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A Systematic Literature Review of Big Data Analytics in Healthcare Digital Transformation

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Abstract. This paper aims to analyse the current literature on big data analytics in healthcare digital transformation and to provide a research agenda for scholars and guidance for practitioners on related research themes. In doing so, it will offer support on further development for researchers and accelerate adoption for practitioners. A systematic literature review was performed based on Brocke et al. A data analysis of 64 articles based on Webster & Watson, which met the SLR review published between 2011 and 2021, was conducted. Five themes were identified in big data analytics in healthcare transformation, namely governance, healthcare, enablement, digital health initiatives and applications, based on previous research publications by various scholars between 2011 and 2021. To the best knowledge of the authors, this is the first research study to review the literature on big data analytics in digital healthcare transformation. The future research agenda sheds light on plenty of topics that can be investigated further through multiple methodologies; however, the availability of datasets for researchers may be a limitation to driving the research forward. A summary of the current literature under the five themes of BDA analytics in healthcare digital transformation is provided.

Keywords: Big data analytics; Healthcare; Digital transformation; Digital health; Healthcare management; Application of big data analytics.

1. Introduction

Big data analytics involves applying advanced analytics techniques to datasets to provide insights and support the decision-making process for managers seeking to drive better outcomes. Furthermore, the larger the dataset, the more difficult it becomes to manage [1]. Big data analytics (BDA) can be conceptualised as the analysis of comprehensive, lively, affordable, enormous and diverse datasets to deliver complex solutions [2-4]. Furthermore, BDA has often been recognised for its capacity to support decision-making as a result of the richness of the data collected and its ability to provide informed simulations for challenges in numerous fields [1, 5]. The healthcare sector has experienced multiple applications of big data analytics, and in order to understand its scope and applications therein, and to understand its potential, it is necessary to elaborate a clear definition of what constitutes "healthcare": in essence, it is the efforts made to maintain or restore physical, mental or emotional wellbeing, especially by trained and licensed professionals [6]. Another significant construct is the healthcare ecosystem [7, 8], which includes hospitals, healthcare providers, payers, industry, patients, regulators and government. This ecosystem demonstrates how different parties play a critical role in driving healthcare and well-being in society. Many studies have investigated the potential application of BDA in healthcare; for instance, Iyamu, Mgudlwa [9] developed a framework to guide healthcare practitioners on the benefits of employing analytics. Wang, Hajli [10], for their part, proposed a business value model for BDA in healthcare to explore its business value, whilst Wilson, Bazzoli [11] focused on predictive analytics applications to improve patient care and optimise costs in a US province's health system. Nordin

et al. [12] used a BDA tool to analyse type 2 diabetes mellitus patients in private hospitals which assessed organisational knowledge through action-based learning to drive value-based healthcare solutions. Riikkinen et al. [13] explored the value of BDA for insurance by applying artificial intelligence chatbots to assess customers' value creation. Singh et al. [14] provided practical guidance for healthcare sector professionals on managing by improving and benchmarking strategies through BDA, and Spanò, Ginesti [15] offered insights into the use of big data in performance management systems in cancer – specifically head and neck cancer treatment, prevention and benefits – from their analysis of archival sources and 19 interviews with physicians in the field. The study used the middle range theory (MRT) framework to determine whether BDA in the case of head and neck cancer favours the authorisation of performance management system discourses in healthcare.

Visualisation techniques in data mining are used for the early and correct diagnosis of different diseases, patient satisfaction measures and identifying a hospital's best leaders. In addition, they provide insights into the usefulness of business intelligence (BI) on two levels, namely the doctor and the hospital level. BI can be utilised to make better strategic decisions in terms of running the hospital and its determining its growth. At the doctor level, on the basis of various symptoms of a disease, a doctor can provide suitable treatment for patients. Doughty, Livingstone [16] described the infrastructure required to implement technology-enabled health and support services successfully.

The many different applications of big data in healthcare vary in their scope. Companies are currently investing heavily in order to adopt new technologies, with big data and associated analytics revenue forecasted to have reached $274.3 billion by the end of 2022 [17]. In the last decade, digital analytics has led the field in terms of total funding in digital health applications [18], reaching $6.2 billion. In 2020, a survey was published by Mercom, citing that capital and data analytics spending in digital health funding totalled $1.838 billion [18].

This figure represents 0.0088% of US GDP in 2020 [19]. Investments made in digital health and new technologies by healthcare organisations are rising; however, much more clarity is needed to unleash the full potential of BDA in healthcare. When looking deeper at the global healthcare big data market in 2016, it was divided into three sections: analytics services had a 40.9% market share, hardware had 26.4% and software had a 32.7% market share. The growth of analytics services has led to a positive upward trend in their use, and it is due to reach 42.1% by 2025 [20]. With the massive investment from healthcare organisations in BDA, and a significantly large body of research literature on the subject, there are fragmented efforts to understand its comprehensive value and effect on digital healthcare transformation.

As discussed earlier, applications for BDA in clinical practice are on the rise, and authors like Nordin et al. [12], Spanò, Ginesti [15] and Riikkinen et al. [13] have researched a number of cases on this topic. What will the future of clinical analytics look like by 2025, and how will companies continue to invest in BDA for better healthcare? In 2016, in the healthcare market, clinical analytics was estimated at $1.65 billion, financial analytics $2.38 billion and operational analytics $0.65 billion. However, it is predicted that by 2025, these figures will have risen exponentially to $11.35 billion, $13.14 billion and $4.45 billion, respectively [20], thereby equating to a 23.9% average yearly increase over a nine-year period.

With the massive investment made by organisations in BDA, how can these investments digitally transform healthcare? Integrating BDA may provide various contextual outcomes from current data and practice in healthcare. To understand what is meant by digital transformation, Gong, Ribiere [21] describe it as 'A fundamental change process, enabled by the innovative use of digital technologies

accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity[1] and redefine its value proposition for its stakeholders'.

So, are senior management teams and CEOs enabling the digital transformation of healthcare? In a survey [22] on big data technology adoption plans in organisations worldwide, as of 2019, 44% of those surveyed in the healthcare sector said that they were using big data, 37.5% said that they may use it in the future and 18.5% said that they had no plans to do so in the future. The research shows that 66% of healthcare organisations are still assessing the use of big data technologies, thus demonstrating that there is still a significant amount of potential and a long road ahead to reach the potential of BDA in the sector.

From this perspective, the main entities of focus are the healthcare organisations that play a role in the healthcare ecosystem.

Examples of BDA in healthcare transformation include disease diagnosis and symptom identification [23] in breast cancer, which are achieved through social media platforms. Utilising genetic blogs online enables a public health tool to enhance the credibility of the digital health application of genetics [24]. Lee et al. [25] investigated the effectiveness of machine learning through emergency department data in terms of transforming emergency departments and helping them deal with critical health issues and avoid readmissions.

Transformational leadership was behind all these examples. A recent survey by NewVantage Partners [26] interviewed 72 C-level executives, mainly from the financial services and healthcare industries, on the principle drivers of artificial intelligence and big data investment in 2020. The outcome concluded that one of the main principal drivers of investment is transformation, with an agreement of 53.7%. The endorsement of the C-level executives for the transformation of healthcare is one of the keys to enablement.

These investments in big data generally – and specifically in BDA – are driven by several objectives and the ways in which they transform of healthcare services and clinical outcomes or drive and optimise innovation, costs, efficiencies, regulatory perspectives and competitive advantage [26].

Research on BDA in healthcare digital transformation is on the rise, albeit with fragmented themes across the years.

The first objective of this study is to classify the literature on this topic into themes that can guide future scholars and practitioners and help them understand the evolution of BDA in healthcare transformation. The second objective is to provide a future research agenda for researchers on BDA in healthcare transformation, using a systematic literature review (SLR) [27].

The research in this paper is based on an SLR of the current literature from 2011 to 2021, in line with two research questions:

RQ1 *What are the current themes of BDA research in healthcare transformation?*

RQ2 *What is the future agenda for BDA in healthcare transformation?*

2. Methodology

A systematic literature review, based on the guidelines suggested by Brocke et al. [27], and Watson, Webster [28], will be used to help understand the use of BDA in healthcare transformation. The choice of the SLR method is due to its rigour, its systematic approach to grouping the literature, which involves systematic data

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[1] An "entity" can be classed as an organisation, a business network, an industry or society.

collection procedures, and several descriptive and qualitative data analysis techniques.

2.1. Database Selection

The databases chosen for this study included Business Source Complete, Emerald Insight, Jstor and Clarivate Web of Science.

A Boolean search used the following advanced search terms: "(BDA) AND (Healthcare) AND (Transformation)"

Other Synonyms also covered were: "(BDA) AND (Healthcare) AND (Digital Transformation)", "(Big analytics) AND (Healthcare) AND (Transformation)", "(Big analytics) AND (Healthcare) AND (Digital Transformation)" "(Data Science) AND (Healthcare) AND (Transformation)", "(Data Science) AND (Healthcare) AND (Digital Transformation)".

Of the 3,810 articles in the results, seven were selected from Business Source Complete. After reading the titles, to assess their relevance to the topic, six articles were further selected to read the abstract, after which five were selected for the final review. For Emerald Insights, 3,684 articles were sorted in terms of relevance to the keywords. The titles were scanned, and relevant titles that fitted the research question were manually selected, with 41 articles chosen. Of these, abstracts were read and 22 articles fitted the research question. Jstor provided 75 articles. After using the matching keywords and filtering based on "Business, economics, health policy, health sciences, public health," 26 articles were selected after reading the titles for relevancy, following which 10 were selected for the final review. From Clarivate Web of Science, the initial search resulted in 40 articles, 35 of which were further investigated by reading the abstracts, and 27 articles were finally selected.

The final results of 64 articles selected for review after checking their relevancy to the research question as shown in Fig. 1.
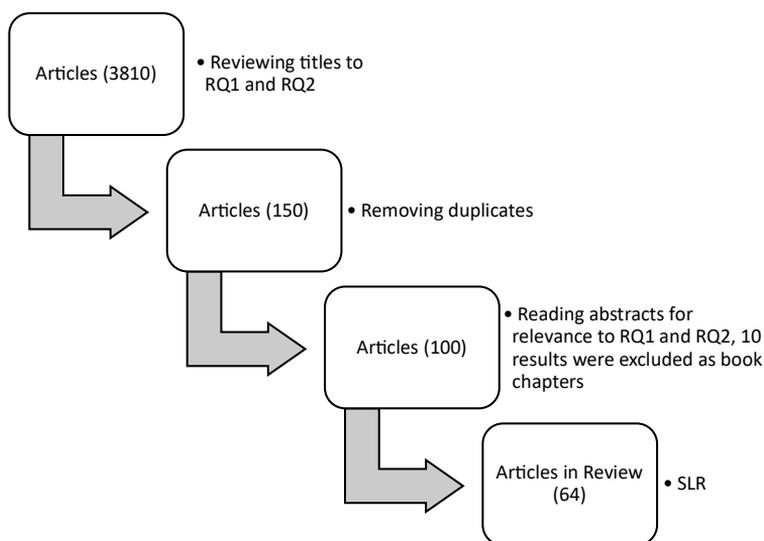

Fig. 1. Illustration of the SLR review process

SLR included only published journal articles and conference proceedings for this paper; book chapters were excluded.

2.2 Theme Classification

The SLR review classified the 64 papers based on a number of themes, in order to help build a structure for the review and provide a comprehensive outcome for researchers on these different topics for future research.

After reviewing previous work on classifying BDA in healthcare, Khanra et al. [3] provided an initial roadmap for BDA themes in the sector. The authors categorised themes in two ways. The first was based on the following five themes: health awareness, healthcare ecosystem, hospital management, specific medical condition and technological aspects. They also developed the secondary themes conceptual evolution, data governance, decision support, disease prediction and strategy formulation.

