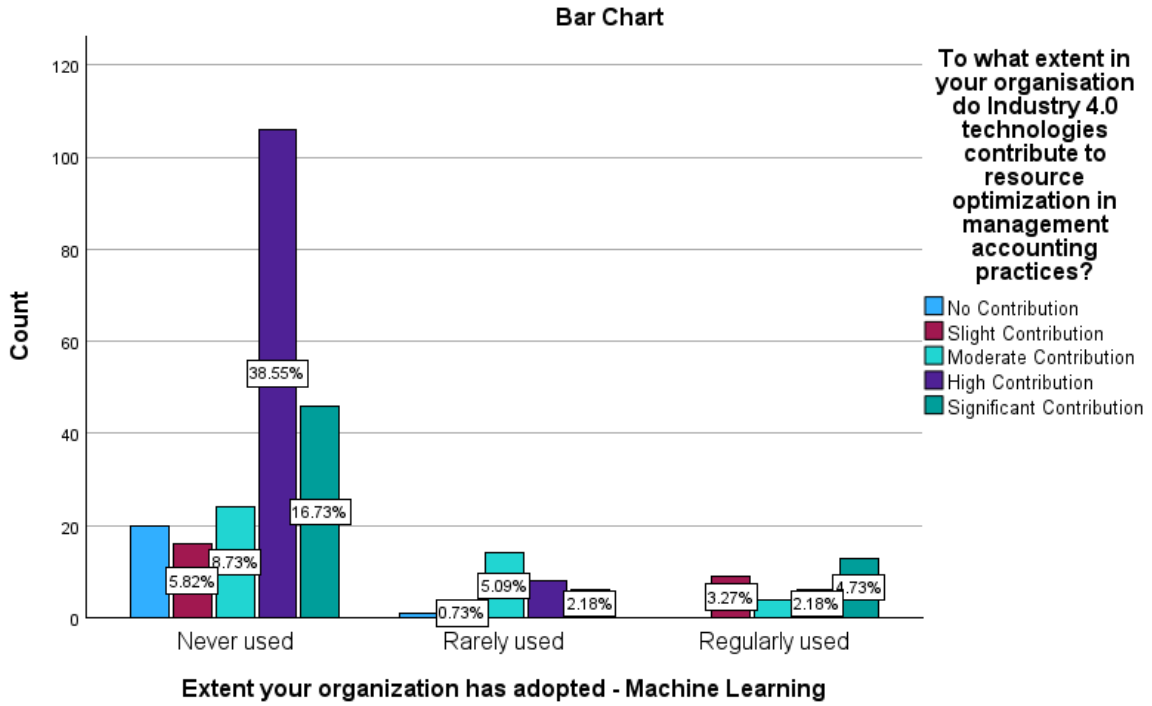

Figure 135. Extent of machine learning adoption influence on resource optimisation in management accounting practices.

The figure 135 above shows, that adopting machine learning, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	50.239[a]	8	<.001
Likelihood Ratio	44.091	8	<.001
Linear-by-Linear Association	.002	1	.968
N of Valid Cases	275		

a. 6 cells (40.0%) have expected count less than 5. The minimum expected count is 2.37.

Table 121. Figure 135 Chi-Square Tests

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 machine learning as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 121 above.

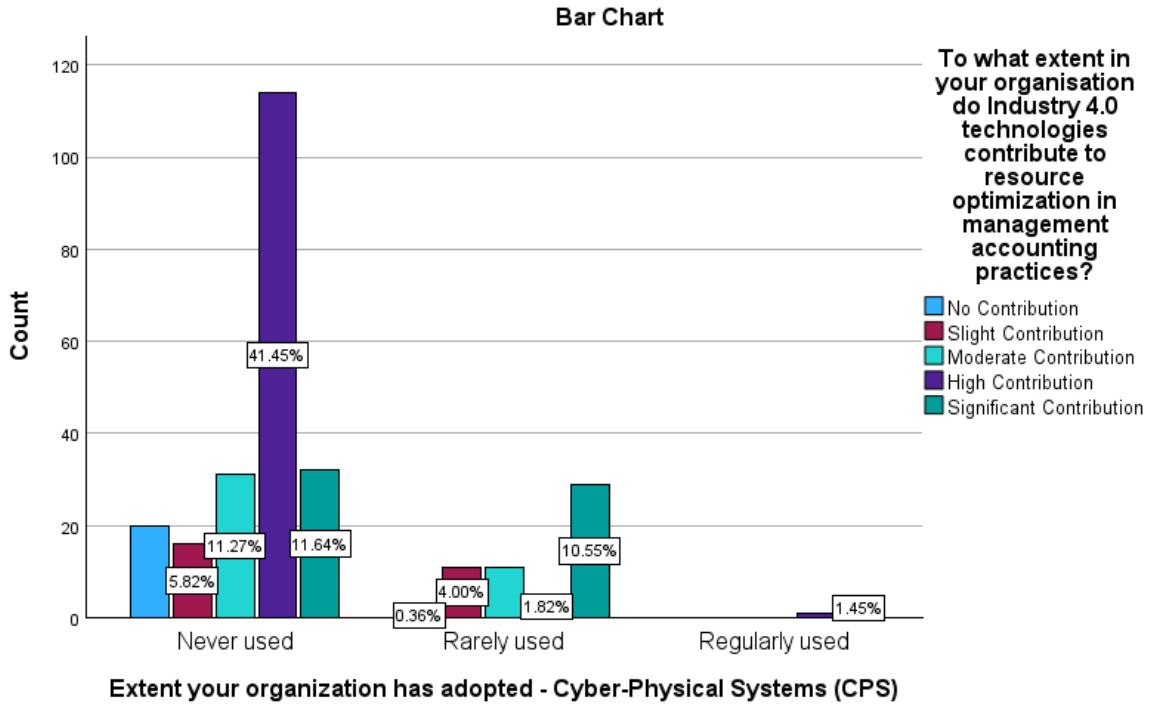

Figure 136. Extent of cyber physical systems adoption influence on resource optimisation in management accounting practices.

The figure 136 above shows, that adopting cyber physical systems, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	64.712[a]	8	<.001
Likelihood Ratio	67.949	8	<.001
Linear-by-Linear Association	6.937	1	.008
N of Valid Cases	275		

a. 6 cells (40.0%) have expected count less than 5. The minimum expected count is .38.

Table 122. Figure 136 Chi-Square Tests

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 cyber physical systems as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 122 above.

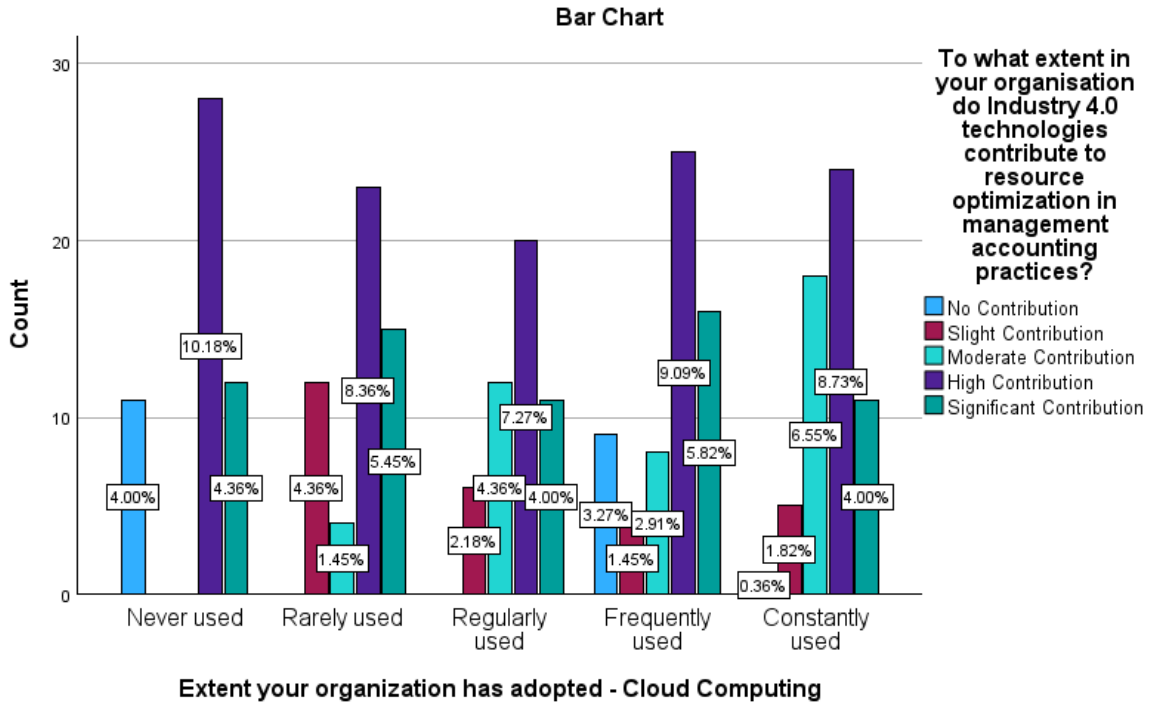

Figure 137. Extent of cloud computing adoption influence on resource optimisation in management accounting practices.

The figure 137 above shows, that adopting cloud computing, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	66.912[a]	16	<.001
Likelihood Ratio	79.523	16	<.001
Linear-by-Linear Association	.019	1	.890
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 3.74.

Table 123. Figure 137 Chi-Square Tests

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 cloud computing as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 123 above.

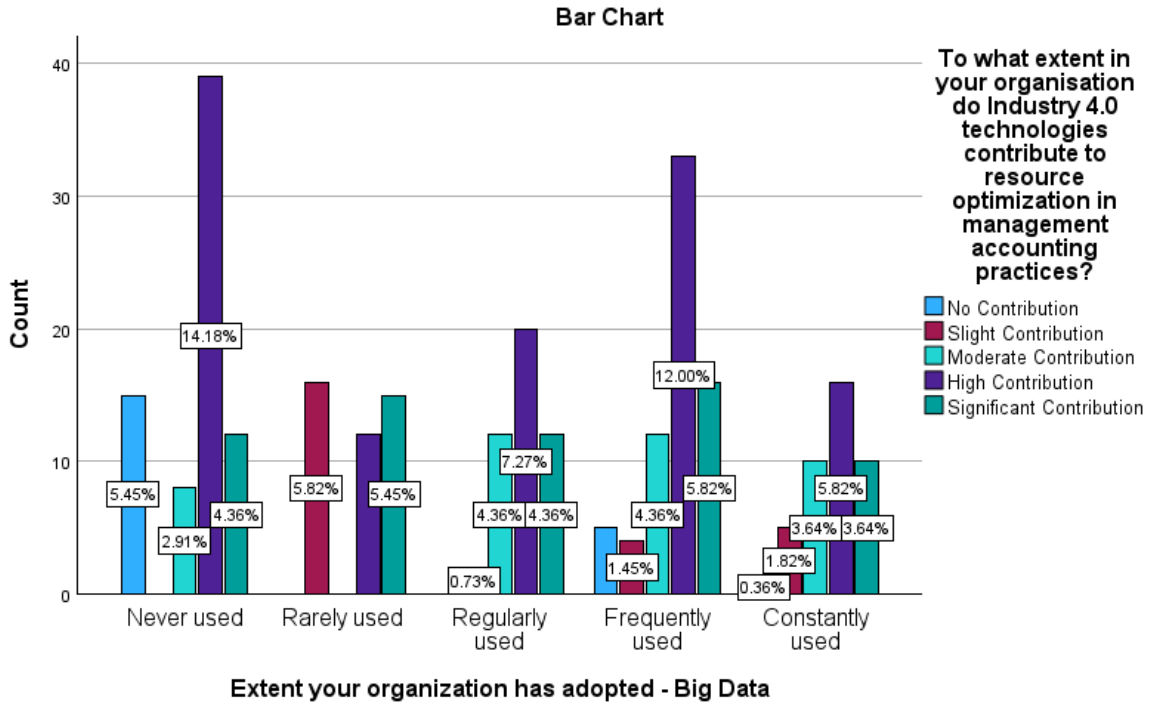

Figure 138. Extent of big data adoption adoption influence on resource optimisation in management accounting practices.

The figure 138 above shows, that adopting big data, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	88.423[a]	16	<.001
Likelihood Ratio	90.916	16	<.001
Linear-by-Linear Association	2.203	1	.138
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 3.21.

Table 124. Figure 138 Chi-Square Tests

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 big data as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 124 above.