Kalaiselvi, Thirumurthi Raja [29] also offered a perspective on classifying applications of BDA in healthcare, and these included staffing, outcomes, electronic medical records, efficiency and productivity, patient engagement and predictive analytics, thereby making a massive contribution to BDA applications in healthcare and to potential guidance for further research in this area.

These themes helped develop the SLR review in this research paper, as they provided a roadmap for BDA in healthcare. Extending further on Khanra et al. [3] and Kalaiselvi and Thirumurthi Raja's [29] work, theme classification evolved in further work with the addition of digital transformation as part of the theme development.

In this theme grouping, in answer to research question 1 (RQ1), the themes identified herein were based on a perspective combining BDA with healthcare digital transformation to provide clarity for future researchers. The first theme was Governance, which relates to the control of data, privacy and the ethical management of big data. Winter, Davidson [30] contended that the characteristics of machine learning will devastate existing data governance methods such as privacy regulation and informed consent. Enhanced governance techniques and tools will therefore be necessary to help safeguard the independence and constitutional rights of individuals, in order to control their personal health information. Agrawal, Madaan [31] presented a structured model of BDA implementation barriers in healthcare within the supply chain sector, which included data quality, security of health data and other vital elements that are beneficial to starting the transformation journey. Examples of digital health initiatives found in the literature include the utilisation of artificial intelligence, the Internet of Things, m-health or e-health initiatives via which generated data are further analysed to provide certain outcomes. Safavi et al. [32] cited the top-funded companies in digital health and emphasised that organisations with biosensors had the most outstanding funding. Furthermore, they argued that digital healthcare corporations have not yet had a proven substantial impact on disease burden or cost efficiencies in the United States healthcare system, and they also highlighted the importance of the governance of digital health and policies issued by government to archive patient data and consumer rights, to develop solutions or products with a high impact on society. Applications include examples of the implementation of BDA in healthcare to improve outcomes in disease management. Wang, Hajli [10] provided new insights for healthcare practitioners on how to establish BDA capabilities for business transformation, as well as a pragmatic basis on which to stimulate a more detailed investigation of BDA implementation. Dhagarra et al. [33] proposed a big data-backed coupled blockchain-based solution that could be obtained voluntarily by citizens of India [34] for healthcare delivery. The conceptual framework was contextualised in the Indian context but had comprehensive appropriateness, as it could serve as a comprehensive solution to the problem of dispersed, poorly maintained and disorganised patient medical records. This would in turn could enhance the interoperability and accessibility of medical records. The model would also give an answer to the unsatisfactory medical service and inept utilisation of available limited resources. The healthcare management theme grouped the literature

based on improving the sector in terms of several elements, ranging from staffing to patient flow management. Mithas et al. [35] addressed a variety of strategy-related service management questions that service providers and consumers face in the context of emerging healthcare and technology trends. They also derived implications for governance choices and questions related to this point. The argument that Mithas et al. [35] developed focused on transformation in healthcare across a broader theme, i.e., information technology that is inclusive of BDA, in order to further develop these findings' validity. Gravili et al. [36] showed that BDA generates a meaningful shift that has made it possible to extend the research to health systems. Through both predictive and prescriptive analysis, BDA represents an efficient choice and a new method that can be employed to solve, manage, assess and report intangible resources – made up of human, relational and structural capital – thus assisting policymakers in identifying policies and practices via intellectual capital. The enablement theme classified the literature based on models utilised to enable BDA adoption. Ram, Zhang [37] devised a model for B2B organisations, such as healthcare ecosystem parties, to adopt BDA, whilst Singh et al. [14] highlighted key strategic issues in managing the healthcare sector, which can serve as guidelines for adopting BDA in this area. In addition, Wang et al. [38] provided a comprehensive BDA transformation model for healthcare organisations based on case studies of BDA implementation in countries such as the United States, Canada, Australia, United Kingdom, China and India, in which massive investment took place to build BDA capabilities in these institutions.

3. Results

As summarised in Table 1, the analysis determined that out of the 64 journal articles, eight addressed the governance of BDA and 11 examined different initiatives on digital health. The highest contribution of the research was in terms of applications of BDA in healthcare, with 19 articles, followed by BDA enablement with 17 articles. Additionally, research on BDA in healthcare management was found in 12 research articles.

Table 1. Themes from the SLR analysis

Themes	Papers	Years	No of Articles
Governance	[30, 31, 39-44]	2015-2021	8
Digital health initiatives	[32, 45-54]	2015-2021	11
Applications	[10-13, 15, 16, 23, 25, 32, 33, 55-64]	2015-2020	19
Healthcare management	[14, 35, 36, 65-72]	2014-2021	10
Enablement	[3, 9, 37, 38, 44, 45, 73-84]	2015-2021	17

An exciting finding (illustrated in Fig. 2) was revealed when the research articles were analysed over time, inclusive of different themes. Generally, in the past three years, there has been a rising research interest in BDA in healthcare transformation; for instance, in 2019, 2020 and 2021, there were 11, 10 and 11 articles, respectively. From 2011 to 2013, there were no research articles captured in the SLR review. Research grew in 2014, with a focus on healthcare management. Kolker, Kolker [70] started the era of healthcare analytics, Harper [68] questioned the role of BDA in transforming electronic medical records and You et al. [72] applied BDA through sparse matrix clustering to provide a new perspective on patients' specialist utilisation records, combined with a statistical learning methodology that could quantify the tightness of links between different specialties and highlight significant specialist clusters. In 2015, contributions were made in line with each of the five themes. In 2017, the focus was more on applications of BDA in healthcare, with six research

articles, and this trend continued in 2018, decreased in 2019, started to rise again in 2020, but was limited in 2021. Applications in BDA made the highest contribution with 19 research articles, written from 2015 to 2021.

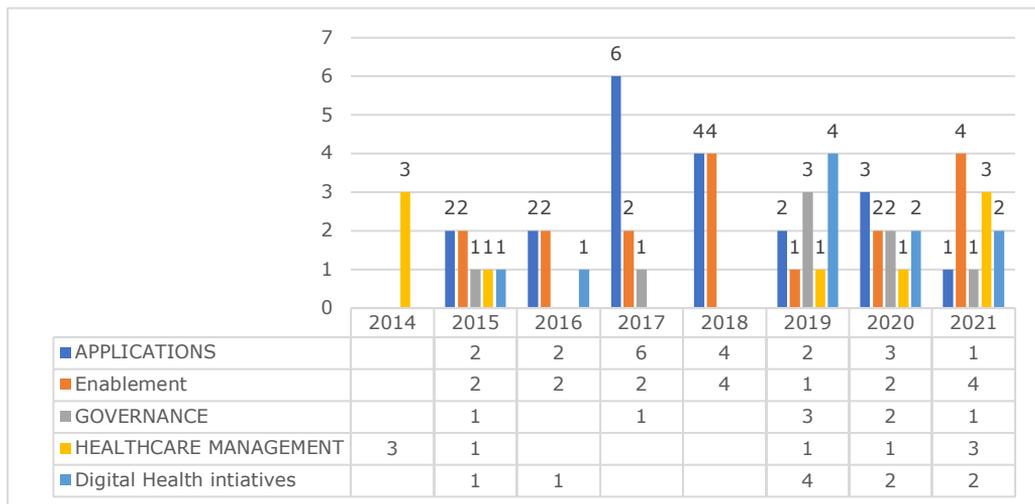|	2014	2015	2016	2017	2018	2019	2020	2021
APPLICATIONS		2	2	6	4	2	3	1
Enablement		2	2	2	4	1	2	4
GOVERNANCE		1		1		3	2	1
HEALTHCARE MANAGEMENT	3	1				1	1	3
Digital Health intiatives		1	1			4	2	2

Fig. 2. SLR analysis of BDA themes in the last decade.

For governance, limited research was done between 2011 and 2018, with only two articles published; however, for 2019-2021, six were published on that theme. Enablement research started in 2016 and continued every year until 2021, with a total of 17 research articles from 2015 to 2021. The digital health initiative theme was limited between 2015 and 2018 to two research articles, while interest increased from 2019 to 2021 with eight articles in these three years.

4. Discussion

The results provide clarity on the latest research themes in BDA in digital healthcare transformation, thereby offering direction for future researchers on the topic. A focus on the "applications" theme was dominant among researchers, which is valid evidence that there is an unmet need in enabling BDA for healthcare transformation, albeit the trend in applications has declined since 2017. On the other hand, "governance" made a limited contribution until 2018, with most of the research appearing in the last three years, from 2019-2021. Is this a coincidence or possibly a mandate to accelerate BDA research in digital healthcare transformation? The governance of data, privacy and ethical views of patient data information needs further investigation until a standard procedure is reached. The BDA governance framework is a critical success factor for digital transformation in healthcare.

Likewise, there may be a correlation between the rise in research on governance and enablement. Between 2019 and 2021, there was a rising trend in the enablement of BDA in healthcare. As the focus is to drive the adoption of BDA in this sector, it is dependent on the governance of data. Priorities for future research on the agenda should focus on enablement and borrow from other industries to accelerate this revolution. Governance should also be considered in this regard, as healthcare is a highly regulated industry, and data governance should be established and systems put in place to ensure continuity and replicability.

The future contribution of enablement and governance topics is a key element in accelerating the practical implications of BDA in healthcare. While the research agenda provided various examples of key topics to cover the five identified themes, it was limited to the current scope of research and focused more on enablement and

governance as key enabling factors for transformation.

Digital initiatives and applications are interconnected, as the former focuses on digital initiatives and the latter on broader patient outcomes. Applications within the agenda propose few research topics to be researched, but the scope is broad. Furthermore, to ensure the potential of digital initiatives and BDA applications in healthcare transformation is unleashed, enablement and governance are the key areas that need further development, in order to add value for practitioners and society.

The limitation of this research paper might be that it is missing some papers or conference proceedings that were not accessible on the selected databases, although efforts were made to use different synonyms for words used in research, to be as thorough as possible. The research accessed four database libraries, which should have captured most of the literature published on the topic.

5. Research Agenda

After analysing the literature, a research agenda on BDA in healthcare transformation was drafted for future research (see Table 3). It is the result of discussions on the findings and corresponding potential opportunities for further research.

Table 3. Proposed Research Agenda

Theme	Selected Research Question	Proposed Research Methods
Enablement	• What are the enabling factors and derailing factors for transforming healthcare through BDA? • What is the role of middle management and senior leadership teams in transforming healthcare through BDA within the healthcare ecosystem? (Learn about each organisation separately) • What is the correlation between governance and enablement in digital transformation in healthcare? • What can the healthcare sector learn from other industries that have successfully implemented big data analytics?	• Qualitative study • Qualitative study • Hypothesis, quantitative study • Literature review
Healthcare management	• How can big data visualisation help healthcare organisations in providing better care to patients? • What are the best analytical tools for big data analytics in healthcare management?	• Qualitative study • Qualitative study/literature review
Governance	• What are the quality factors that impact big data analytics in healthcare? • What is the effect of big data analytics management in healthcare governance? • Define big health data analytics management • What are the actions required to ensure big data privacy in healthcare?	• Qualitative study • Hypothesis, quantitative study • Construct development • Qualitative study
Digital Health initiatives	• How can digital consumerisation in healthcare enhance the value of BDA in its management? • How can an integrated model of IoT, medical E-commerce and BDA transform healthcare?	• Qualitative study • Qualitative/quantitative study (case-based with datasets)
Applications	• What are the current applications of BDA analytics in healthcare? • What are the diseases that primarily benefit from BDA in healthcare? • How has BDA influenced value-based pricing in healthcare? • What is the relationship between BDA implementation and hospital readmission? Assess healthcare institutions that implement BDA to manage in-patient care • What is the role of life sciences organisations in healthcare digital transformation? A big data and AI-focused study	• Literature review • Literature review • Literature review and theory development • A quantitative study, datasets to develop a hypothesis • Qualitative study, to develop a theoretical model for life sciences organisations

The research on enablement is a key element in driving the acceleration of BDA in healthcare digital transformation, with a focus on factors enabling and derailing this transformation, understanding the role of senior leaders in empowering middle management to adopt BDA and also understanding the role of governance in enabling BDA in healthcare, since it is a highly regulated industry and scrutiny from authorities and society places a high emphasis on privacy. Finally, it would be beneficial to uncover learning from other industries, especially the technology industry, in terms of enabling BDA in the transformation journey.

For healthcare management, one of the most vital areas, regardless of applications, is big data visualisation, i.e., for healthcare administrators, managers and practitioners, what impact can BDA visualisation have on healthcare outcomes, and how can it provide better healthcare? Additionally, what tools should be chosen what are the best practices that should be adopted?

Governance is a barrier to the adoption of BDA in healthcare transformation. Understanding the quality of the data and sources of information for accuracy, and building a standard procedure framework for precise governance, is one of the key success factors for transforming healthcare. Research should be conducted through interviews with health authorities, industries, insurance companies and patients to define a broad scope of pinch points to be considered while developing a standard procedure for data governance.

Digital initiatives focus on two main topics that can help practitioners and researchers alike. The impact of digital consumerisation in healthcare can be further investigated in line with the rise of internet hospitals in China, as a tele-health model for healthcare management [85] has driven the digital consumerisation and the establishment of a new business model. Consequently, BDA can play a critical role in estimating patient adherence, quality of care, hospital customer experience and medication errors – the applications and outcomes of which are unlimited.

Furthermore, when we look at the amount of data generated from various IoT healthcare devices and link that to the e-commerce model of internet hospitals or e-pharmacies, or patients' electronic medical records, a thorough case can be researched to measure its impact on healthcare management quality and patient care.

The last theme identified is "applications", which focuses on BDA case studies that enhance patient care outcomes. Studies into what disease areas BDA has added value to could contribute to further research developments and help practitioners provide better healthcare management solutions. Additionally, a focus on value-based costing in healthcare, aligned with an understanding of how BDA can drive better decision-making in terms of the cost evaluation of biosimilars, generics and new medicines, will help us assess re-admissions into hospitals. This could be achieved via a study comparing a group of hospitals that have implemented BDA and others which do not do so, thereby providing plenty of insights into its impact and how it influences healthcare outcomes.

The use of both BDA and artificial intelligence can create synergy in automated healthcare decision-making, albeit this an area in which limited research has been done to review the integration of both technologies on healthcare outcomes.

Finally, the role of life sciences companies, pharmaceuticals, medical devices and diagnostics is focused on providing multiple solutions to drive and improve healthcare outcomes. However, in relation to their role in accelerating technologies, especially BDA, artificial intelligence can help in supporting the evolution of digital healthcare transformation.

BDA in healthcare offers a vast research opportunity across a broad range of themes. The healthcare industry is lagging behind when it comes to adopting new technologies [86], mainly when it comes to big data and AI technologies. Consequently, a proposed theme-based question to drive the research into BDA in

healthcare should be developed alongside relevant methodologies to aid future scholars.

6. Conclusion

This systematic literature review has comprehensively explored the landscape of Big Data Analytics (BDA) within the realm of healthcare digital transformation, identifying critical themes and providing a structured overview of the current academic discourse. Our analysis of 64 pertinent articles published between 2011 and 2021 has revealed five major themes: *governance, digital health initiatives, applications, healthcare management,* and *enablement*. These themes highlight the diverse applications of BDA in healthcare, ranging from operational enhancements to governance and policy-making, underlining the pivotal role of BDA in advancing healthcare services and management practices.

The findings indicate a robust growth in research focused on the applications of BDA in healthcare, suggesting a strong recognition of its potential to transform healthcare outcomes. However, the themes of governance and enablement have emerged as critical areas needing further exploration, especially considering the rapid evolution of digital technologies and their integration into healthcare frameworks.

Our study is not without limitations. The review was restricted to articles available in selected databases, potentially omitting relevant studies published in other venues or in non-English languages. Additionally, the rapid pace of technological advancements may have led to the emergence of new trends not captured in this review. Future research should address these gaps.

Furthermore, empirical research is needed to evaluate the practical impacts of BDA implementations in healthcare settings. Investigating the interplay between governance, enablement, and technology adoption will also be crucial in understanding how best to leverage BDA for healthcare transformation. This approach will not only enrich the academic literature but also provide actionable insights for practitioners aiming to harness the power of big data in healthcare.

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The Integration of Machine Learning and Explainable AI in Business Digitization: Unleashing the Power of Data – A Review

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Abstract. The integration of machine learning (ML) and explainable artificial intelligence (XAI) within business digitization is a critical area for innovation and enhanced decision-making. This review synthesizes recent literature, sourced from academic databases like IEEE Xplore, Springer, ScienceDirect, and PubMed, focusing on peer-reviewed studies from the last five years to ensure relevance. Key applications of ML across healthcare, finance, and marketing are explored, highlighting its ability to handle complex datasets and improve predictive accuracy. The review discusses AutoML for automating ML model building, making advanced analytics more accessible, and examines the synergy between ML and IoT in small and medium-sized enterprises (SMEs) for innovation and efficiency. Explainable AI (XAI)'s role in providing transparency, building trust, and ensuring ethical AI deployment in business is also underscored. The findings indicate that strategic ML and XAI use in business digitization enhances operational efficiency and decision-making, providing a comprehensive overview of current trends, applications, benefits, challenges, and future research directions.
Keywords: Machine Learning, Explainable AI(XAI), Business Digitization

1. Introduction:

In today's rapidly evolving business landscape, the integration of machine learning (ML) and business digitization has emerged as a pivotal driver of transformation and innovation. As organizations worldwide embark on their digitalization journeys, harnessing the power of data has become paramount to gaining a competitive edge and staying relevant in the market. Machine learning, as a subset of artificial intelligence (AI), offers the potential to unlock valuable insights from vast amounts of data, enabling data-driven decision-making and propelling businesses towards greater efficiency, productivity, and profitability.

The convergence of ML and business digitization presents an unprecedented opportunity to leverage data as a strategic asset. By adopting advanced ML algorithms and techniques, organizations can uncover hidden patterns, predict trends, and optimize operations across various sectors, from marketing and finance to supply chain management and customer service. Moreover, ML empowers businesses to personalize their offerings, enhance customer experiences, and create targeted marketing campaigns that resonate with individual preferences.

This conceptual paper aims to explore the profound impact of the integration of ML and business digitization in today's dynamic economic landscape. We delve into the significance of data-driven strategies, illustrating how ML-driven insights can revolutionize decision-making processes and enable organizations to adapt swiftly to changing market demands. Additionally, we shed light on the role of Python, a popular programming language for ML and data analysis, in facilitating the implementation and deployment of ML models within the context of business digitization.

Furthermore, the paper discusses the use of Explainable AI (XAI) in business. XAI enhances the transparency and interpretability of AI models, making it easier for

organizations to understand and trust AI-driven decisions. By integrating XAI, businesses can address ethical and regulatory concerns, thereby increasing the trustworthiness and accountability of their AI systems.

By examining relevant case studies, theoretical frameworks, and industry best practices, this paper seeks to elucidate the synergistic potential of ML, XAI, and business digitization in unleashing the power of data. Through a comprehensive exploration of this transformative partnership, we aim to provide readers with valuable insights and considerations for strategically integrating ML and XAI into their digitization endeavors, ultimately propelling their organizations towards sustainable growth and success.

The remainder of this paper is structured as follows: Section to 2 presents the research questions that mainly focused on this review. Section 3 provides an overview of business digitization, setting the stage for the subsequent literature review. Section 4 presents a comprehensive literature review, discussing the integration of machine learning (ML) with business digitization and illustrating how ML technologies are transforming business processes and enhancing efficiency. This section also explores the possibilities of applying explainable AI (XAI) in a business context, emphasizing the benefits of transparency, trust, and accountability in AI-driven decisions. Section 5 describes the methodology used for this paper. Section 6 provides with some key findings and themes extracted from the literature. Section 7 examines the benefits and challenges associated with integrating ML and business digitization, highlighting both the advantages and potential obstacles that businesses may face. Finally, Section 8 concludes the paper by summarizing the key findings and suggesting future research directions to further advance the field. This structured approach ensures a comprehensive and coherent exploration of the intersection between machine learning, explainable AI, and business digitization.

2. Research Questions

This review aims to focus mainly on following key research questions:

1. How does machine learning improve business decision-making?

This question explores the practical applications and benefits of machine learning in Enhancing the decision-making processes within various business sectors.

2. What impact does explainable AI have on trust in AI-driven business processes?

This question examines the role of explainable AI in fostering transparency and trust among stakeholders in business environments that utilize AI-driven decisions.

3. What are the main challenges of integrating ML and XAI in business digitization?

This question identifies the primary obstacles businesses face when incorporating machine learning and explainable AI into their digital transformation strategies and suggests potential solutions.

By addressing these research questions, the review aims to provide a comprehensive understanding of the integration of ML and XAI in business digitization, highlighting current trends, applications, benefits, challenges, and future research directions.

3. Overview of Business Digitization

Business digitization, a term often used interchangeably with digitalization and digital transformation, has become a crucial aspect of contemporary management and organizational strategies. The process of digitization involves the conversion of analog data to digital formats, while digitalization refers to the restructuring of various domains of social life around digital communication and technologies. Digital transformation, on the other hand, is a broader process that aims to improve an entity by triggering significant changes to its computing, communication, and connectivity technologies [1]. Fig. 1 demonstrates framework of business digitization.

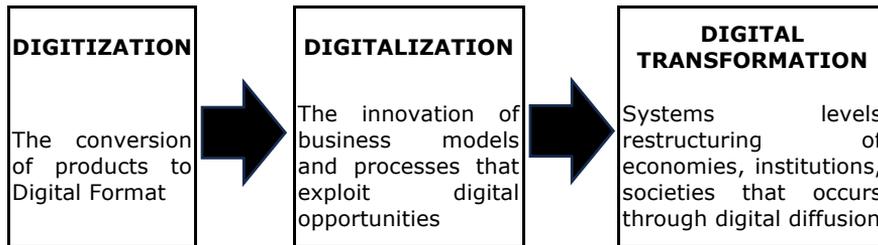| DIGITIZATION	DIGITALIZATION	DIGITAL TRANSFORMATION
The conversion of products to Digital Format	The innovation of business models and processes that exploit digital opportunities	Systems levels restructuring of economies, institutions, societies that occurs through digital diffusion

Fig. 1. A framework of Business Digitization. Source: [2].

In recent years, there has been a significant amount of research conducted on digital transformation, examining changes in organizational strategies, processes, structures, decision-making, culture, and industry shifts. However, despite the extensive research, there is still much to be learned about this phenomenon, particularly in terms of its complex interplay with various forces that affect it [1].

Understanding the role of digitalization in business and management is essential for organizations to remain competitive in the digital world. This involves not only adopting digital technologies but also transforming business models and processes to leverage these technologies effectively. Research has shown that digitalization can have significant impacts on various aspects of business, including management, marketing, and finance and accounting [3].

This study aims to provide and overview of the current status of research on digital transformation in business and management, highlighting key themes and findings that have emerged from recent studies. It will also explore the conceptual frameworks and models that have been developed to understand and analyze digital transformation, as well as the implications of these findings for practice [4].

4. Review of Literature

4.1 Introduction to Machine Learning

Machine learning (ML) is a rapidly evolving field of artificial intelligence that enables systems to learn and improve from experience without being explicitly programmed. It involves the development of algorithms and statistical models that allow computers to perform specific tasks effectively by utilizing data [5]. Machine learning has found widespread applications across various domains, including healthcare, finance, marketing, and natural language processing, among others [6].