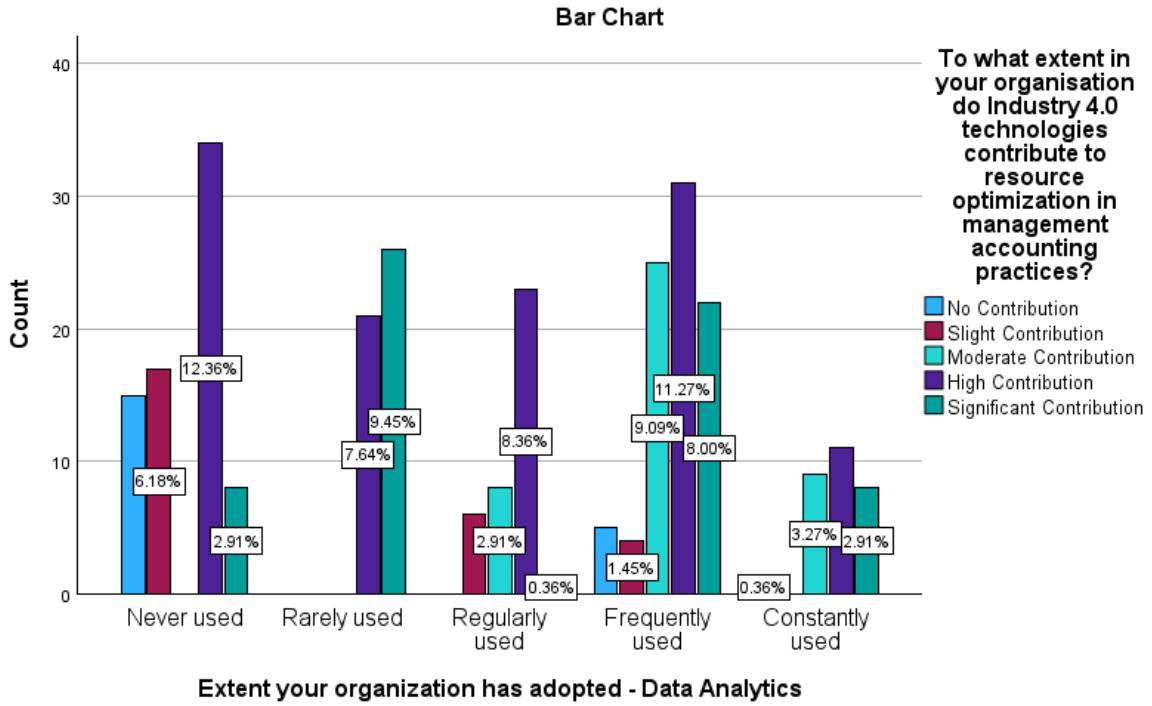

Figure 139. Extent of data analytics adoption influence on resource optimisation in management accounting practices.

The figure 139 above shows, that adopting data analytics, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	118.259[a]	16	<.001
Likelihood Ratio	139.550	16	<.001
Linear-by-Linear Association	5.782	1	.016
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.21.

Table 125. Figure 139 Chi-Square Tests

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 data analytics as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 125 above.

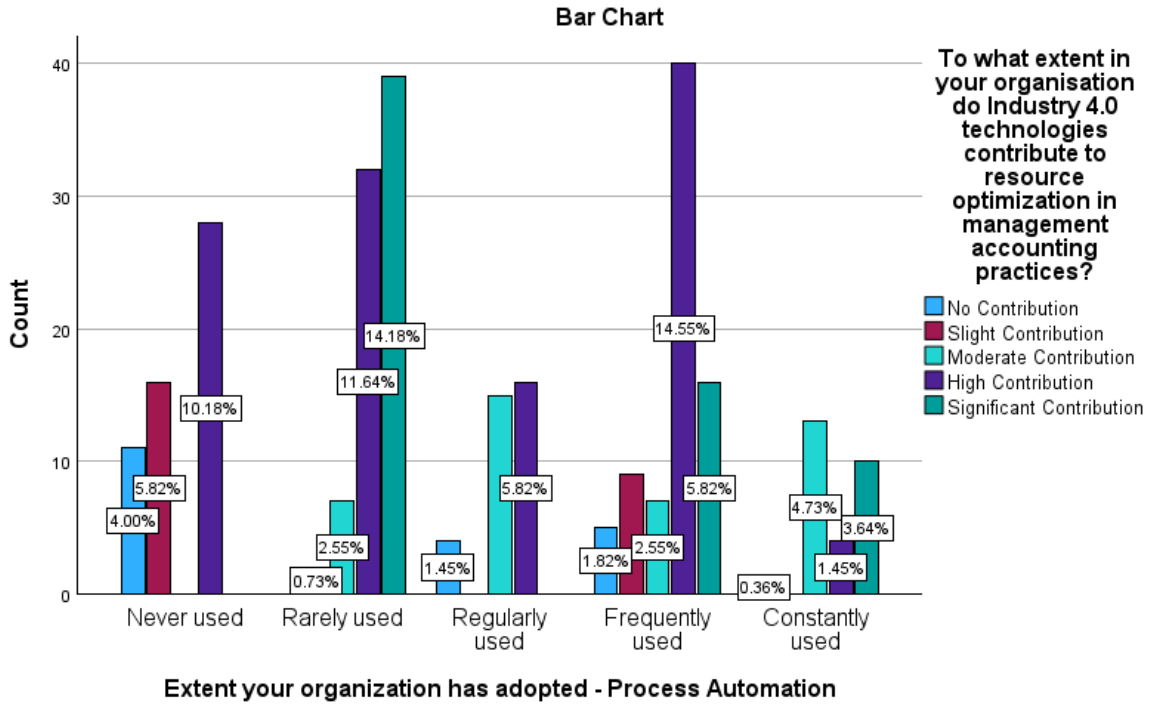

Figure 140. Extent of process automation adoption influence on resource optimisation in management accounting practices.

The figure 140 above shows, that adopting process automation, positively resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	150.239[a]	16	<.001
Likelihood Ratio	168.658	16	<.001
Linear-by-Linear Association	3.341	1	.068
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 2.14.

Table 126. Figure 140 Chi-Square Tests

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 as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 126 above.

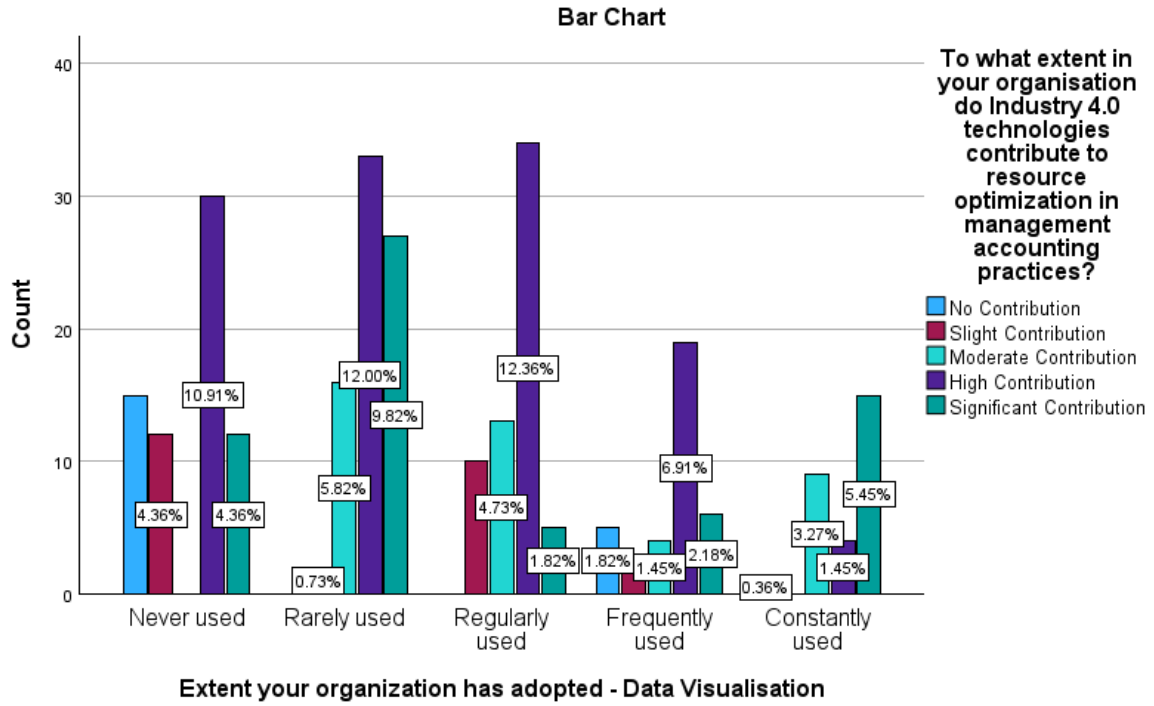

Figure 141. Extent of data visualisation adoption influence on resource optimisation in management accounting practices.

The figure 141 above shows, that adopting data visualisation, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	93.399[a]	16	<.001
Likelihood Ratio	112.022	16	<.001
Linear-by-Linear Association	4.500	1	.034
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 2.21.

Table 127. Figure 141 Chi-Square Tests

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 data visualisation as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 127 above.

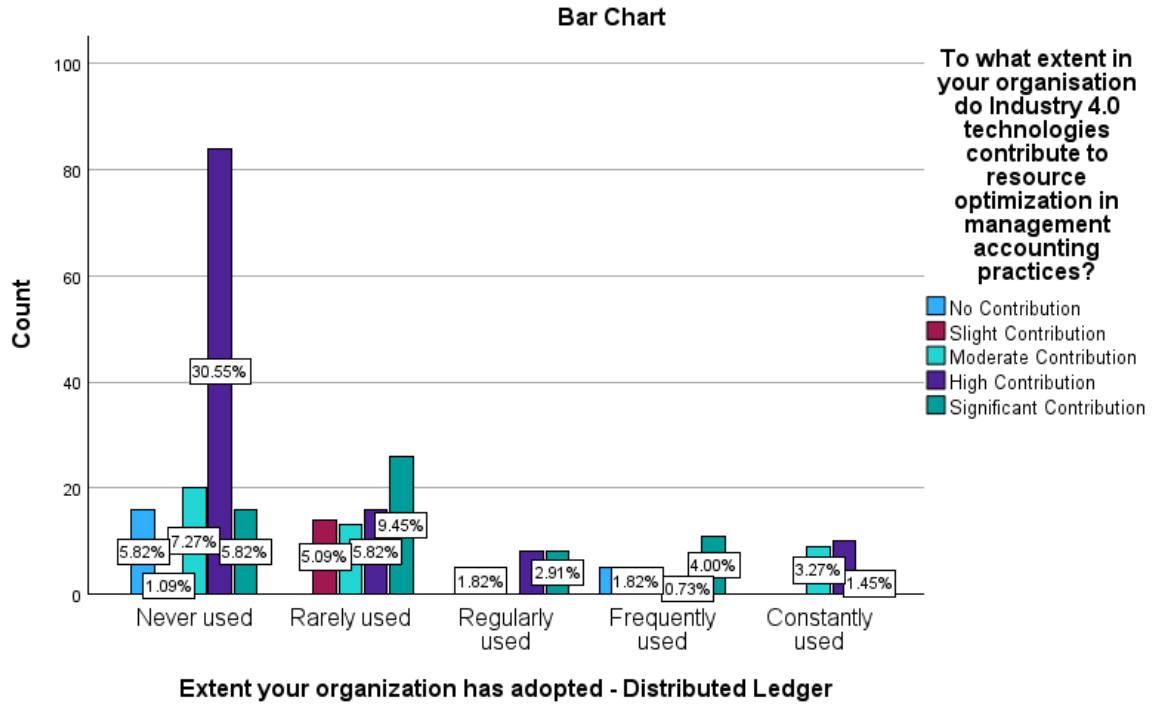

Figure 142. Extent of distributed ledger adoption influence on resource optimisation in management accounting practices.

The figure 142 above shows, that adopting distributed ledger, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	103.593[a]	16	<.001
Likelihood Ratio	119.334	16	<.001
Linear-by-Linear Association	.230	1	.631
N of Valid Cases	275		

a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is 1.60.

Table 128. Figure 142 Chi-Square Tests

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 distributed ledger as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 128 above.

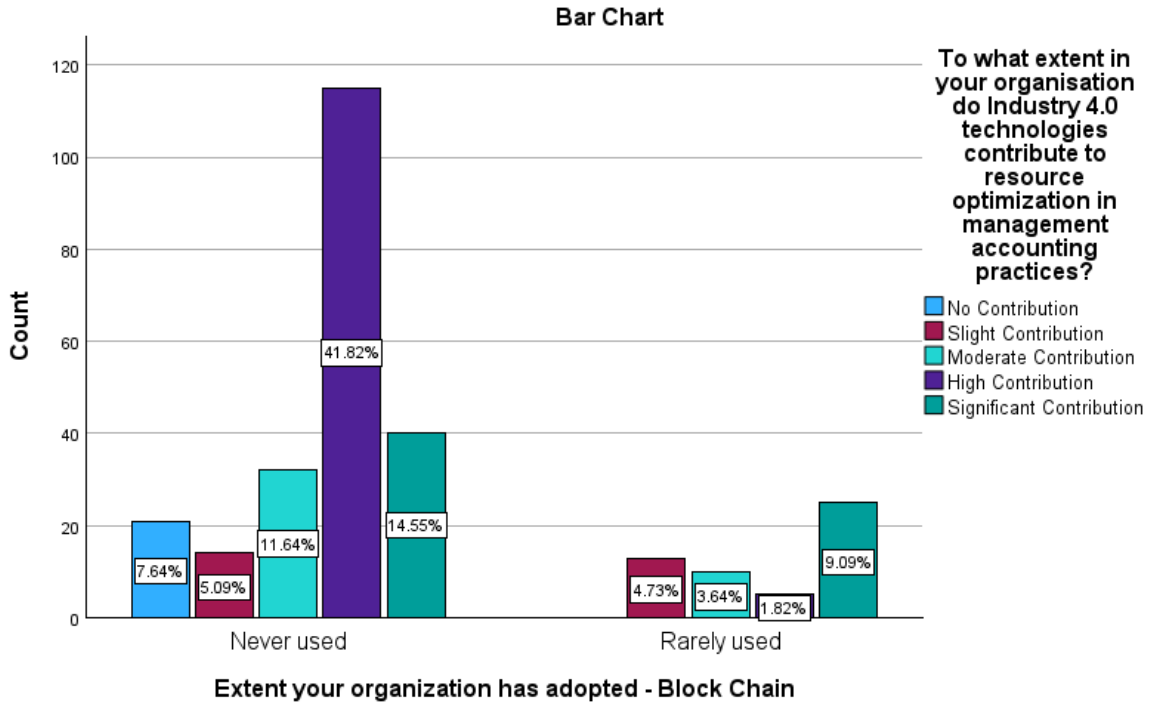

Figure 142. Extent of block chain adoption influence on resource optimisation in management accounting practices.

The figure 142 above shows, that adopting block chain, does not positively impact resource optimisation.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	53.022[a]	4	<.001
Likelihood Ratio	57.901	4	<.001
Linear-by-Linear Association	.872	1	.350
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 4.05.

Table 129. Figure 142 Chi-Square Tests

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 block chain as well as resource optimisation, with p-values well below the 0.05 threshold as per table 129 above.

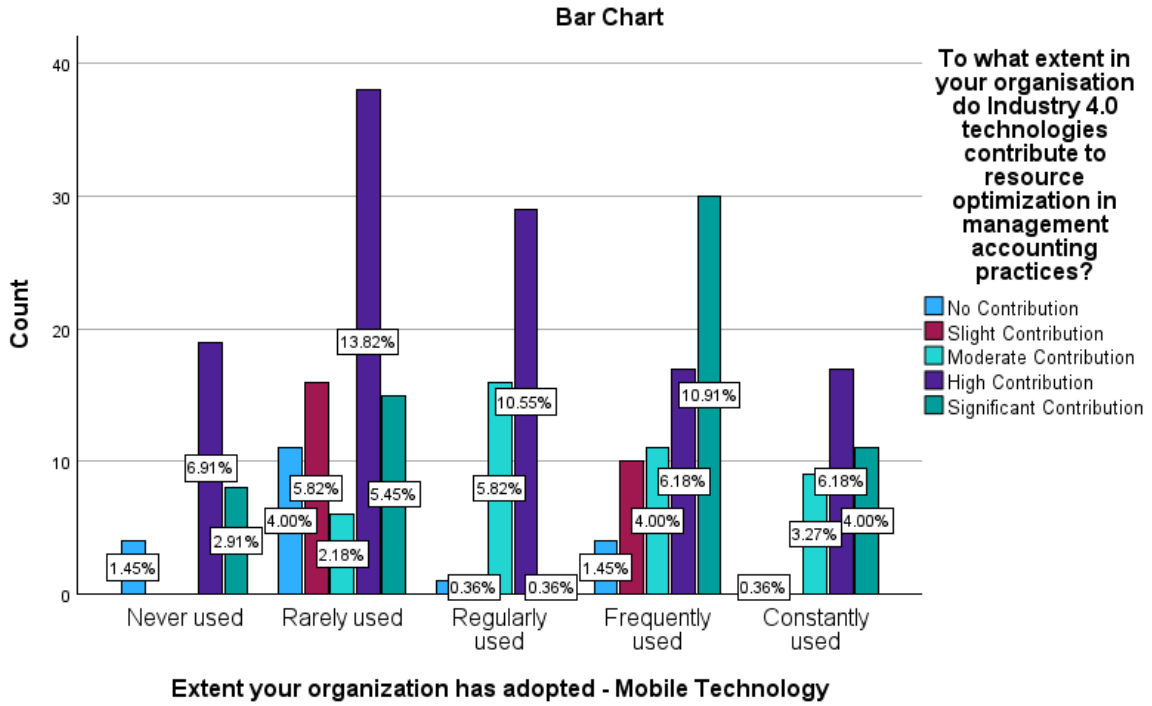

Figure 143. Extent of mobile technology adoption influence on resource optimisation in management accounting practices.

The figure 143 above shows, that adopting mobile technology, positively impacts resource optimisation significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	79.202[a]	16	<.001
Likelihood Ratio	94.641	16	<.001
Linear-by-Linear Association	4.076	1	.043
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.37.

Table 130. Figure 143 Chi-Square Tests

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 mobile technology as well as resource optimisation, with p-values well below the 0.05 threshold, as per table 130 above.

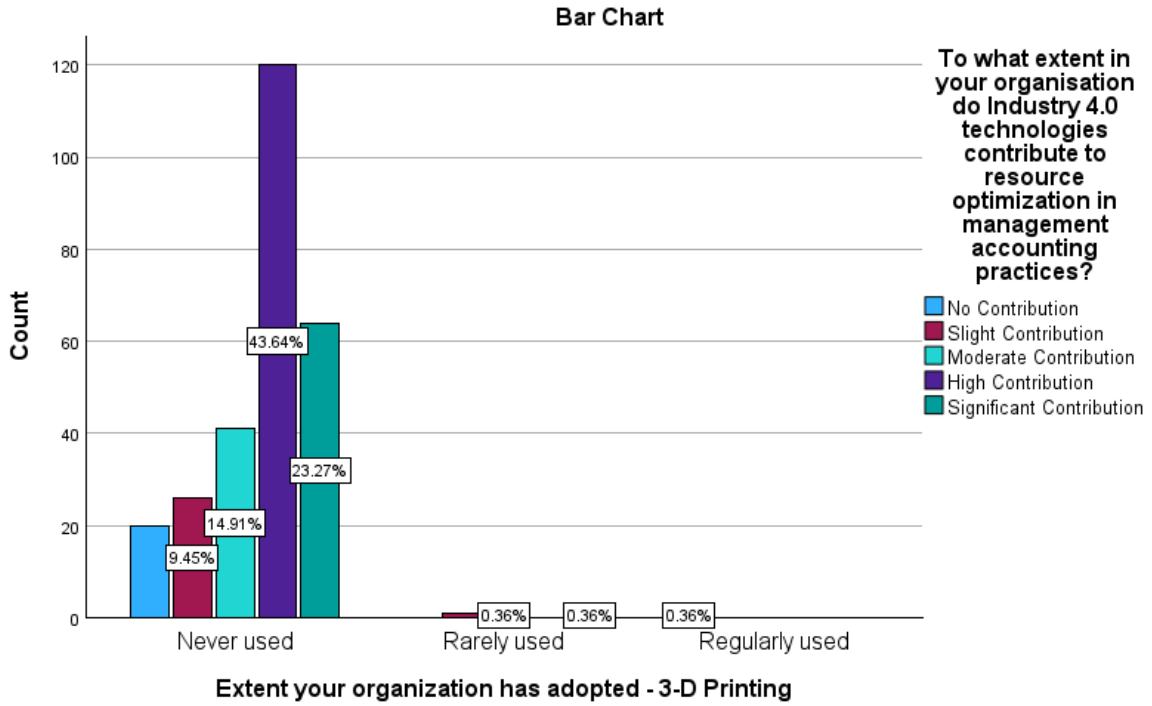

Figure 144. Extent of 3-D printing adoption influence on resource optimisation in management accounting practices.

The figure 144 above shows, that adopting 3-D printing, does not positively impact resource optimisation strategies.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.150[a]	8	.040
Likelihood Ratio	9.905	8	.272
Linear-by-Linear Association	4.221	1	.040
N of Valid Cases	275		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .08.

Table 131. Figure 144 Chi-Square Tests

There appears to be no statistically significant correlation between adoption of 3-D printing influencing resource optimisation in management practices, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 131 above.

4.2iii Impact on Cost Reduction

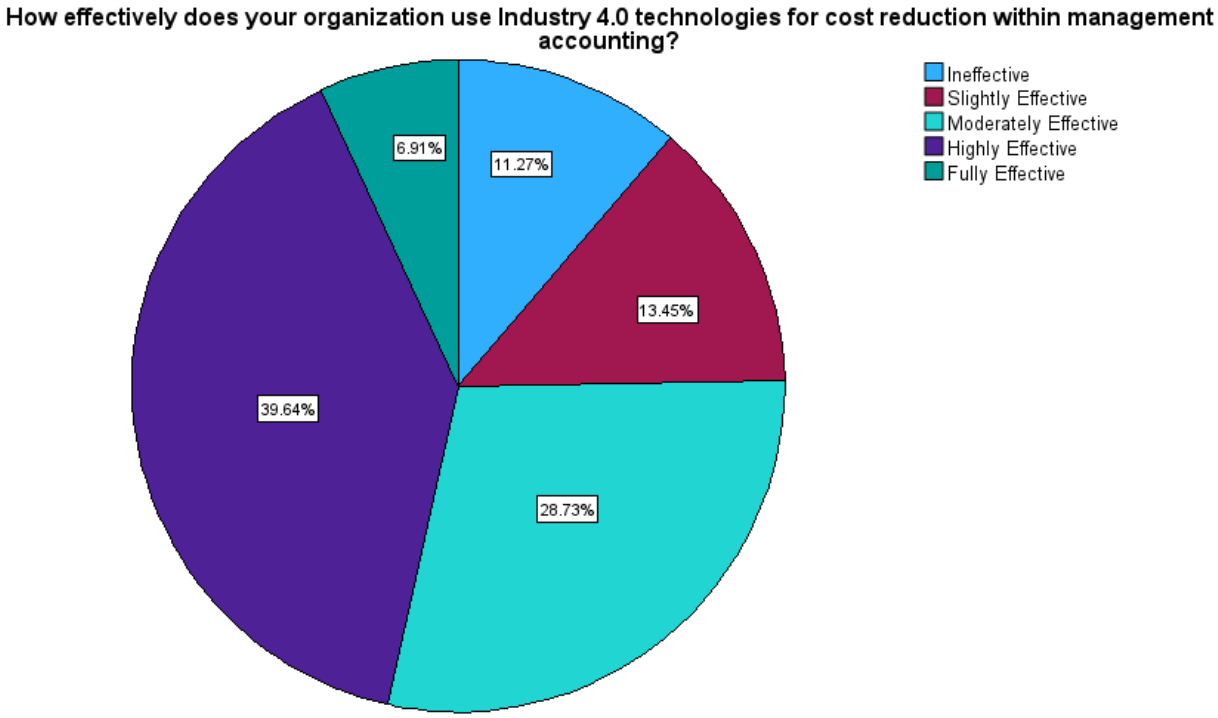

Figure 145. Extent of usage of industry 4.0 adoption influence on cost reduction within management accounting.

The efficiency of Industry 4.0 technology in cutting management accounting costs is demonstrated by the pie chart. Five categories are used to group the responses: Fully Effective, Highly Effective, Moderately Effective, Slightly Effective, and Ineffective. 39.64% of respondents, or most of them, believe that using these technologies is very effective. 28.73% of respondents think them to be somewhat effective, which comes next. A smaller portion of respondents 13.45% rates the technologies as somewhat effective, while 11.27% finds them to be ineffective. Merely 6.91% of respondents think that the technology can effectively reduce costs. According to these results, a sizable fraction of participants believe that Industry 4.0 technologies would help reduce costs. Most of them acknowledge that these technologies are highly effective, but more work needs to be done before they reach their maximum potential.