One of the key advantages of machine learning is its ability to handle large and complex datasets that would be difficult for humans to process manually. By identifying patterns and relationships within the data, ML algorithms can make accurate predictions, detect anomalies, and assist in decision-making processes [7]. For instance, in the healthcare domain, machine learning techniques have been

employed for early disease detection, personalized treatment recommendations, and drug discovery [8].

Another important aspect of machine learning is its adaptability to different types of problems. Depending on the nature of the task and the available data, various ML algorithms can be applied, such as supervised learning (e.g., classification and regression), unsupervised learning (e.g., clustering and dimensionality reduction), and reinforcement learning (e.g., decision-making in dynamic environments). The choice of algorithm depends on the specific requirements of the problem at hand [7].

Despite the numerous benefits of machine learning, there are also challenges and limitations that need to be addressed. One of the main challenges is the need for large and high-quality datasets for training the models. Insufficient or biased data can lead to inaccurate predictions and suboptimal performance [6]. Additionally, the interpretability and explainability of machine learning models, particularly in complex systems, is an area of ongoing research [9].

In conclusion, machine learning has revolutionized various domains by enabling data-driven decision-making and automation of complex tasks. As the field continues to evolve, it is expected to have an even greater impact on society, with potential applications in areas such as autonomous vehicles, personalized education, and sustainable energy management. However, it is crucial to address the challenges associated with machine learning, such as data quality, model interpretability, and ethical considerations, to ensure its responsible and effective deployment.

4.2 Integration of Machine Learning and Business Digitization

As the demand for data-driven solutions continues to grow, researchers and practitioners have turned their attention to fitting machine learning models fully automatically, leading to the emergence of a new research topic known as AutoML [10]. AutoML aims to automate the process of building and fine-tuning machine learning models, enabling organizations to leverage the power of data analytics without requiring extensive expertise in machine learning.

In the realm of Internet of Things (IoT) applications, [11] provide comprehensive surveys on the development lifecycle of ML-based IoT applications, highlighting the significance of integrating machine learning with IoT technologies to create intelligent and data-driven solutions. To address the challenges faced by small and medium-sized enterprises (SMEs) in the manufacturing sector, [12] propose a systemic concept for enhancing existing learning factories into innovation labs that simulate the digitization of production processes. This approach utilizes Edge Computing, an advanced implementation of virtualization, to achieve collaborative innovation between academic science and industry.

Virtualization's potential for solving various challenges is further explored by [13], who discuss how virtualization can offer solutions in the context of Edge Computing and related complexities.

Shifting the focus to the future of business intelligence, [14]encourages readers to contemplate the integration of AI in business intelligence and its potential benefits for enterprises in terms of advanced analytics and data-driven decision-making.

In the context of digital transformation, [15] provide a clear understanding of essential concepts such as "digitization," "digitalization," "digital transformation," and "automation," offering insights into the pivotal role of these concepts in modern business strategies.

Moreover, the application of big data analytics and machine learning in the maritime industry is explored by [16], specifically focusing on achieving fuel efficiency for harbor craft vessels through data-driven optimization. These influential works, emphasize the growing importance of integrating machine learning and business digitization. By leveraging data-driven technologies, organizations can unlock new

opportunities for innovation, efficiency, and strategic decision-making, making this integration a critical area of research and development in the digital era.

4.3 Possibilities of applying Explainable AI in Business Context

The integration of explainable AI (XAI) in business contexts is increasingly recognized as a critical factor for building trust, ensuring transparency, and facilitating decision-making processes within companies. As highlighted in the study "Do We Need Explainable AI in Companies? Investigation of," the exploration of XAI's applications across various industries enables businesses to fully harness the potential of artificial intelligence while concurrently addressing ethical and regulatory concerns.

Explainable Artificial Intelligence (XAI) has emerged as a focal point in the business domain due to its ability to provide transparency and accountability in AI-driven decision-making processes. The primary objective of integrating XAI into business settings is to enhance the trustworthiness and comprehensibility of AI systems, thereby mitigating issues associated with the opacity of traditional black-box AI models [17].

Recent research underscores the necessity of developing AI techniques that not only produce accurate predictions but also furnish explanations for these predictions. This is particularly crucial in sectors where regulatory compliance, risk assessment, and ethical considerations are paramount. By delivering interpretable explanations for AI decisions, businesses can foster user acceptance, facilitate regulatory compliance, and improve overall decision-making processes [18].

A systematic review conducted by [19] on XAI models and applications across various sectors—including manufacturing, transportation, and finance—highlights the importance of XAI in enhancing transparency, trustworthiness, and accountability in high-stakes applications. This review provides valuable insights into diverse XAI approaches and their practical applications, offering a roadmap for future research and implementation.

Further, literature review by [20] suggests that effectively communicating AI systems to end users should prioritize goals such as understandability, trustworthiness, transparency, controllability, and fairness. Recommended design strategies include providing personalized and on-demand explanations, as well as focusing on the explainability of key functionalities rather than attempting to elucidate the entire system .

Therefore, the development and integration of XAI techniques have provided valuable insights into the decision-making processes of AI models. Methods such as saliency maps, attention mechanisms, rule-based explanations, and model-agnostic approaches offer a deeper understanding of how AI models arrive at their predictions or decisions. This interpretability not only builds trust in the technology but also enables stakeholders to identify and address potential biases and unfairness [21].

In conclusion, the adoption of Explainable AI in business environments presents a promising opportunity for enhancing decision-making processes, fostering trust, and ensuring adherence to regulatory standards. By addressing the challenges of interpretability and transparency in AI systems, businesses can leverage XAI to bolster the trustworthiness and accountability of their AI-driven decisions, ultimately driving strategic value and competitive advantage.

4.4 Benefits and Challenges of Integrating ML and Business Digitization

The integration of machine learning (ML) and business digitization offers a plethora of benefits, yet it also presents significant challenges. Various studies have explored these aspects across different sectors.

In the manufacturing sector, [22] propose a semantically interoperable

framework that combines historical data analysis with real-time data acquisition and analytics. This integration enhances production forecasting precision, illustrating the critical role of ML in optimizing manufacturing processes and decision-making. However, the challenge lies in ensuring seamless interoperability and real-time data processing.

[23] examine the new working conditions and digital identities of firms, emphasizing the need to adapt to digital landscapes. They provide recommendations for future research, underscoring the importance of understanding the evolving dynamics within organizations. The challenge here is managing the transition to new digital environments and maintaining workforce adaptability. [24] discusses the potential of AI and ML solutions in the energy sector, addressing current challenges, industry trends, and cybersecurity requirements. The benefits include enhanced operational efficiency and robust security measures, while the challenges involve addressing complex cybersecurity threats and integrating AI within existing infrastructures. [25] explore widely publicized ML algorithms, highlighting their advantages and benefits. These algorithms can significantly enhance decision-making processes and operational efficiencies. However, the challenge is in ensuring the proper application of these algorithms and managing the large volumes of data they require.

[26] emphasizes the significance of new skill sets that drive digitization within organizations, linking the correct skill sets to successful digital transformation. The benefit is a more skilled and adaptable workforce, while the challenge lies in effectively training and upskilling employees to meet the demands of a digitized business environment.

[27] evaluate the challenges in service design thinking for enabling stakeholder engagement during the B2B innovation process. They propose a research agenda to address these challenges, aiming to facilitate more effective stakeholder collaboration. The benefit is improved innovation and stakeholder engagement, whereas the challenge is in designing services that meet diverse stakeholder needs. [28]devise a pipeline consisting of static and dynamic modules, contributing to advanced ML frameworks. This can lead to more robust and adaptable ML systems, but the challenge lies in managing the complexity of integrating static and dynamic components.

Lastly, influential work by [29] adds valuable insights into the domain of ML research, further enriching the understanding of its application in business digitization.

In conclusion, while integrating ML and business digitization offers substantial benefits such as enhanced efficiency, improved decision-making, and better stakeholder engagement, it also poses challenges including data management, cybersecurity, workforce adaptation, and the complexity of integration. Ongoing research and innovation are crucial to addressing these challenges and maximizing the benefits.

5. Methodology

This review paper synthesizes existing literature on the integration of machine learning (ML), explainable AI (XAI), and business digitization. The methodology involved systematic searches in academic databases, including IEEE Xplore, Springer, ScienceDirect, PubMed, and other significant sources. The selection process included the following **Inclusion criteria**:

• Publication Date: Only studies published within the last five years were considered to ensure relevance and currency.

• Source Type: Focused on peer-reviewed journals, conference proceedings, books, and industry reports.

• DOI Inclusion: Only papers with a Digital Object Identifier (DOI) were included to ensure credibility and traceability.

• Relevance: Studies had to be directly related to the subtopics of ML, XAI, and business digitization.

Exclusion Criteria:

• Outdated Publications: Studies published more than five years ago were excluded to maintain up-to-date findings.

• Non-Peer-Reviewed Sources: Articles from non-peer-reviewed sources, such as opinion pieces or non-scientific magazines, were excluded.

• Irrelevance: Studies not directly related to the main subtopics of ML, XAI, and business digitization were excluded after initial screening.

• Non-English Publications: To maintain consistency and comprehensibility, studies not published in English were excluded.

The selection process involved an initial screening of titles and abstracts to identify potentially relevant studies. This was followed by a full-text review of studies that met the inclusion criteria. The review is structured around four key subtopics: Introduction to Machine Learning, Integration of Machine Learning and Business Digitization, Possibilities of Applying Explainable AI in Business Context, and Benefits and Challenges of Integrating ML and Business Digitization.

Data was extracted and synthesized from the selected studies to highlight current trends, applications, benefits, challenges, and future research directions. This comprehensive approach ensures a thorough overview of the state of knowledge in this field.

6. Findings and Themes

According the literature review, integration of Machine Learning (ML) and Explainable AI (XAI) in business digitization has been the focal point of numerous studies, emphasizing its transformative potential in various sectors. The findings can be categorized into several key areas:

- **Enhanced Predictive Capabilities**: ML algorithms have demonstrated significant improvements in handling large and complex datasets, leading to more accurate predictions and enhanced decision-making processes. This is particularly evident in the manufacturing sector, where ML has been used to optimize production forecasting by combining historical data analysis with real-time data acquisition.

- **Operational Efficiency**: The adoption of ML in business processes has led to substantial gains in operational efficiency. Studies highlight that integrating ML with Internet of Things (IoT) technologies creates intelligent, data-driven solutions that streamline operations and improve productivity.

- **Decision-Making Transparency with XAI**: The incorporation of XAI into business processes enhances the transparency and interpretability of AI models. This is crucial for building trust and ensuring that AI-driven decisions are understandable and justifiable.

- **Innovation and Adaptability**: The synergy between ML and business digitization fosters innovation by enabling businesses to adapt swiftly to

market changes and technological advancements. This is particularly evident in the context of digital transformation, where businesses can leverage ML to develop new business models and processes that exploit digital opportunities effectively.

- **Interoperability and Real-Time Processing**: Ensuring seamless interoperability between different systems and the capability for real-time data processing is critical in dynamic and fast-paced environments such as manufacturing and logistics.

7. Future Directions and Implications

The integration of machine learning and business digitization has significant implications for future research and practice. Developing more advanced AutoML techniques can further automate the process of building and fine-tuning machine learning models, enabling even greater accessibility for non-experts. Exploring the synergies between machine learning, IoT, and edge computing can create highly intelligent and data-driven solutions across various industries. Investigating how virtualization can provide solutions for the complexities arising from edge computing and related technologies is another area worth exploring. Examining the long-term implications of integrating AI into business intelligence and its transformative potential for enterprises is crucial for understanding the future of this partnership. Expanding the application of explainable AI (XAI) across diverse sectors can enhance transparency, trustworthiness, and accountability in high-stakes AI-driven decisions. Addressing the challenges of data management, cybersecurity, workforce adaptation, and integration complexity is essential to fully harness the benefits of machine learning and business digitization.

8. Conclusion

The integration of machine learning and business digitization has emerged as a transformative force, enabling organizations to unlock the power of data and drive innovation in the digital age. By harnessing the potential of ML, businesses can uncover valuable insights, optimize operations, and personalize their offerings to gain a competitive edge. The convergence of ML and business digitization presents an unprecedented opportunity to leverage data as a strategic asset, propelling organizations towards greater efficiency, productivity, and profitability.

Moreover, the adoption of explainable AI (XAI) in business contexts is crucial for building trust, ensuring transparency, and facilitating decision-making processes. By providing interpretable explanations for AI decisions, XAI can foster user acceptance, facilitate regulatory compliance, and improve overall decision-making.

However, the integration of ML and business digitization also presents significant challenges, including data management, cybersecurity, workforce adaptation, and the complexity of integration. Ongoing research and innovation are essential to addressing these challenges and maximizing the benefits of this transformative partnership.

As the digital landscape continues to evolve, the integration of ML and business digitization will become increasingly vital for organizations seeking to thrive in the competitive global market. By embracing these technologies and addressing the associated challenges, businesses can unlock new avenues for growth, innovation, and success in the digital era.

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Social Engineering Attacks: How to Prevent

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Abstract. We present the pervasive threat of social engineering attacks in cyber security. The article explores interdisciplinary perspectives, such as psychology and information technology discipline, the social engineering attack types, sequence and traits. Through an in-depth analysis of social engineering attacks, this paper aims to raise awareness about the evolving threat landscape and provides actionable strategies for effective prevention. Nowadays social engineering attacks are incredibly important for all mobile and computer users. Beyond spotting an attack, one can also be proactive about privacy and security. Keeping your devices themselves is just as important as all your other digital behaviors. 90 % of cyber attacks involve social engineering. "Human hacking" scams tend to lure unsuspecting users into exposing data, spreading malware infections, or giving access to restricted systems. In this article we have been presenting pervasive and growing threat-social engineering, interdisciplinary perspectives, such as psychology and information technology discipline, the social engineering attack types, sequence and traits. Therefore, in the article we have been studying social engineering attacks and ways of preventing them.

Keywords: Social Engineering, Social Engineering Attacks, Interdisciplinary view of social engineering, Psychology of information security, Human Error, Cyber Security.

1. Introduction

As technology advances, so do the strategies employed by cyber attacks. Social engineering has emerged as a leading threat vector, exploiting the weakest link in the security chain; human psychology. We explore the various types of social engineering attacks, their impact on psychology and information technology, and robust prevention strategies.

Social engineering is a manipulation technique that exploits human error to gain private information, access, or valuables. Attacks can happen in a variety of ways: online, in-person, and via other interactions.

Scams based on social engineering are built around how people think and act. Social engineering attacks are especially useful for manipulating a user's behavior. Once an attacker understands what motivates a user's actions, they can deceive and manipulate the user effectively [1].

Users also may not realize the full value of personal data, like their phone number. As a result, many users are unsure how to best protect themselves and their information.

It's important to beware of social engineering as a means of confusion. Many employees and consumers don't realize that just a few pieces of information can give hackers access to multiple networks and accounts [2].

By masquerading as legitimate users to IT support personnel, they grab your private details - like name, date of birth or address. From there, it's a simple matter to reset passwords and gain almost unlimited access. By understanding the tactics used by social engineers and implementing effective countermeasures, organizations can enhance their security posture and protect themselves against these deceptive attacks.

In this section we provide an overview of social engineering attacks and their increasing prevalence in the digital age. We highlight the significance of understanding and addressing social engineering as a critical component of cyber security. We also outline the research objectives and the structure of the paper approach.

Let's Discuss: How Does Social Engineering Work? Most social engineering attacks rely on actual communication between attackers and victims. The attacker tends to motivate the user into compromising themselves, rather than using brute force methods to breach your data [3-5].

The attack cycle gives a reliable process for deceiving. Steps for the social engineering attack cycle are usually as follows:

● Prepare by gathering background information on you or a larger group you are a part of.

● Infiltrate by establishing a relationship or initiating an interaction, started by building trust.

● Exploit the victim once trust and a weakness are established to advance the attack.

● Disengage once the user has taken the desired action.

This process can take place in a single email or over months in a series of social media chats. It could even be a face-to-face interaction. But it ultimately concludes with an action you take, like sharing your information or exposing yourself to malware.

Pervasive and growing threat-social engineering: Cyber-attacks have been increasing at an alarming rate with one occurring about every 39 seconds. Different industries are hit by social engineering. The COVID-19 pandemic has caused an increase in social engineering attacks [6].

Social engineering is more effective than other hacking methods because it relies on human error rather than finding and exploiting vulnerabilities in computer systems. It typically happens through email, text messages, online chat and phone calls. Human error can be attributed to about 95% of data breach cyber-attacks, meaning that social engineering, which is predicated on the human element of actions and behaviors, is likely involved in most cyber-attacks. With advancements in technology and modern security systems in place, hackers can't break into systems easily.

That is why it's a very contemporary subject and they target the weakest link in the security chain - the user. In the article we have been showing that it's much easier to trick someone into providing confidential information.

The article includes introduction, 3 paragraphs, conclusion and references.

2. Interdisciplinary perspectives, psychology and information technology discipline

Heavy reliance on the internet and technology are catalysts for social engineering occurrences. System protections are certainly helpful to mitigate some social engineering attacks, but it is not enough, it is necessary to use an interdisciplinary approach to understand this phenomenon and all its complexities.

Cyber attackers today prefer attacking humans rather than technology, because it is simpler. While the security technology keeps advancing and security systems

become stronger and more complicated to compromise, human psychology has remained the same over centuries and is easier to predict and to exploit. It is easier to approach cyber threat actors.

Psychological approach to understanding the concept of deception in social engineering is of the utmost importance to grasp the underlying thoughts and behaviors of both the attacker and victim. Psychological methods are used to bypass the protections.

Persuasion is one of the key elements used in social engineering, which is important to an attack; it is an inherent quality of social engineering and focuses on the connection between the attacker and the victim. The various influences are based on qualities found in the victim but are used on behalf of the attacker to exploit a psychological trait leading to the desired access [7].

Normative social influence, or the desire to be liked and recognized by others, has been identified as a factor in social engineering attacks [8].

If an attacker can identify a person with a penchant for gaining approval from others, perhaps relaying the message that the employee, by providing that information, would be helping the requestor immensely, that employee may be more likely to share data. By complying with the request for information, the employee's desire to be liked by someone outweighs adhering to the protocols that one knows should be followed.

Information technology discipline: One of the most common approaches of social engineering from an information security perspective is phishing scams in which seemingly legitimate emails are sent to individuals with the hope that the recipients click on a link or provide information to the sender of the email [9].

The phishing attempt had a sense of urgency, hoping the user would react quickly and provide the requested information. Some Information security professionals lean on psychological and demographic aspects to identify susceptibility to phishing attacks.

Capitalizing on some psychological factor, such as fear of losing or the hope of gaining something, helps attackers successfully use a mode of communication, such as email, to get access to a system or data. The researchers found that when people received an email offering them the possibility of free items such as an iPad or a gift card, they were more susceptible to the social engineering attack. This supports the connection between information technology and the psychology discipline [9].

Even though the focus of computer and information technology research is usually on the systems and processes, a study featured in a computer science publication relied on psychological theories as the foundation for the research [10].

Planned behavior is important to study information security awareness and determine that those individuals who exhibit non-risky behavior tend to have high information security awareness.

3. Methodology. The social engineering attack types, sequence, traits

The methods are developed by planning, conducting, and reporting. The planning phase determines the research question and makes it clear and answerable.

Social engineering can impact you digitally through <u>mobile attacks</u> in addition to desktop devices. However, some can just as easily be faced with a threat in-person. Here are some common methods used by social engineering attackers [4]:

Phishing Attacks pretend to be a trusted institution or individual in an attempt to persuade you to expose personal data and other valuables.

Attacks using phishing are targeted in one of two ways:

●Spam phishing, or mass phishing, is a widespread attack aimed at many users. These attacks are non-personalized and try to catch any unsuspecting person.

●Spear phishing and by extension, whaling, use personalized info to target particular users. Whaling attacks specifically aim at high-value targets like celebrities, upper management, and high government officials.

Whether it's direct communication or via a fake website form, anything you share goes directly into a scammer's pocket.

Voice phishing (vishing) phone calls may be automated message systems recording all your inputs. Sometimes, a live person might speak with you to increase trust and urgency.

SMS phishing (smishing) texts or mobile app messages might include a web link or a prompt to follow-up via a fraudulent email or phone number.

Email phishing is the most traditional means of phishing, using an email urging you to reply or follow-up by other means. Web links, phone numbers, or malware attachments can be used.

URL phishing links tempt you to travel to phishing websites. These links are commonly delivered in emails, texts, social media messages, and online ads. Attacks hide links in hyperlinked text or buttons, using link-shortening tools, or deceptively spelled URLs.

Physical breaches involve attackers appearing in-person, posing as someone legitimate to gain access to otherwise unauthorized areas or information.

Attacks of this nature are most common in enterprise environments, such as governments, businesses, or other organizations. Attackers may pretend to be a representative of a known, trusted vendor for the company. So, if someone is attempting this method, they've identified clear potential for a highly valuable reward if successful [11, 12].

Unusual Social Engineering Methods

In some cases, cybercriminals have used complex methods to complete their cyber attacks, including:

Fax-based phishing: When one bank's customers received a fake email that claimed to be from the bank - asking the customer to confirm their access codes – the method of confirmation was not via the usual email / Internet routes.

Traditional mail malware distribution: The disks were delivered to the clients of a Japanese bank. The clients' addresses had previously been stolen from the bank's database.

A four-step sequence is used for social engineering attack [4, 12]:

1. Information gathering: A huge amount of time is invested in this phase. Verbal communication methods such as phone calls or written communication can be used to gather information about a targeted organization. In more extreme examples, physical methods such as shoulder surfing, intrusion/role-play, tailgating, and dumpster diving can also be used. Technical methods such as online searches and utilizing Open-Source Intelligence (OSINT) tools are used to gather information. These methods, known as pretexting, can yield valuable information.

2. Establish a relationship and rapport: Maintaining a deceptively harmonious, positive approach with the target by using a couple of factors such as sympathy, validation, quid pro quo, asking questions, and ego suspension are used to establish trust. Sharing personal stories, and providing a sympathetic ear to the target, or using impersonation and authority to get the target to provide information are also common, yet different techniques.

3. Exploitation: The social engineer uses both the information and the relationships to infiltrate the target without raising suspicion while maintaining the gained trust. Examples of successful exploitation include the threat actor being

allowed in the facilities, exposure of trade secrets, disclosure of passwords and usernames over the phone, or opening an infected mail attachment.

4. Execution: This is the final stage of the social engineering scam. If successfully carried out, the attack ends before the target even notices. The target might even assume that they did a positive thing, and further future interactions might continue. Two goals are accomplished at this stage, first, the target does not know an attack took place, and second, the attacker keeps his true identity hidden.

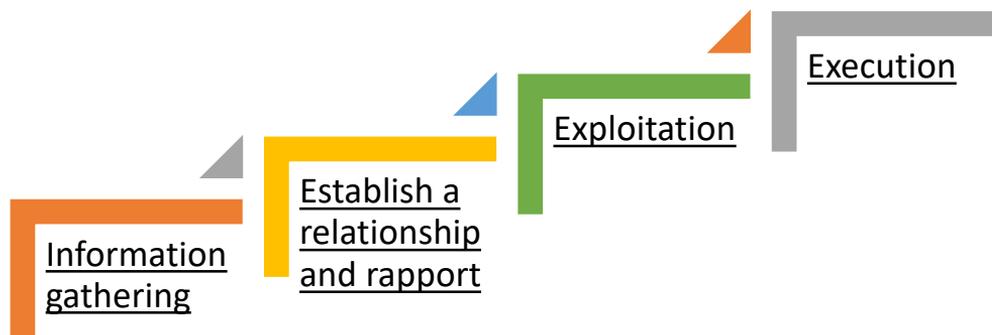The visual representation of the above four-step sequence is shown in Fig. 1.