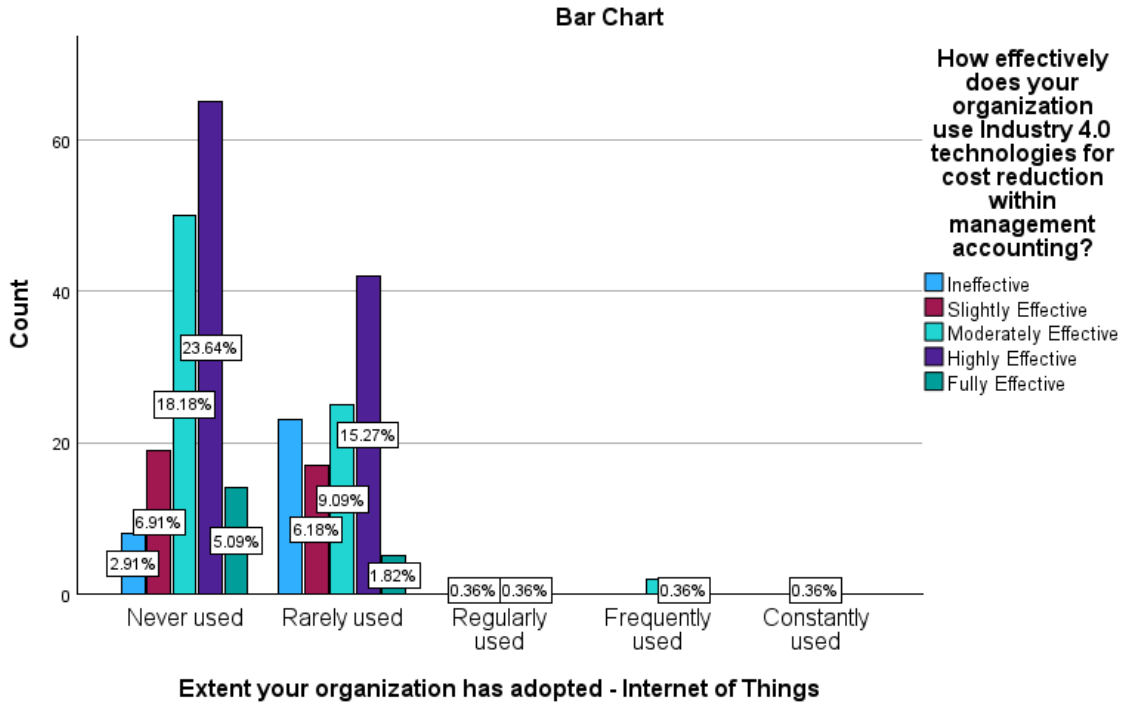

Figure 146. Extent of Internet of Things adoption influence on cost reduction within management accounting.

The figure 146 above shows, that adopting Internet of Things, positively impacts cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.051[a]	16	.069
Likelihood Ratio	25.715	16	.058
Linear-by-Linear Association	7.392	1	.007
N of Valid Cases	275		

a. 15 cells (60.0%) have expected count less than 5. The minimum expected count is .07.

Table 132. Figure 146 Chi-Square Tests

There appears to be no statistically significant correlation between adoption of Internet of Things influencing cost reduction within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 132 above.

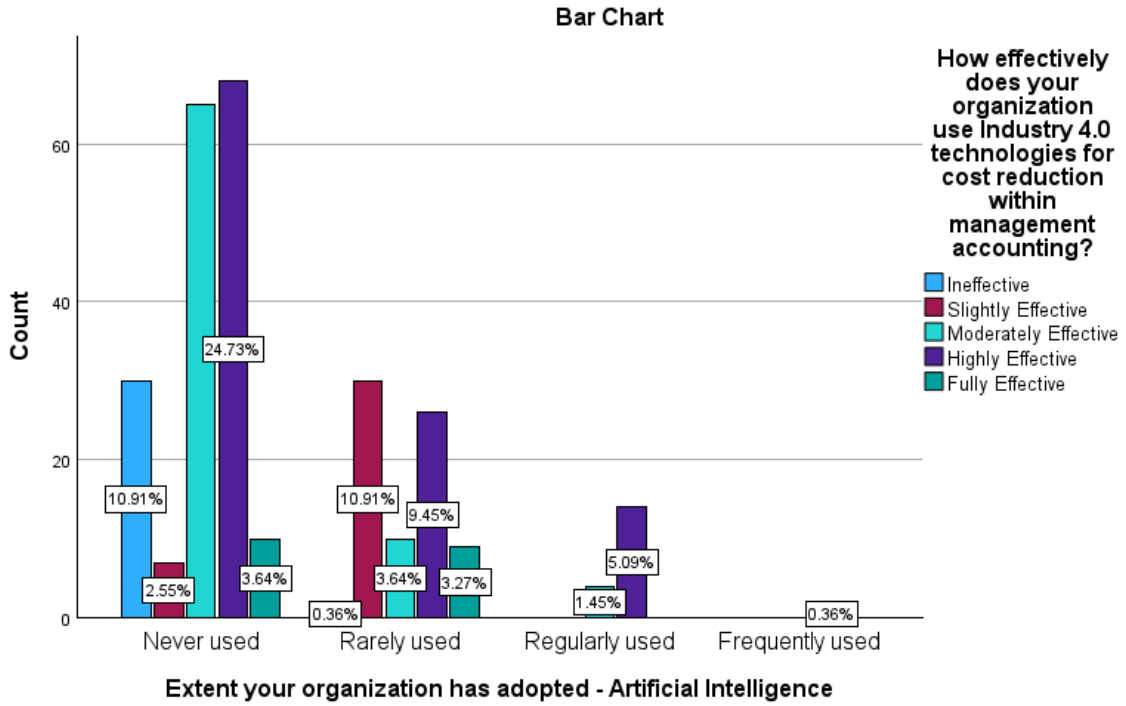

Figure 147. Extent of artificial intelligence adoption influence on cost reduction within management accounting.

The figure 147 above shows, that adopting artificial intelligence, positively impacts cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	89.606[a]	12	<.001
Likelihood Ratio	90.313	12	<.001
Linear-by-Linear Association	3.917	1	.048
N of Valid Cases	275		

a. 8 cells (40.0%) have expected count less than 5. The minimum expected count is .07.

Table 133. Figure 147 Chi-Square Tests

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 cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 133 above.

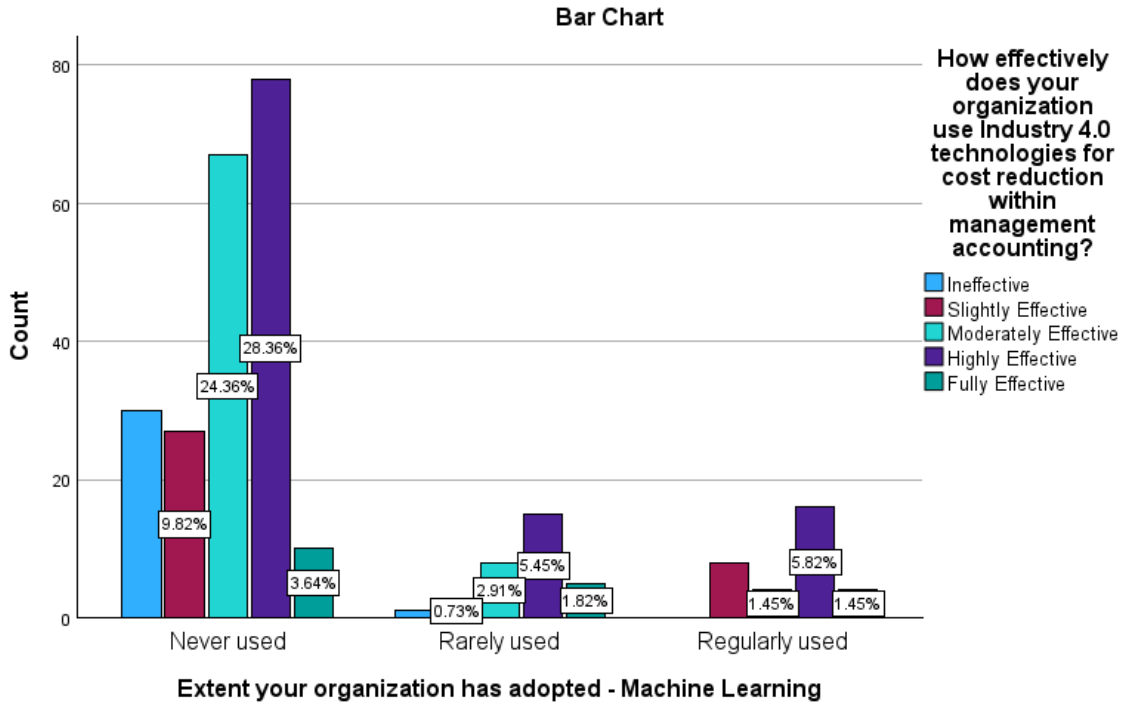

Figure 148. Extent of machine learning adoption influence on cost reduction within management accounting.

The figure 148 above shows, that adopting machine learning, positively impacts cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	23.598[a]	8	.003
Likelihood Ratio	26.955	8	<.001
Linear-by-Linear Association	8.530	1	.003
N of Valid Cases	275		

a. 6 cells (40.0%) have expected count less than 5. The minimum expected count is 2.14.

Table 134. Figure 148 Chi-Square Tests

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 machine learning influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 134 above.

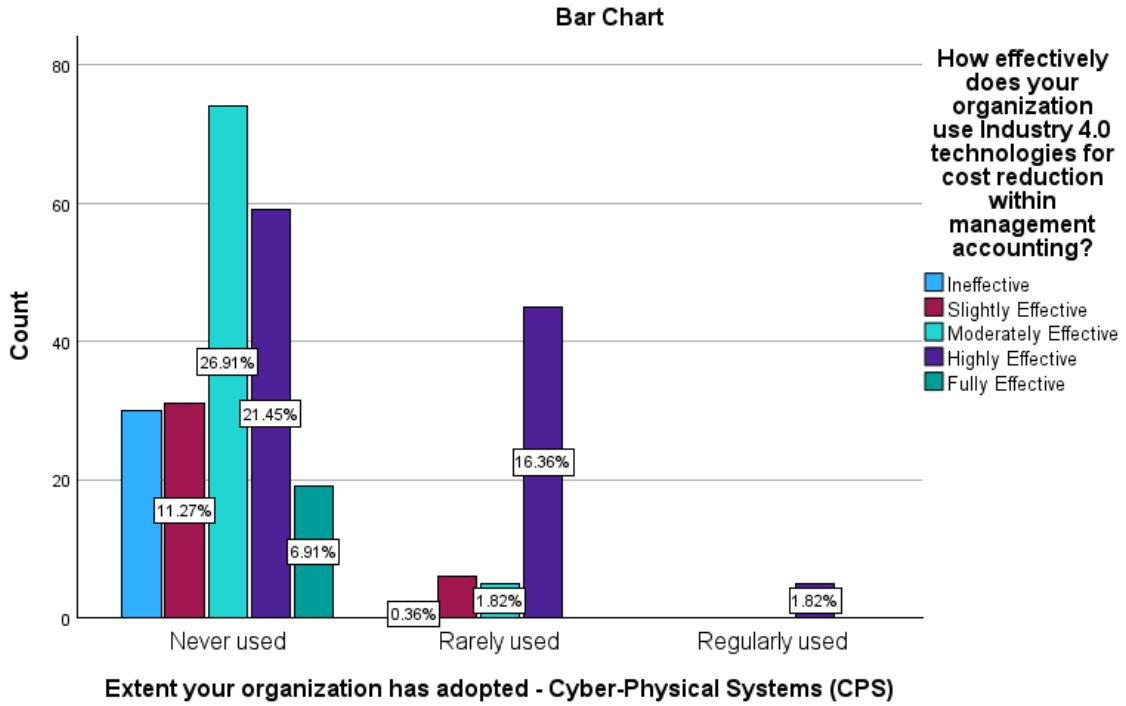

Figure 149. Extent of cyber physical systems adoption influence on cost reduction within management accounting.

The figure 149 above shows, that adopting cyber physical systems, positively impacts cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	59.893[a]	8	<.001
Likelihood Ratio	66.529	8	<.001
Linear-by-Linear Association	16.672	1	<.001
N of Valid Cases	275		

a. 6 cells (40.0%) have expected count less than 5. The minimum expected count is .35.

Table 135. Figure 149 Chi-Square Tests

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 cyber physical systems influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 135 above.

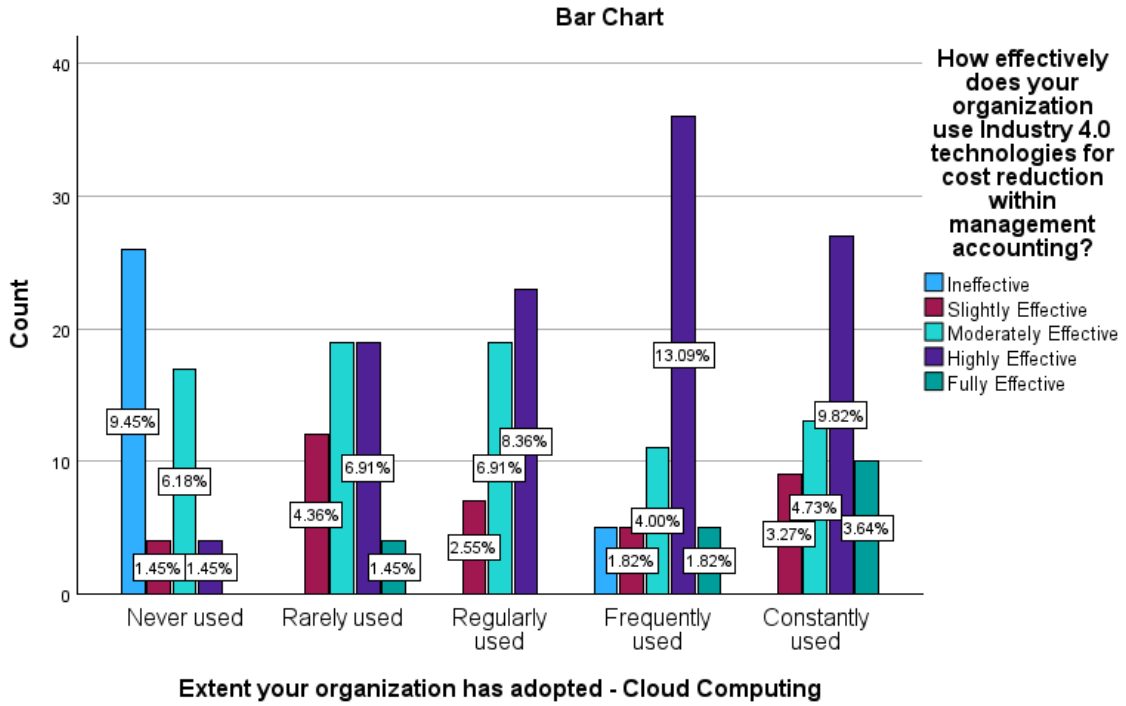

Figure 150. Extent of cloud computing adoption influence on cost reduction within management accounting.

The figure 150 above shows, that adopting cloud computing, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	137.815[a]	16	<.001
Likelihood Ratio	133.081	16	<.001
Linear-by-Linear Association	53.905	1	<.001
N of Valid Cases	275		

a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is 3.39.

Table 136. Figure 150 Chi-Square Tests

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 cloud computing influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 136 above.

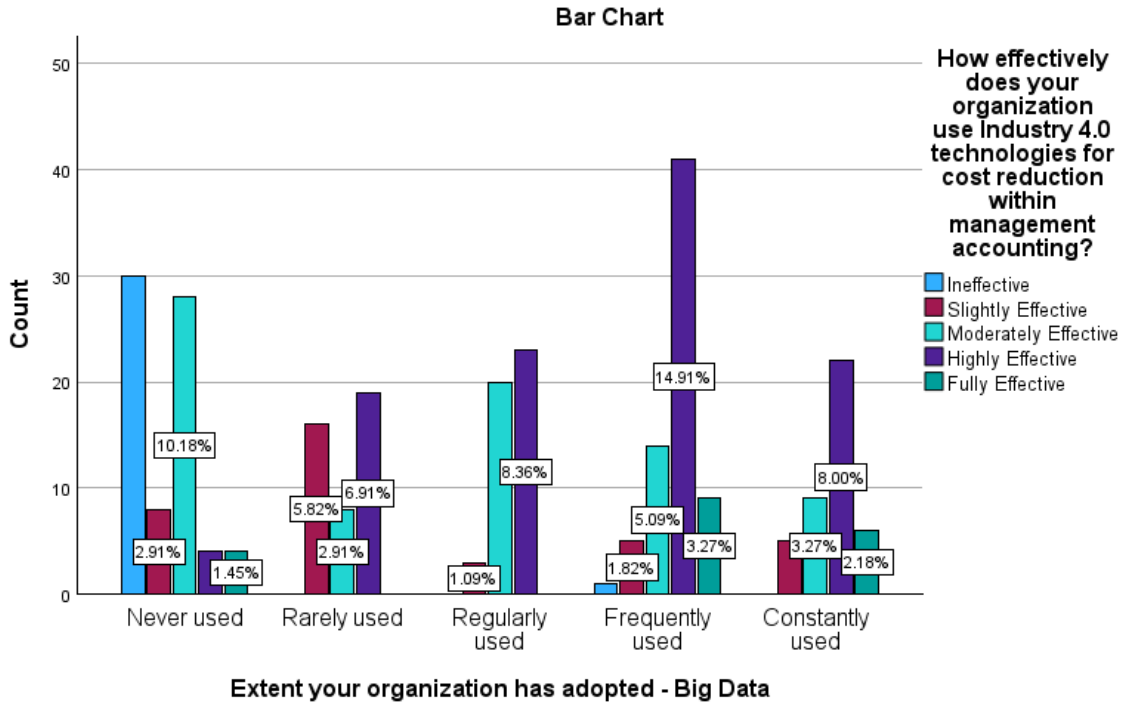

Figure 151. Extent of big data adoption influence on cost reduction within management accounting.

The figure 151 above shows, that adopting big data, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	153.701[a]	16	<.001
Likelihood Ratio	160.546	16	<.001
Linear-by-Linear Association	72.117	1	<.001
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 2.90.

Table 137. Figure 151 Chi-Square Tests

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 big data influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 137 above.

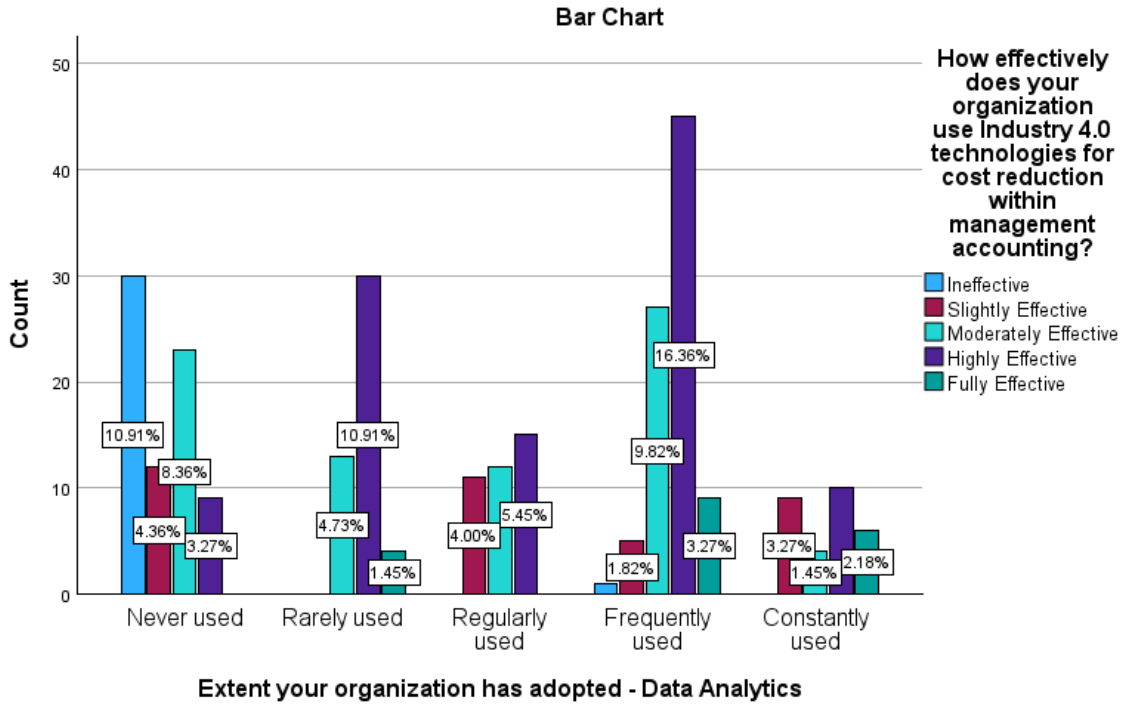

Figure 152. Extent of data analytics adoption influence on cost reduction within management accounting.

The figure 152 above shows, that adopting data analytics, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	145.503[a]	16	<.001
Likelihood Ratio	153.779	16	<.001
Linear-by-Linear Association	48.284	1	<.001
N of Valid Cases	275		

a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 2.00.

Table 138. Figure 152 Chi-Square Tests

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 data analytics influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 138 above.

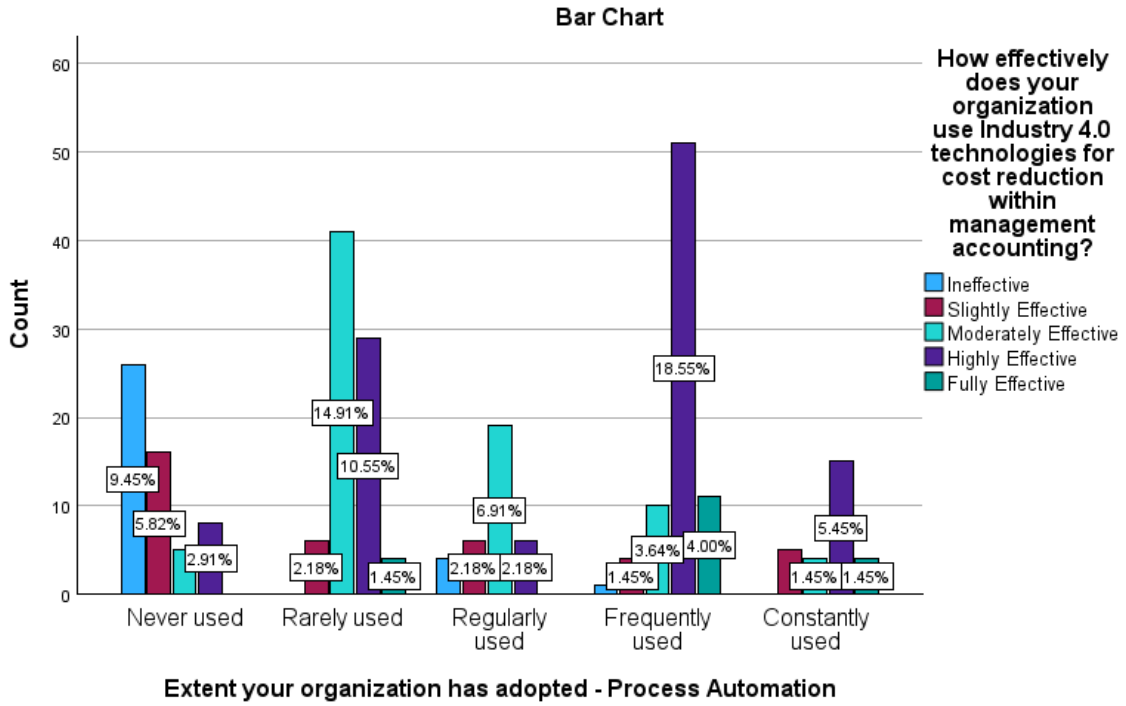

Figure 153. Extent of process automation adoption influence on cost reduction within management accounting.

The figure 153 above shows, that adopting process automation, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	180.568[a]	16	<.001
Likelihood Ratio	174.136	16	<.001
Linear-by-Linear Association	69.361	1	<.001
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 1.93.

Table 139. Figure 153 Chi-Square Tests

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 cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 139 above.