Execution

Exploitation

Establish a
relationship
and rapport

Information
gathering

Fig. 1. Four-step sequence of social engineering attack.

Traits of Social Engineering Attacks

Social engineering attacks center around the attacker's use of persuasion and confidence. When exposed to these tactics, you are more likely to take actions you otherwise wouldn't [4].

Heightened emotions: Emotional manipulation gives attackers the upper hand in any interaction. You are far more likely to take irrational or risky actions when in an enhanced emotional state. The following emotions are all used in equal measure to convince you.

- Fear
- Excitement
- Curiosity
- Anger
- Guilt
- Sadness

Urgency: Time-sensitive opportunities or requests are another reliable tool in an attacker's arsenal. You may be motivated to compromise yourself under the guise of a serious problem that needs immediate attention.

Trust: Believability is invaluable and essential to a social engineering attack. Since the attacker is ultimately lying to you, confidence plays an important role here. They've done enough research on you to craft a narrative that's easy to believe and unlikely to rouse suspicion.

4. Results. How to Prevent Social Engineering Attacks

Here are some important ways to protect against all types of cyber attacks [11-12]:

Safe Communication and Account Management Habits

Online communication is where you're especially vulnerable. Social media email, text messages are common targets, but you'll also want to account for in-person interactions as well.

Never click on links in any emails or messages: You'll want to always manually type a URL into your address bar, regardless of the sender. Never engage with any URL you have not verified as official or legitimate.

Use multi-factor authentication: Online accounts are much safer when using more than just a password to protect them. Multi-factor authentication adds extra layers to verify your identity upon account login.

Use strong passwords (and a password manager): Each of your passwords should be unique and complex. Aim to use diverse character types, including uppercase, numbers, and symbols.

Avoid sharing names of your schools, pets, place of birth, or other personal details: You could be unknowingly exposing answers to your security questions or parts of your password.

Be very cautious of building online-only friendships: While the internet can be a great way to connect with people worldwide, this is a common method for social engineering attacks.

Safe Network Use Habits: Compromised online networks can be another point of vulnerability exploited for background research. To avoid having your data used against you, take protective measures for any network you're connected to.

Never let strangers connect to your primary Wi-Fi network: At home or in the workplace, access to a guest Wi-Fi connection should be made available. This allows your main encrypted, password-secured connection to remain secure and interception-free.

Use a VPN: In case someone on your main network — wired, wireless, or even cellular — finds a way to intercept traffic, a virtual private network (VPN) can keep them out. VPNs are services that give you a private, encrypted "tunnel" on any internet connection you use.

Keep all network-connected devices and services secure: Securing your network itself, in addition to all your smart devices and cloud services is just as important. Be sure to protect commonly overlooked devices like car infotainment systems and home network routers.

5. Conclusion

The aim of the paper is about protection against social engineering, which starts with education. Thus, if all users are aware of the threats, our safety as a collective society will be improved. Be sure to increase awareness of these risks by sharing what you've learned with your coworkers, family, and friends. Thus, in the article one can find the corresponding guideline.

A huge challenge in today's cyber security efforts is the lack of effective information security awareness and training. Many organizations and companies of the public and the private sector continue to believe that cyber security is only a technical, not a strategic and behavioral discipline. In the paper it is shown that multifactor authentication is a common and often effective way for organizations to confirm that the person accessing the systems should actually have that access.

In the article it is shown that with the increasing sophistication and abundance of social engineering attacks, it is imperative to recognize the dangers they pose and take proactive steps to protect against them. Thus, in the article it is claimed: by combining education, robust technical controls, and stringent policies, individuals, as

well as organizations can fortify their defenses and minimize the potential impact of social engineering attacks.

Many researchers have established methods and frameworks for social engineering attacks prevention, but still social engineering attacks are unpredictable for victims. Different cases and actors, especially for social media or social network cases, can modify social engineering attack techniques.

Summarizing we emphasize the proactive role individuals and organizations must play in mitigating social engineering threats. Heightened awareness, continuous education, and the implementation of robust cyber security measures are in paramount importance.

The reviews we found can be used by practitioners in overcoming social engineering attacks. They can carry out development based on a collaboration of several approaches to prevent social engineering attacks.

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Comparative Analysis of Television and Email as Digital Marketing Channels Through a Case Study

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Abstract. This paper presents the research of findings regarding the traditional and digital forms of marketing today. The principal goal of the research is to demonstrate the advantages of digital marketing through a case study related to a dominant player in the field of email marketing as a digital marketing channel. In this paper are analyzed various parameters for the success of a marketing campaign such as: percentage of opened emails, percentage of responded emails and percentage of interested potential customers. Although it is difficult to draw a conclusion through generalization for an entire segment of marketing analyzed through one subtype of marketing promotion, however, the study provides conclusions about the effectiveness of digital marketing. Additionally, the paper presents the declining influence of the traditional forms of marketing which, although still relevant, are increasingly not the first choice of marketers. The motivation for making this analysis comes from fast-growing technologies that can be very easily used in any company to reach consumers more easily. This research aims to provide basic information about the use of email marketing as a digital tool for promoting businesses and maintaining contact with consumers.
Keywords: percentage of opened emails, percentage of responded emails and percentage of interested potential customers.

1. Introduction

Digital marketing is the marketing of the new age. It includes online advertising, search engine optimization, social media advertising, content marketing, email advertising, video advertising, etc [1], [2]. Digital marketing enables full audience targeting that shows interest towards a particular product or service. Through digital marketing, the results can be monitored in real time and it is known which segments of the brand's target audience buy products or services. At the same time, it is monitored which segments of the target group are interested, but not ready to buy the service. This provides an opportunity for proper structuring of marketing campaigns [3], [4].

The paper provides an overview of the main advantages and disadvantages of both types of marketing – the traditional and the digital. In this paper is analyzed the email marketing as a representative of the digital marketing and through these two media, the position of the traditional and the digital marketing has been compared [5], [6].

2. Literature Review

The television as a representative of the traditional marketing is a declining medium in the world that is forced to adapt towards the nowadays changes. The huge trend of streaming platforms like Netflix is reducing the number of viewers to the traditional forms of television. However, in R. N. Macedonia, the media is a sufficiently

relevant marketing tool that still has access to large capital, both from advertisers and from political parties [1], [7].

The differences between the traditional and digital marketing are segmented in their ability to target audience, monitor the results in real time, and understand the interests and buying habits of the target group. Digital marketing enables a different approach to the customers and better management of the marketing campaigns which makes it more effective and professional in today's digital age [8], [9]. On the other hand, the traditional forms of marketing focus predominantly on mass audience tactics. They are less productive and more expensive methods of geographically restricted advertising. Campaigns based on traditional marketing are one-way and enable communication with an audience that is delayed. Such campaigns do not adjust in real time, because any change in traditional marketing is extremely expensive. It is certain that the traditional marketing is less flexible than the digital one [4], [10].

On the other hand, the email marketing is representative of the digital marketing and it is an extremely cost-effective form of marketing with a high return on investment. As a tool, the email marketing is an extremely focused means of use that puts the business in contact with a highly defined audience and enables potential sales [3], [8].

The main purpose of the research in this paper is to demonstrate the advantages of digital marketing through a case study related to a dominant player in the field of email marketing as a digital marketing channel [11], [12].

3. Data and Methodology

In this paper are analyzed various parameters for the success of a marketing campaign, including the percentage of opened emails, the percentage of responded emails and the percentage of interested potential customers. Through the research, it was concluded that the campaigns are successful in certain industries and that these services are highly demanded by the global customers, which indicates on a great confidence in this type of services. These metrics reflect the success of a campaign at an internal, company level. But for each customer, the most important metric is the return on the invested capital, i.e., how many of these generated emails that indicate interest will turn into meetings with their sales team and then into paying customers.

It is important to indicate that in the paper is analyzed the success metrics provided by the companies themselves such as Sopro and their competitor Flowd [11], [12]. The return on capital from the customers themselves is not offered in these documented case studies. But the shown case studies contain a number of sent emails, which if it is high, it indicates mutual trust between the two companies.

4. Analysis of the results

Sopro is a company headquartered in Brighton, United Kingdom [11]. The company has an operational headquarters in Skopje, R.N. Macedonia as well as an office in Miami, USA. The company also has representatives in London, Dubai and Belgrade. The company has 300 employees in all these locations, but most of them are deployed in the office in Skopje. The company was founded in 2015 with the idea

of two co-founders from Brighton. In 2016, the co-founders employ the first employee in Macedonia, thus, the company begins its rise.

Sopro started as a company for sending emails from one business to another. Sopro implements an email marketing campaign, i.e., a social selling service to a defined target group. At its core, this is still the central service that the customer receives. The basic package that customers can pay amounts to 3,000 GBP per month ш [11]. In return, the customer receives 1000 sent emails per month.

The service offered by the company to the customer is structured as follows. The customer receives two managers on his/her account, one representative from the **Operations** Department and another representative from the **Customer Success** Department.

The company offers several types of social selling campaigns:
➢ Selling the company's product;
➢ Selling the company's service;
➢ Saling the tickets for an event organized by the company;
➢ Directing the target audience towards registration for some type of company's paid service, product or event.

From the aspect of success of an email marketing campaign, different metrics are measured:
➢ Percentage of opened emails;
➢ Percentage of responded emails;
➢ Percentage of interested parties;
➢ Emails;
➢ Percentage of clicks on a link in an email;
➢ Cost per interested potential customer.

These metrics reflect the success of a campaign at an internal, company level. However, for each customer, the most important metric is the **return on invested capital**, i.e., how many of these generated emails that show interest will turn into meetings with their sales team and then into paying customers.

Below are presented the analyzes of the success metrics provided by Sopro itself. In these documented case studies is not offered the return on capital from the customers themselves. But the shown case studies contain a number of sent emails, which if it is high, indicates mutual trust between two companies. Furthermore, considering that an email sent through these companies amounts to 3,00 GBP, the volume itself further indicates the weight of the amount in cooperation with those companies [11].

In addition, the company CoFace, which uses the services of Sopro, will be analyzed.

The company CoFace offers credit insurance to the businesses to protect them against trade risks. It supports companies globally to make credit decisions that will improve their ability for sale on the domestic and global market. The company CoFace aims to become the most agile, global trading partner for credit insurance in the industry overall and to achieve this goal, it has requested Sopro's help in order to develop its own business. Some basic data about the company CoFace are shown in Table 1.

Table 1. Basic data and customer target group for the company CoFace, Sopro's customer

	Company	Coface
Basic data about the company	Customer location	United Kingdom, Ireland
	Product/Service offered	Credit insurance
	Sales cycle time*	1 - 2 years
Customer target group data	Target locations	Globally (focus on England and Ireland where the customer has a presence)
	Number of employees in the companies targeted by the customer	4000+
	Work roles of the persons who are the target group of the customer	Finance Director, Finance Manager, Credit Control Manager, etc.
	Industries that the customer is targeting	Information Technology, Software, Finance, Food and Beverage etc.**

* How long does the process take from the generation of an interested contact to the moment when it becomes a customer of the company
**The industries are not indicated, but they are estimated to be the most popular for such offers, thus their inclusion and participation in the success of the campaign is logical.

Source: [11]

The company CoFace wanted to increase the activities around the generation of interested potential customers, as well as to increase the return on invested capital in digital marketing channels. The company wanted to perform all this without exhausting its limited financial resources, thus, the desire to cooperate with Sopro was born. The company Sopro responded to this challenge with providing quality data for their potential market. Specifically, what CoFace needed was expertise in generating interest through this type of marketing. The Table 1 provides an overview of the data about the target group that the customer has chosen for advertising its services.