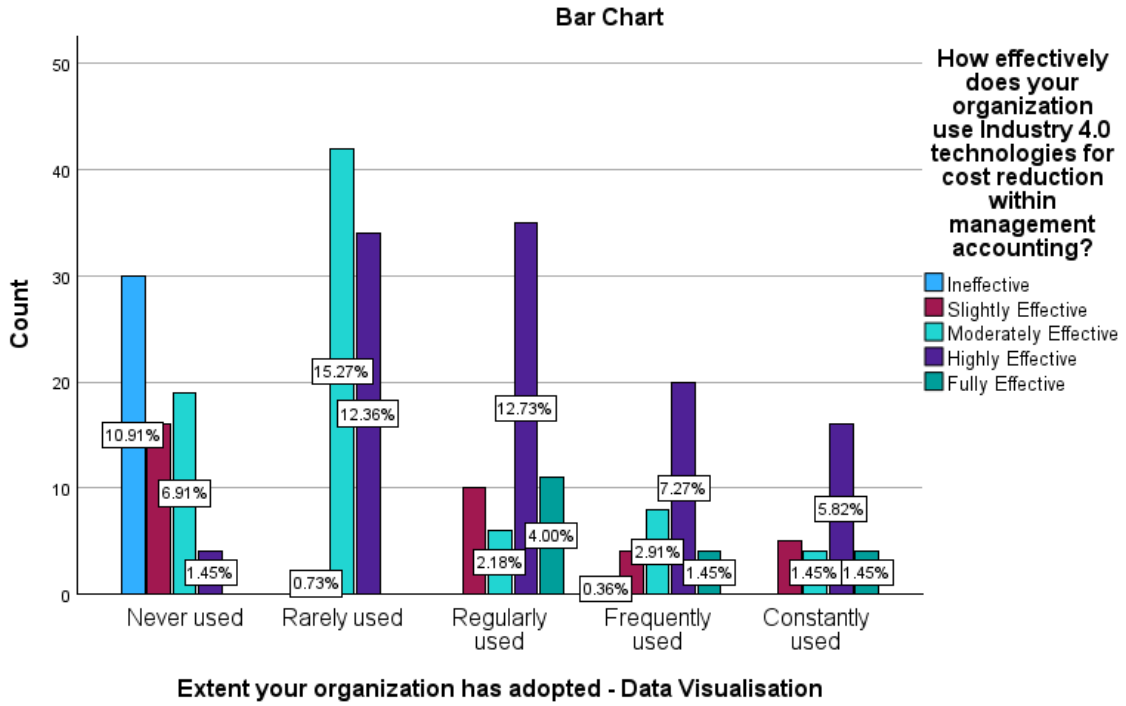

Figure 154. Extent of data visualisation adoption influence on cost reduction within management accounting.

The figure 154 above shows, that adopting data visualisation, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	177.276[a]	16	<.001
Likelihood Ratio	189.668	16	<.001
Linear-by-Linear Association	66.703	1	<.001
N of Valid Cases	275		

a. 8 cells (32.0%) have expected count less than 5. The minimum expected count is 2.00.

Table 140. Figure 154 Chi-Square Tests

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 data visualisation influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 140 above.

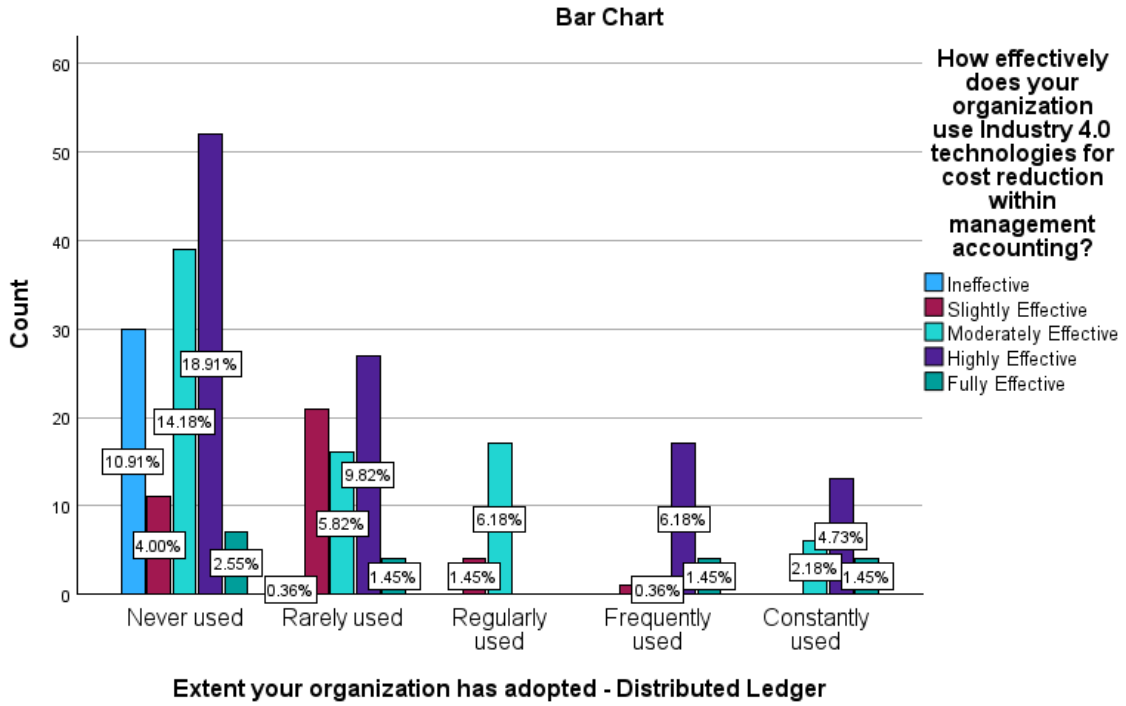

Figure 155. Extent of distributed ledger adoption influence on cost reduction within management accounting.

The figure 155 above shows, that adopting distributed ledger, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	101.606[a]	16	<.001
Likelihood Ratio	112.241	16	<.001
Linear-by-Linear Association	22.389	1	<.001
N of Valid Cases	275		

a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is 1.45.

Table 141. Figure 155 Chi-Square Tests

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 distributed ledger influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 141 above.

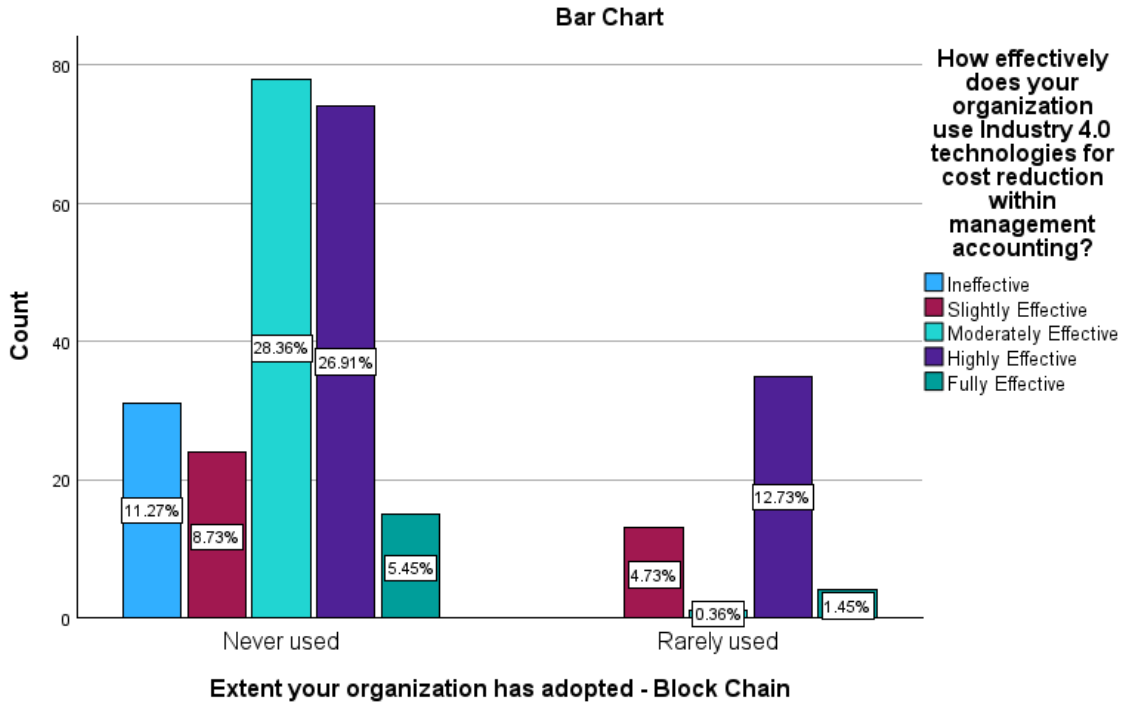

Figure 156. Extent of block chain adoption influence on cost reduction within management accounting.

The figure 156 above shows, that adopting block chain, positively impacts cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	41.433[a]	4	<.001
Likelihood Ratio	54.491	4	<.001
Linear-by-Linear Association	8.166	1	.004
N of Valid Cases	275		

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 3.66.

Table 142. Figure 156 Chi-Square Tests

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 block chain influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 142 above.

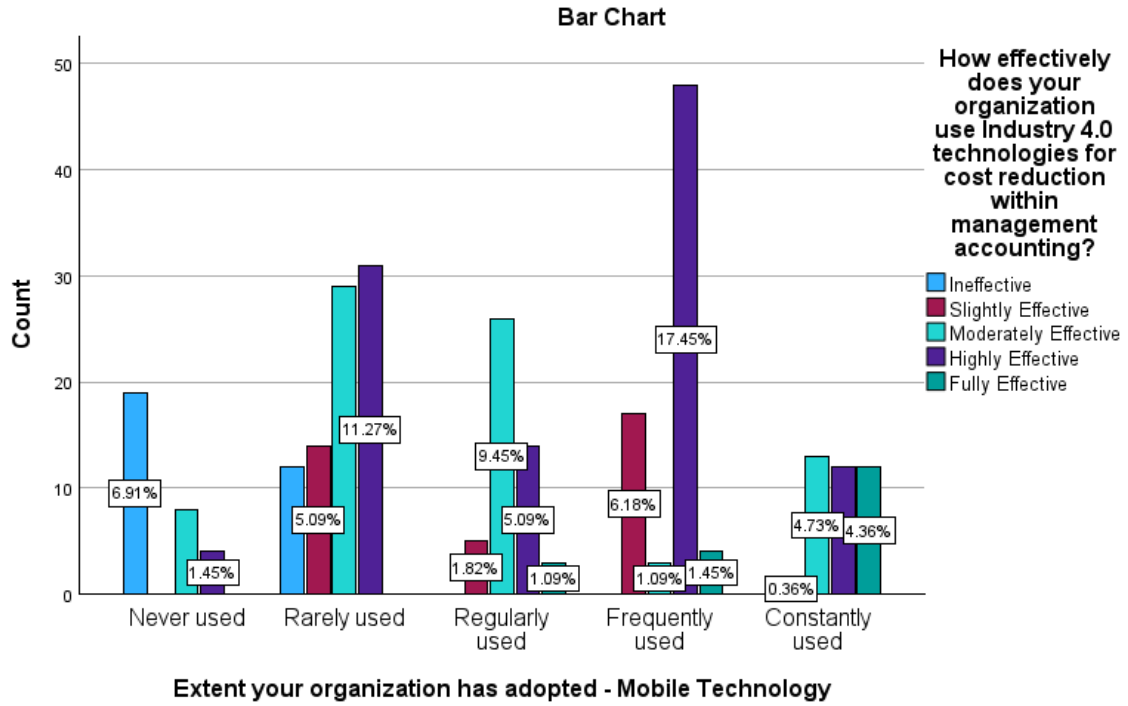

Figure 157. Extent of mobile technology adoption influence on cost reduction within management accounting.

The figure 157 above shows, that adopting mobile technology, positively impacts cost reduction within management accounting significantly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	191.033[a]	16	<.001
Likelihood Ratio	176.750	16	<.001
Linear-by-Linear Association	63.309	1	<.001
N of Valid Cases	275		

a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 2.14.

Table 143. Figure 157 Chi-Square Tests

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 mobile technology influencing cost reduction within management accounting, with p-values well below the 0.05 threshold as per table 143 above.