The Sopro company delivered exactly what the customer was looking for: data of high quality exactly from the industries with which the customer cooperates, targeting exactly towards that market. In addition, the Sopro team implemented a high level of personalization in the emails that were sent on behalf of the customer CoFace. When CoFace's commercial director was asked about the results of the campaign, he stated that Sopro allowed the sales teams to focus only on selling, which positively affected the growth of the business. Furthermore, their statements are that the return on invested capital from the campaign was very positive. Table 2 shows the results of the email campaign implemented by the company Sopro for the customer CoFace.

Table 2. Results of the email campaign implemented by the company Sopro for the customer CoFace

Email campaign results	
Sent emails	40,000
Percentage of opened emails	37%
Percentage of responded emails	13%
Cost per interested potential customer	92,00 GBP
Percentage of interested potential customers	3%

Source: [11].

If the average email marketing campaign that takes place in such a digital channel counts 1000 emails per month, thus, it is perceived that the results indicate more than three years of cooperation between these two companies. At the same time, it can be indicated that the percentage of opened emails is above the average that you would expect for such channels, which is at least 30%. Furthermore, it can be concluded that the percentage of responded emails is in line with the average in such campaigns, which ranges from 10% to 1%. Finally, this campaign can be concluded to be successful due to the high percentage of generated interest and the average cost per interested potential customer which is generated. For an average, 3% can be taken as an indicator of the success of such an email marketing campaign.

Furthermore, a comparison will be made of a campaign implemented by the company Sopro in the Human Resources Sector, more specifically, a campaign for the customer Green Cross Training which offers a corporate training. A similar campaign of a close competitor of Sopro, the company Flowd, which also advertises services to a corporate training customer, will also be analyzed.

Green Cross Training is the largest independent provider of health and safety, first aid and e-learning training. The company has 50 locations across the UK, which means that it can offer training with a physical presence in the company or training that would be carried out at the customer's place of work on a national level.

Only Red Cross and the hospital "Sveti Jovan" could offer the same training coverage, but Green Cross Training is 40% cheaper than them in terms of these services and their flexible approach and wide range of services make them the only choice for many customers. The company cooperates with several extremely well-known brands. Customers that count in their portfolio are Tesco, BT, Asda, Sainsbury's and Debenhams.

When the company approached Sopro, it was needed to get in touch with the employees in the Human Resources and Health and Safety Departments, in order to offer training courses in Mental Health and Pediatrics. The following Table 3 provides an overview of the basic data for the company Green Cross Training.

Table 3: Basic data and customer target group for the company Green Cross Training, Sopro's customer

	Company	Green Cross Training
Basic data about the company	Customer location	United Kingdom
	Product/Service offered	First aid courses and pediatrics courses
	Sales cycle time*	3 Months
Customer target group data	Target locations	United Kingdom
	Number of employees in the companies targeted by the customer	All (1-10,000+)
	Work roles of the persons who are the target group of the customer	Human Resources roles and Health and Safety roles
	Industries that the customer is targeting	Health Industries, State Administration, Financial Services, Construction, NGOs, Information Industries, etc.

Source: [11].

The company had set ambitious growth targets over the next few quarters which would be difficult to achieve by the current sales team. Therefore, instead of adding human resources, the company entered into a working relationship with the company Sopro in order to transfer all sales activity through an email. Thus, the sales team of Green Cross Training has significantly increased their efficiency by using this digital channel. The Table 3 provides an overview of the target group to which the company Green Cross Training was aiming.

The Director of Business Development of the company Green Cross Training declare that Sopro actively monitor and suggest improvements in the campaigns in order to target the right audience through the digital channel. The company has used Sopro's services for many years and through this cooperation it has concluded many national key contracts. The return on invested capital in this digital channel has been outstanding. The following Table 4 shows key details of the results produced by this campaign.

Table 4: Results of the email campaign implemented by the company Sopro for the customer Green Cross Training

Email campaign results	
Sent emails	21,000
Percentage of opened emails	23%
Percentage of responded emails	22%
Cost per interested potential customer	29,00 GBP
Percentage of interested potential customers	7%

Source: [11].

If the average email marketing campaign that takes place in such a digital channel counts 1000 emails per month, then it can be concluded that the results indicate almost two years of cooperation between these two companies. At the same time, it can be indicated that the percentage of opened emails is below the average that you would expect for such channels, which is at least 30%. This percentage has increased significantly in recent years due to the fake opening of emails by Apple that automatically open emails that have a pixel to measure the rate of opened emails. Furthermore, it can be concluded that in such campaigns the percentage of responded emails is significantly above the average, which ranges from 10% to 14%. Finally, this campaign can be concluded to be successful due to the high percentage of generated interest and the average cost per interested potential customer which is generated. For an average, 3% can be taken as an indicator of the success of such an email marketing campaign.

Analysis of success metrics provided by Flowd itself are presented below.

Flowd is a marketing agency that was founded in Manchester in 2019 [12]. The company is also known in the market under the name "A&M Media" (Crunchbase, 2024). This second name derives from the first letters of the names of the two founders of this agency - Mitch and Ashley, a young couple of entrepreneurs who founded the agency.

The company offers two types of services:

- Email marketing (selling products/services via email);
- Consulting for the growth of companies.

The second type of service is a type of marketing through content marketing. Namely, a team of marketers develops a strategy for publishing content on the social network LinkedIn, where they develop the personal brand of a specific customer and through this publicity, they help the customer to sell more products/services. Thus, we can qualify the growth consulting service as a kind of branding [12].

If a little comparative analysis is performed between Sopro and Flowd, it will be noticed that Sopro has been on the market much longer than Flowd. However, Flowd achieves greater success much faster. If it took six years for Sopro to expand in the US, Flowd achieved it for a year less [12]. It can be also indicated that the company Sopro invested significantly in developing local talent in the Macedonian labor market, while Flowd expanded in Macedonia when the labor market was already trained to perform this type of marketing. Flowd directly benefited from Sopro's investment in talent which is evidenced by the fact that a certain percentage of Flowd's workforce derives from Sopro, including the current manager of the company's Macedonian branch. In addition, the company Mavericks, which uses the services of Flowd, will be analyzed.

Mavericks offers leadership development services and corporate training to executive teams in emerging, high-growth and creative companies. Among the company's customers portfolio are impressive, growing brands such as Depop and Publicis. The following Table 5 shows the basic data for the company Mavericks.

Table 5. Basic data and target group data for the company Mavericks

	Company	Mavericks
Basic data about the company	Customer location	United Kingdom
	Product/Service offered	Corporate and leadership trainings
	Sales cycle time*	3-12 Months
Customer target group data	Target locations	England and Ireland where the customer has a presence
	Number of employees in the companies targeted by the customer	100-500
	Work roles of the persons who are the target group of the customer	HR Director, HR Manager, Learning and Development Manager/Director etc.
	Industries that the customer is targeting	Retail, Marketing and Advertising, Healthcare, Pharmaceuticals, etc.

* How long does the process take from the generation of an interested contact to the moment when it becomes a customer of the company

Source: [12]

The challenge for the company Mavericks is in finding opportunities for cooperation with Human Resources Departments in companies that have between 100 and 500 employees. Thus, the company aimed to secure a partner that would be able to support their growth plans. As a solution to the problem of Mavericks, the Flowd directed its activities precisely to the upper echelons of the companies and also to the main managers in the Human Resources Departments. Flowd has focused on companies which have firstly received finances from investors. In the following (Table 6) follows data on the target group of the company Mavericks, Flowd's customer.

The collaboration between these two companies has lasted 11 months and the results generated by the Flowd team have been impressive as Mavericks has converted many interested people from the campaign into paying customers for their services. Table 6 provides data on the results that were generated through the campaign of the company Flowd [12].

Table 6. Results of an email campaign conducted by Flowd for the customer Mavericks

Results of an email campaign	
Sent emails	15,000
Percentage of opened emails	58%
Percentage of responded emails	12%
Interested potential customers	289
Interest rate	1.93%
Cost per interested potential customer	104,00 GBP*

Source: [12].

Flowd has been successful in generating interest from companies that have themselves generated an average of 20 milions GBP in revenue and have over 100 employees mainly based in the UK. If we analyze the campaign, it will be concluded that the number of sent emails indicates at least 15 months of cooperation between these two companies based on an estimate that about 1000 emails were sent per month for the company Mavericks. Thus, moving on to the percentage of opened emails, it can be concluded that it is significantly above the average of such campaigns, which is 30%. The high percentage of open emails indicates a well-defined target group in the campaign, with more than one in two have opened the email which was sent. When analyzing the percentage of opened emails, it can be indicated that it falls within the limits of a normal which is expected in such campaigns. Taking into consideration the location of the campaign (to where the emails are sent), the same percentage can vary from 10% to 14% and it can be considered as average, i.e. expected. When analyzing the number of interested employees and the percentage of interest of the campaign, it can be indicated that it is slightly below the average for an email marketing campaign. Although this percentage varies significantly and depends on the target group, in general, it is considered a success factor if this percentage is above 3%.

However, it must be indicated that the email marketing market itself has become significantly saturated in the past decade, and thus, this has affected the percentage of interested employees generated in an email marketing campaign. It has been in continuous decline for the past 3 years.

5. Discussion of the results

If the percentages of opened emails are compared as separate metrics, it can be determined that Flowd generated a higher percentage of opened emails for its customer Mavericks. However, such a parameter has no importance if we look at it on a separate level. If we move on to the percentage of responded emails, we can conclude that the company Sopro has generated 22% for its customer, compared to 12% by Flowd. Again, these statistics will not be analyzed separately and the conclusion will not be made that Sopro is the absolute winner in this field. If Flowd achieved a significantly higher open rate than Sopro (58% vs. 23%) and received 12% of responded from opened emails, this is much better than the rate of 22% of responded emails from the rate of 23% of opened emails.

Here arises the question of how the formula for the percentage of responded emails was calculated, whether on the basis of the opened emails or on the basis of all sent emails. Although these two companies' business models are close, it can be concluded that the percentages of opened emails are based on the same methodology. Since there is no insight into the background operations of the two companies, we put the emphasis on the last and most important factor for a campaign, which is the lead rate of interest that is generated. We concluded that Sopro has generated interest of 7% versus the less than 2% generated by Flowd for its customer. Objectively, the two companies are very close in terms of business models, so we will combine this parameter with the parameter cost per interested potential customer and we will notice that the company Sopro had more success for its customer than Flowd. It is important to note that both companies did not detail in

their case studies exactly how much new business was generated from the interested potential customers found through their digital marketing style. Therefore, we cannot compare them completely.

It is difficult to make direct and specific comparisons between the television and the email marketing as representatives of the traditional and digital marketing, respectively. However, the examples are adequate to capture some general trends in both types of marketing separately.

In the email marketing segment, although companies from the same industry have been compared, it cannot be claimed that the results are directly comparable. The email marketing market is dependent on many factors, such as the reputation of the advertising company, the season in which a certain product/service is advertised, the time in which the emails were sent, etc. Table 7 shows the analysis of campaigns from the corporate training sector.

Table 7. Analysis of campaigns from the corporate training sector

Mavericks - Flowd	Green Cross Training - Sopro
Sent emails – 15,000	Sent emails – 21,000
Percentage of opened emails – 58%	Percentage of opened emails – 23%
Percentage of responded emails - 12%	Percentage of aresponded emails – 22%
Percentage of interest – 1.93%	Percentage of interest – 8%
Cost per interested potential customer – 104,00 GBP	Cost per interested potential customer– 29,00 GBP

6. Conclusion

The paper analyzed various parameters for the success of a campaign, including the percentage of opened emails, the percentage of responded emails and the percentage of interested potential customers. In this paper was concluded that the companies are successful in certain industries and that these services are in high demand by the global customers, indicating a high level of confidence in this type of service.