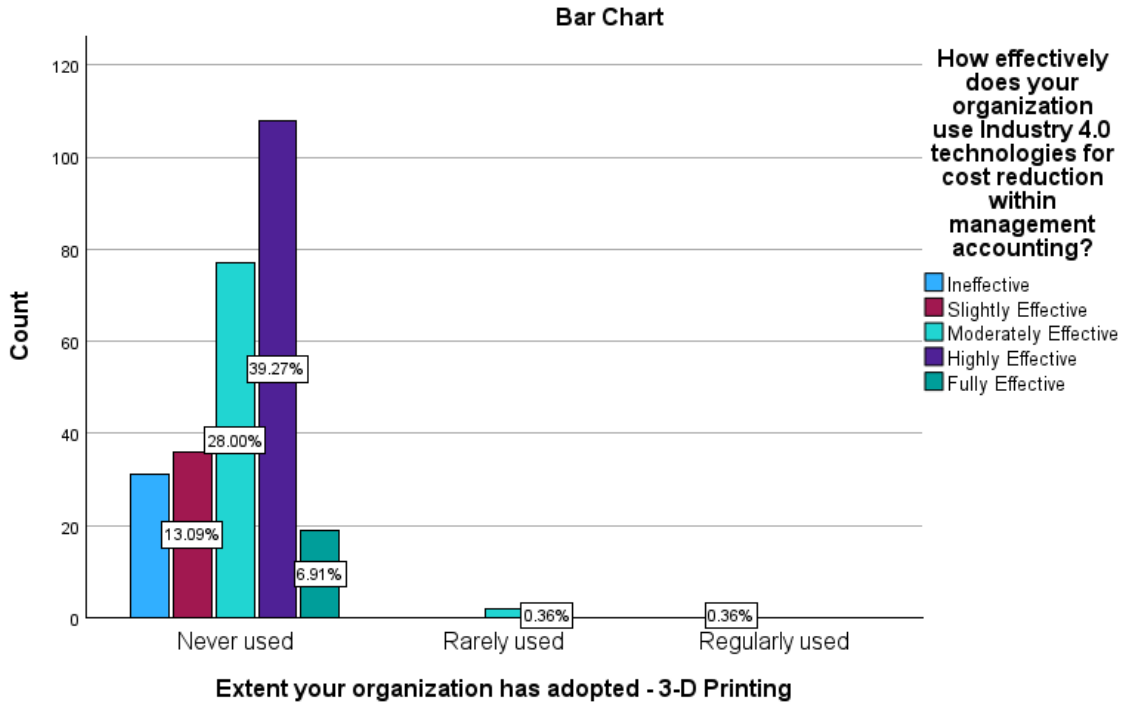

Figure 158. Extent of 3-D printing adoption influence on cost reduction within management accounting.

The figure 158 above shows, that adopting 3-D printing, does not impact cost reduction within management accounting fairly.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.944[a]	8	.347
Likelihood Ratio	7.062	8	.530
Linear-by-Linear Association	.412	1	.521
N of Valid Cases	275		

a. 10 cells (66.7%) have expected count less than 5. The minimum expected count is .07.

Table 144. Figure 158 Chi-Square Tests

There appears to be no statistically significant correlation between adoption of 3-D printing influencing cost reduction within management accounting, according to the findings of the Linear-by-Linear Association, Likelihood Ratio, and Pearson Chi-Square tests as per table 144 above.

4.2iv Qualitative Analysis of the Impact on Cost Efficiency Optimization

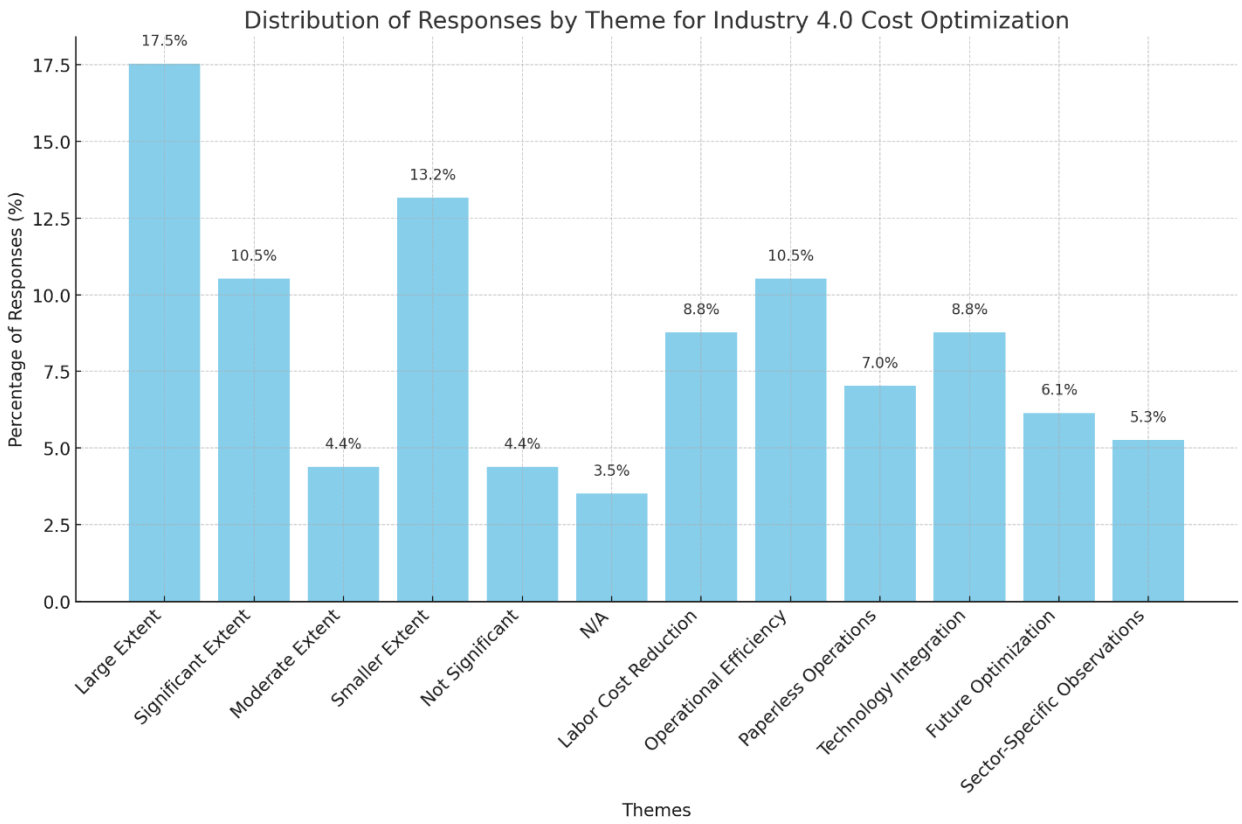

Figure 159. Major themes on cost optimisation from thematic analysis.

Figure 159 above shows the main themes coming from cost optimisation interviews and open ended questions.

4.3 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.

5.0 Discussion, Impact on Cost Efficiency

In what ways does the strategic adoption of Industry 4.0 technologies optimize cost efficiency in management accounting practices among organizations in Botswana.

5.1 Impact of industry 4.0 on the efficiency of the traditional cost management strategies

The findings presented in Figure 119 and Table 106 suggest that implementing the Internet of Things can greatly enhance the effectiveness of conventional cost management techniques. High significance p-values are found in the Chi-Square tests; for example, the Pearson Chi-Square value of 38.415 with a p-value of.001 shows a strong correlation between increased cost management effectiveness and Internet of Things adoption. Real-time

data collection and monitoring made possible by Internet of Things technologies allows for more precise and effective cost management techniques. In Botswana, where mining and agriculture are important sectors, Internet of Things can help operations run more smoothly by optimizing resource usage and providing predictive maintenance, which lowers operating costs.

Likewise, Table 107 and Figure 120 show that implementing artificial intelligence has a favourable effect on conventional cost management techniques. The results of the Chi-Square tests point to a statistically significant correlation between the use of artificial intelligence and effective cost management, with a Pearson Chi-Square value of 70.709 and a p-value of less than.001 confirming this relationship. Large data sets can be processed by artificial intelligence technologies, which also offer predictive insights that improve the accuracy of cost management and decision-making. Artificial intelligence artificial intelligence has the potential to be especially helpful in Botswana in industries like financial services and telecommunications, where data-driven choices can improve cost management, fraud detection, and customer service optimization.

On the other hand, Figure 131 and Table 118 show that the effectiveness of conventional cost management techniques is not considerably affected by the use of 3-D printing. There isn't a strong correlation, despite the Pearson Chi-Square test having a value of 20.362 and a p-value of.009, according to the Likelihood Ratio test, which has a p-value of.120. The fact that 3-D printing technology is still in its infancy as it relates to cost management in Botswana may be the reason for the lack of noticeable impact. The advantages and integration of 3-D printing may not have been fully embraced or utilized in conventional cost management techniques. Botswana's manufacturing industry is still in its infancy, and obstacles to its growth may include the high upfront costs and lack of trained labor for 3-D printing.
The implementation of additional Industry 4.0 technologies, like big data, cloud computing, and process automation, has a positive impact on traditional cost management strategies as well. For instance, scalable and affordable data processing and storage solutions are offered by cloud computing (Figure 123 and Table 110), which lowers the cost of IT infrastructure and increases data accessibility. Because it eliminates the need for costly on-premise hardware and makes use of remote servers, this can assist businesses in Botswana in managing costs more effectively.

Big data (Figure 124 and Table 111) makes it possible to analyze enormous volumes of data in order to find trends and insights that may motivate cost-cutting actions. Big data analytics can enhance pricing tactics, inventory control, and customer engagement in Botswana's retail and tourism industries, resulting in more effective cost management.

Process automation reduces labor costs and human error by streamlining repetitive tasks (see Figure 126 and Table 113). Automation can lower operating costs, increase the effectiveness of service delivery, and free up human resources for more strategically important work in Botswana's public and healthcare sectors.
In summary, real-time data collection, predictive insights, scalable solutions, and process automation are some of the ways that Industry 4.0 technologies dramatically improve the effectiveness of conventional cost management techniques. This is fully backed and supported by the following authors, (Anshari, 2022), (Buer, 2021)and (Cooper, 1998). These advancements are especially pertinent to Botswana, where the use of these cutting-edge technologies can have a significant positive impact on a number of industries, including mining, agriculture, financial services, telecommunications, manufacturing, retail, tourism, healthcare, and public services.

5.2 Cost Optimization Practices Using Industry 4.0 Technologies in Botswana

Adoption of the Internet of Things and Optimization of Resources (Figure 133, Table 119) under the results section indicate that, although it is not statistically significant, Internet of Things adoption has a positive effect on management accounting practices' resource optimization. It is evident from the Pearson Chi-Square value of 17.303 and p-value of 0.366 that there is little to no correlation between resource optimization and Internet of Things adoption. This might be because Botswana's industries, which might still be in the early stages of integrating Internet of Things technologies, have limited infrastructure and high implementation costs. As a result, the Internet of Things' potential benefits for cost management and resource optimization are still unrealized.

The use of artificial intelligence (Figure 134, Table 120) has a major impact on resource optimization in management accounting procedures, as demonstrated by a p-value of less than 0.001 and a Pearson Chi-Square value of 61.666. Machine learning and data analytics are two examples of artificial intelligence technologies that improve decision-making and prediction accuracy. Artificial intelligence has the potential to significantly improve forecasting, cut waste, and boost efficiency in Botswana's financial and agricultural sectors by optimizing resource allocation.

Adoption of machine learning (Figure 135, Table 121) has a p-value of less than 0.001 and a Pearson Chi-Square value of 50.239, which indicates a significant positive impact on resource optimization in management accounting practices. Large datasets can be analyzed by machine learning algorithms to find trends and maximize resource use. Better predictive maintenance and operational efficiency can result from the use of machine learning in Botswana's mining industry, which can lower costs.

With a Pearson Chi-Square value of 64.712 and a p-value of less than 0.001, the adoption of cyber-physical systems (Figure 136, Table 122) has a significant impact on resource optimization. These systems lower costs and increase efficiency by fusing digital control with physical processes. Cyber-physical system implementation in Botswana's manufacturing and energy sectors can improve cost-efficiency by streamlining production procedures and managing resources better.

Adoption of cloud computing (Figure 137, Table 123) has a p-value of less than 0.001 and a significant positive impact on resource optimization, according to a Pearson Chi-Square value of 66.912. Scalable and affordable options for processing and storing data are provided by cloud computing. Businesses in Botswana can use cloud computing to lower the cost of IT infrastructure, improve data accessibility, and manage costs better by using resources more effectively.

Resource optimization is significantly impacted by big data adoption (Figure 138, Table 124), with a p-value of less than 0.001 and a Pearson Chi-Square value of 88.423. Large-scale information can be analyzed using big data analytics to find patterns that lead to cost-cutting initiatives. Big data can improve cost management in Botswana by optimizing pricing strategies, inventory control, and customer engagement in the retail and tourism sectors.

A significant positive impact on resource optimization is demonstrated by the adoption of data analytics (Figure 139, Table 125), with a Pearson Chi-Square value of 118.259 and a p-value of less than 0.001. When allocating

resources and making decisions, data analytics can offer insightful information. Data analytics can improve the efficiency of service delivery and save operational costs in Botswana's public and healthcare sectors.
Resource optimization is greatly impacted by process automation (Figure 140, Table 126), as evidenced by the p-value of less than 0.001 and the Pearson Chi-Square value of 150.239. Automation speeds up repetitive tasks and lowers labor costs and human error. Process automation can reduce costs and increase operational efficiency in industries like manufacturing and banking in Botswana.

Adoption of data visualization (Figure 141, Table 127) has a p-value of less than 0.001 and a significant beneficial influence on resource optimization (Pearson Chi-Square value of 93.399). Tools for data visualization aid in the understanding of complex data and the formulation of wise conclusions. Businesses in Botswana may measure performance indicators, allocate resources more effectively, and control costs more effectively all by using data visualization.

Resource optimization is greatly impacted by the use of distributed ledger technology (Figure 142, Table 128), with a p-value of less than 0.001 and a Pearson Chi-Square value of 103.593. Block chain and other distributed ledgers offer transaction security and transparency. Adopting block chain technology in Botswana's supply chain management can improve cost control by lowering fraud, boosting traceability, and optimizing resource use.
A considerable positive influence on resource optimization is demonstrated by block chain adoption (Figure 143, Table 129), with a Pearson Chi-Square value of 53.022 and a p-value of less than 0.001. Block chain technology lowers fraud and increases transparency. Block chain technology has the potential to significantly enhance resource management and save costs in Botswana, especially in the financial and logistical sectors.
Resource optimization is considerably impacted by the deployment of mobile technology (Figure 144, Table 130), with a Pearson Chi-Square value of 79.202 and a p-value of less than 0.001. Access to data and real-time communication are made possible by mobile technologies. Mobile technology adoption in Botswana can improve field operations, optimize resource allocation, and cut costs in industries including agriculture and healthcare.

The adoption of 3-D printing (Figure 145, Table 131), with a p-value of 0.040 and a Pearson Chi-Square value of 16.150, does not demonstrate a statistically significant influence on resource optimization. Since the technology is still in its infancy, its potential for resource optimization has not yet reached its full potential. The high initial cost and lack of competent labor for 3-D printing in Botswana may limit its usefulness in conventional cost control techniques.

In conclusion, the integration of Industry 4.0 technologies which provide real-time data gathering, predictive insights, scalable solutions, and process automation significantly improves resource optimization in management accounting procedures. These advancements are especially pertinent to Botswana, where the use of these cutting-edge technologies can have a significant positive impact on a number of industries, including mining, agriculture, financial services, telecommunications, manufacturing, retail, tourism, healthcare, and public services. To fully realize the advantages of Industry 4.0 for cost optimization in Botswana, however, issues including limited infrastructure, high implementation costs, and the early stages of some technologies, such 3-D printing, need to be resolved.

5.3 Cost Reduction Practices Using Industry 4.0 Technologies in Botswana

The examination of study findings concerning the impact of several Industry 4.0 technologies on management accounting cost reduction offers valuable perspectives on their efficacy and statistical importance as shall be detailed below.

Figure 146 indicates that the use of Internet of Things reduces costs in management accounting; nevertheless, no statistically significant correlation is seen in the results of the statistical tests (Pearson Chi-Square, Likelihood Ratio, and Linear-by-Linear Association).

The tests indicate that, even though the figure shows a positive trend, the association between Internet of Things usage and management accounting cost reduction may not be statistically significant at the 5% level. Adoption of Internet of Things in Botswana might improve productivity across a range of industries, including mining, logistics, and agriculture. Internet of Things enabled sensors, for example, can monitor crop health and soil conditions in agriculture to optimize resource use and lower operating costs.

Figure 147 shows how the use of artificial learning in management accounting has a considerable positive influence on cost reduction. Strong statistical associations are indicated by p-values that are well below 0.001 in both the Pearson Chi-Square and Likelihood Ratio tests. It has been demonstrated that artificial learning technologies greatly lower management accounting process expenses. This is probably due to automation, predictive analytics, and enhanced decision-making skills. In Botswana, industries like healthcare and banking could undergo a transformation because to artificial learning. Artificial learning driven analytics can boost financial decision-making procedures and improve patient care in remote locations, which can lower expenses related to inefficiencies.

Adopting machine learning has a positive impact on management accounting cost reduction, as shown in Figure 148. Significant correlations are revealed by statistical tests (Pearson Chi-Square, Likelihood Ratio) with p-values less than 0.01. Adoption of machine learning aids in process optimization and data-driven decision-making, which greatly reduces costs. Applications of machine learning can be very important for Botswana's tourism industry and wildlife preservation. By forecasting visitor preferences and wildlife movement patterns, machine learning algorithms can optimize resource allocation and cut expenses.

Every statistical test with a p-value less than 0.001 indicates that the use of cyber-physical systems significantly improves management accounting cost reduction, as seen in Figure 149. Cyber-physical systems integration increases physical process automation and efficiency, which lowers costs and improves management accounting procedures. By combining digital and physical technologies, cyber physical systems can enhance the diamond business in Botswana. This connection can lower maintenance costs, increase manufacturing efficiency, and decrease downtime.

All statistical tests with p-values less than 0.001 corroborate Figure 150's finding that cloud computing adoption significantly effects management accounting cost reduction. Cloud computing lowers infrastructure and maintenance costs by providing improved data accessibility, cost-effective scalability, and operational flexibility. In Botswana, cloud computing can improve government and educational services. Cloud solutions can improve service delivery, save infrastructure costs, and expedite administrative chores by centralizing data processing and storage.

Both Figures 151 (Big Data) and 152 (Data Analytics) provide noteworthy advantages in terms of lowering management accounting costs. Highly substantial connections are shown by statistical testing ($p < 0.001$). With the use of real-time insights, advanced analytics, and better resource allocation, these technologies facilitate better decision-making and result in significant cost reductions. Planning for tourism and wildlife management in Botswana can both benefit from big data analytics. Large databases on tourism and wildlife movements can be analyzed to reduce wasted spending by improving marketing campaigns and conservation programs.

Adopting process automation has a considerable influence on management accounting cost reduction, as shown in Figure 153, where all statistical tests have p-values less than 0.001. Automation significantly lowers operating costs by streamlining procedures, minimizing errors, and increasing productivity. Automation can streamline production processes and cut expenses in Botswana's mining and industrial industries. Repetitive operations can be precisely handled by automated systems, reducing errors and increasing total efficiency.

Based on all statistical tests with p-values less than 0.001, Figure 154 shows that implementing data visualization has a substantial impact on cost reduction within management accounting. Data visualization helps insights be understood and communicated more effectively, leading to more efficient decision-making. Botswana's environmental and public health monitoring initiatives can benefit from the use of data visualization tools. Enhancing decision-making procedures through the visualization of environmental factors and health data patterns can result in more economical interventions and resource allocation.

Strong statistical tests indicate that both Figures 155 (Distributed Ledger) and 156 (Block chain) have a considerable positive influence on cost reduction within management accounting ($p < 0.001$). Distributed ledger technology and block chain improve record-keeping and transaction transparency, security, and efficiency, which lowers costs and increases operational dependability. Financial transactions and land registration in Botswana can be secured by block chain technology and distributed ledger technology. By using decentralized ledgers, property and financial transaction transparency can be improved and administrative costs related to maintaining centralized records can be decreased.

All statistical tests with p-values less than 0.001 corroborate Figure 157's finding that implementing mobile technology has a substantial impact on management accounting's ability to reduce costs. Through enhanced communication, operational agility, and real-time information availability, mobile technologies lower administrative costs. In Botswana's remote communities, mobile technology can facilitate better access to medical and educational services. By enabling remote consultations, e-learning, and agricultural consulting services, mobile applications can lower trip expenses and increase service accessibility.

Based on all statistical tests with non-significant p-values (above 0.05), Figure 158 indicates that the use of 3-D printing has no meaningful effect on cost reduction in management accounting. Comparing the technology to other Industry 4.0 technologies, it might not yet provide appreciable cost savings inside management accounting procedures. Rapid prototyping and manufacturing in Botswana's creative industries can be facilitated by 3-D printing. But compared to other technologies, its effect on management accounting cost reduction can be smaller because of setup and material expenditures up front.

Botswana could undergo a number of sectoral transformations as a result of the adoption of Industry 4.0 technology, thanks to increased productivity, lower expenses, and better decision-making. While technologies such as Internet of Things and 3-D printing may need customized tactics to maximize their influence in the local context, others, like artificial intelligence, Cloud Computing, and Big Data analytics, offer tremendous potential in driving cost reduction across multiple industries. This is supported by literature, examples of which include, (Allioui, 2023), (Barney J. B., 2000), (Cai, 2022)as well as many others. All things considered, by encouraging innovation and operational excellence, adopting these technologies can help Botswana achieve its goals for sustainable development and economic prosperity.

5.4 Qualitative themes on Industry 4.0 adoption influence on cost optimisation

The research data on cost optimization efficiency in management accounting firms in Botswana, may be categorized into five main themes using the notes that have been provided and the answers to open-ended and interview questions.

Extent of Optimization Achieved

Numerous answers suggest that Industry 4.0 technologies have significantly improved cost effectiveness. Businesses report increased operational efficiency, significant cost savings, and quicker and more accurate reporting. This agrees with other writers such as (Karmańska, 2021), (Manesh, 2020)and (Mian, 2020). While other businesses report continuing manual interventions and areas in need of optimization, they are experiencing only modest improvements. According to a number of respondents, the impact is minimal right now but will increase as long as businesses keep integrating these technologies.

Specific Benefits Observed

Cost savings from lower labor expenses, less utilization of physical resources, and lower IT infrastructure costs are all mentioned in great detail. Numerous companies point to increased operational efficiency as a result of improved resource management and automating repetitive work.

Challenges and Limitations

According to certain comments, there hasn't been much progress in the fields of project management and accounting, suggesting that the use and influence of these technologies are still limited. While there aren't many immediate benefits because some firms are still in the early phases of adoption, there may be opportunities for future optimization.

Environmental and Social Impact

Reactions emphasize how implementing Industry 4.0 technologies can save the environment by consuming less energy and paper. There has been a noticeable shift toward remote and digital work settings, which lessens the requirement for physical office space and the related expenses.

Future Outlook and Expectations

Many firms are positive about the impact these technologies will have in the future and anticipate increased cost savings and efficiency gains as adoption grows. Everyone agrees that once Industry 4.0 technologies are widely and deeply integrated, their advantages will become more apparent and result in significant increases in cost efficiency.

In summary

These subjects offer a thorough summary of the, cost benefits, advantages, difficulties, and anticipated future developments around the deployment of Industry 4.0 technology in Botswana's management accounting firms.

5.5 Conclusion: Industry 4.0 Technologies Impact on Cost Optimisation Efficiency

In Botswana, the implementation of Industry 4.0 technology has yielded inconsistent outcomes about cost reduction in management accounting processes. Artificial intelligence, machine learning, cloud computing, big data, data analytics, process automation, data visualization, distributed ledger, block chain, and mobile technology are among the technologies that have been shown to statistically significantly affect cost efficiency, according to quantitative analyses. Artificial intelligence and machine learning, for example, have enhanced operational efficiency and resulted in significant cost savings by streamlining procedures, decreasing human labor, and enabling data-driven decision-making. On the other hand, current state of the art technologies such as 3D printing and the Internet of Things have not shown appreciable cost savings, indicating that their full potential has not yet been reached. Efficiency in cost optimization is yet another crucial area, as evidenced by the findings of (Cooper, 1998) and (Frederico, 2021) showing that Industry 4.0 technologies significantly improve cost management.

These conclusions are supported by a thematic analysis of the qualitative replies, which shows notable cost savings via automation, decreased use of physical resources, and increased operational effectiveness. Notwithstanding, certain obstacles persist, including restricted instantaneous advantages and regions necessitating manual inputs. Benefits to the environment include lower energy and paper use as well as the freedom that comes with working remotely. As Industry 4.0 technologies are increasingly incorporated into management accounting procedures, there is hope for sustained development in cost reductions and efficiency. All things considered, even if these technologies are augmenting more conventional cost management techniques, their complete potential in resource optimization is yet to be realized, indicating increased future efficiency.

6.0 Future Research Areas

Integration of Technology and Interoperability

Look into the best ways to incorporate Industry 4.0 technologies into the current workflows and systems. Examine the difficulties and fixes involved in reaching seamless interoperability.

Effect on Workforce and Organizational Culture

Examine how the implementation of Industry 4.0 affects workforce dynamics and corporate culture. Examine how employee responsibilities, skill requirements, and general job satisfaction are affected by these technologies.

6.1 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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