The paper provides a comparison of the percentage of opened emails as separate metrics, whereby we determined that Flowd generated 58% for its customer Mavericks versus Sopro's generated 23% for its customer Green Cross Training. Sopro's email response rate is 22% compared to Flowd's rate of 12%. However, if we did not analyze them separately, we can not make a conclusion that Sopro is better than Flowd because of Flowd's higher percentage of opened emails (58% vs. 23% of opened emails) and received 12% of responded emails, which we come to the conclusion that it is better than Sopro's 23% opened and 22% responded emails.

According to the analysis conducted in the email marketing segment for the companies Sopro and Flowd, i.e. their customers Green Cross Training and Mavericks Unlimited, it can be concluded that the email marketing market is dependent on many factors such as the geographical position, i.e., in which country or continent a specific product/service is advertised, the size or reputation of the company being advertised, the period/season in which certain products/services are advertised, the specific time of sending emails, etc. are just a few of the many factors that play a big role in the whole process. In order to get a clear picture and a complete analysis of which company is more successful, internal data from the customer is needed about how

much money the customer invested and returned, i.e. how many potential customers are acquired from that campaign.

In general, although no direct conclusion can be drawn for a comparison between television and email marketing, it can be determined that email marketing is a highly popular form of advertising. In this industry, we do not have a downward trend of investment, as can be seen in the national marketing budgets in Macedonia and globally. Thus, digital marketing is emerging as superior nowadays, ready to meet the complex needs of businesses today.

The purpose of this analysis is to show us a picture of how much technology can help any company today. This paper discusses email marketing as a digital tool compared to television, how they reach consumers and what their results are. Through research, we can see the results of real campaigns of companies that have extensive professional experience in the field of digital marketing.

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Technique of Government Digital Auditing

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Abstract. The actions that must be taken to consider government digital auditing, given that we all function in the conditions of the "World Wide Web" (www). The use of www reality is essential for the functioning of government digital auditing. It enables the search for ways to solve the challenges of the rational use of budgetary resources and to optimise budgetary relations in a government. This article is about the benefits, challenges and technique of government digital auditing that intended to safeguard public interest and preserve government assets. The goal of this article is to provide a clear and concise representation of the main blocks of the technique for Government Digital Auditing. This technique is based on Author's insights and practical experience as a government auditor, Chief of accountants, Professor of Accounting and Auditing.
Keywords: Government Digital Auditing, public sector institutions, technique, cyber-crime, Data Breach, Financial Statements, Primary Documentations.

1. Introduction

The budget system allocates more than one third of the gross domestic product (GDP) and ensures the financing of all areas of state activity: maintaining security and public order, free education and health care, creating conditions for economic development, providing old-age and invalidity pensions, reducing poverty and smoothing out interregional differences. As international experience shows, the transition to the new system of budget planning requires not only budget stability, but also structural changes in the entire government auditing system.

Government auditing has become increasingly critical in the public sector, driven by the need to safeguard public interest and preserve government assets. This emphasis largely mirrors the significance of public funds, which are fundamental to a country's stability and prosperity. As a result, government/internal control units have emerged as the primary safeguard for protecting and managing government assets. While enhancing the efficiency of carrying out public duties in entities in the public finance sector is important, management control remains critical. This concept encompasses a range of activities designed to ensure that goals and tasks are achieved legally, effectively, economically, and on time. [1]

Recently, technology has advanced rapidly, and as a result, it has significantly influenced the audit profession, especially in performing the audit function [2]. The use of digital auditing in the government control system will contribute to the analysis of the functioning and evaluation of the effectiveness of public sector institutions/budget users, to the search for ways to solve the problem of the rational use of budgetary resources and to the optimisation of budgetary relations in a government. The phrase "computer-assisted audit techniques" first appeared in a publication in 1974. For this reason, computer-based financial systems have grown significantly in recent years. Many more instruments have been devised since then IT now greatly shapes the auditing industry. General audit software is one of the tools most widely utilized as a computer-assisted audit approach. [3].

Since the computers are becoming more smarter and also the risk associated with manual or traditional auditing system such as the paper information may

disappear for different reasons, thus the need to use advanced technology in auditing. [4]. In general, the ease of use of the technology is mainly based on the technological skills. These is always varied from auditor to auditor. With the rapid development of information technology (IT), IT is no longer a specific domain for only information technology specialists that requires paying more attention to improving the technical and analytical skills of auditors.[2]. On another hand there are "limited human resources with the technical skills to manage e-budgeting, …, and often insufficient quality of data uploaded into the e-budgeting system, complicating the audit process" [5].

And, also, we should not forget that auditing has accounting as their starting point, which requires a good knowledge of accounting [6]. Successful auditors typically have practical experience as an accountant.

Despite the importance to control budget money expenditures in any country, there is not so many publications about practical auditing procedures to reveal budget law violations with budget money. For example, by searching term "Government/Internal auditing NEAR/3 technique" in ProQuest database on May 22.2024 it was found only 94 articles in Scholarly journals for five previous years (2020 – 2024).

The goal of this article is to provide a clear and concise representation of the main blocks of the technique of Government Digital Auditing. This technique is based on Author's insights and practical experience as a government auditor, Chief of accountants, Professor of Accounting and Auditing.

2. Data and Methodology

The data and methodology for current study was obtained from numerous scientific projects, practical experience, and some previous authors' publications during decades covered in the analysis [7-10]. The subject of this study is the government audit institution with government auditors and the object is the auditee - public sector entities belonging to the Public Sector that present financial statements to the International Monetary Fund (IMF). Since the most of countries are a member of IMF this article considers Government Digital Auditing complying with definitions and reporting forms of IMF Government Financial Statistic Manual (GFSM, 2014) [11].

3. Benefits of Government Digital Auditing

In view of the fact that today's reality is intertwined with the "World Wide Web", it is advisable to use electronic storage facilities in the process of state auditing (for example, a single information portal). The digital auditing methodology is used to focus on controlling high-risk operations. Using this approach, auditing is able to identify the facts of unlawful use of budget funds on the basis of the information obtained from electronic resources and independently of the data provided by the auditee entities. In this case, the database of the control body should be created as the central repository, which is formed during the integration of data from resources on the basis of the results of audit. These results will be uploaded into the system, enabling analysis of the effectiveness of controls and the dynamics of changes in financial violations by established public entities. These data can be used for decision-making, providing proof of testing and confirming quality of testing performed.

During a digital audit, government auditors can follow each document in a matter of minutes. At the same time, government auditors can quickly review supporting documents, identify errors and gaps in the accounting of budgetary institutions, as well as automate the detection of fraud and preventive measures. Moreover, in this case there is no need to request various certificates from the audited entities or to spend time preparing requests [12]. With an innovative digital approach,

the control is carried out continuously and in real time. Having focused on the standardisation of data elements on public sector entities and the integration of the main financial systems, auditors will be able to take advantage of digital audit, such as a significant increase in data reliability, reducing the need to resolve discrepancies. Other benefits:

✓ Increasing the consistency of audits through the use of appropriate tools;

✓ Immediate identification of gaps and deficiencies in the organisation of accounting in state institutions, which may lead to violations of the law or the use of budget funds in the interests of the audited entities;

✓ Easy detection of fraud and embezzlement;

✓ More detailed search results that fully identify the causes of violations;

✓ Identification of hidden relationships between persons, organisations or events, in particular the ownership of companies interacting with state institutions;

✓ Identification and analysis of suspicious transactions;

✓ the ability to continuously monitor the occurrence of fraud threats.

4. Challenges of Government Digital Auditing

Every government is concerned about data security and needs to control access to state secret and other important information. Cyber-crime is one of the most serious problems to save and protect important data. Since digital technology is embedded deeply across every institution today, producing a fast-changing array of cybersecurity risks. "Cyber is in everything," Katcher said.

Legislation is needed to protect government information. Efforts to improve digital government auditing are also needed to comply with this policy. In order to gain an understanding of the extent of cybercrime, it is necessary to consider at least reports of US government.

The US Federal Bureau of Investigation (FBI) continues to combat this evolving cyber threat. Critical to the FBI's efforts is the Internet Crime Complaint Center (IC3). IC3 gives the public a direct way to report cybercrime to the FBI from 2001 and enables to collect data, advance investigations, and identify changes in the threat landscape. Related to budget money transactions we can consider three cybercrime types defined in Internet Crime Report of IC3 [13]:

	Data Breach: A data breach in the cyber context is the use of a computer intrusion to acquire confidential or secured information. This does not include computer intrusions targeting personally owned computers, systems, devices, or personal accounts such as social media or financial accounts.
	Extortion: Unlawful extraction of money or property through intimidation or undue exercise of authority. It may include threats of physical harm, criminal prosecution, or public exposure.
	Malware: Software or code intended to damage, disable, or capable of copying itself onto a computer and/or computer systems to have a detrimental effect or destroy data.

Fig. 1. Some cybercrime types' definitions and illustrations.
Source: Author's compilation based on [13].

The amount of above-mentioned type of cyber-crime is presented on diagram (Fig.2).
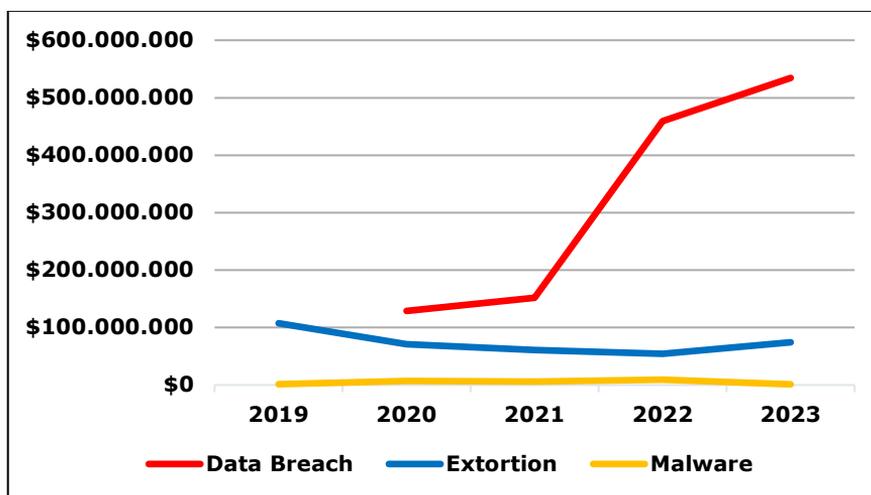

Fig. 2. Last five-year comparison by complaint loss, USD.
Source: Authors' compilation based on [13].

According to the data presented on the above diagram (Fig. 2), the most significant financial losses were incurred by victims of cybercrime "Data Breach" (above 500 million USD in 2023) as a result of computer intrusion. To avoid huge budget money loss, in case of weakness of the audittee' cybersecurity resilience, the auditors must record this fact in their final opinion. Cybersecurity is a fast-paced area, and Government Audit Institutions should continue to learn about technical and policy developments. Spreading good practice and awareness can help auditors adapt. And government auditors will have cybersecurity literacy. Consequently, auditors must undergo training provided by high-qualified cyber specialists.

The reports of thousands of budgetusers can be found and analysed on their official websites. However, it is necessary to know at least the composition of the financial reports and the main indicators they contain. For this, the auditors must have high-level knowledge and practice in accounting and budgeting systems of budgetary institutions/entities, which is currently a big problem due to absent of rich practical accounting experience of the auditors. Therefore, it is necessary to organise training and certification courses not only for the employees of budgetary institutions/entities, but also for the auditors who will audit them.

In addition, in accordance with the agreement with the bodies of the Treasury, it is necessary to provide auditors with access to information on the movement of funds in the accounts of audittee. The Treasury bodies have been working in electronic format using BLOND technology many years and have information on payments made by all recipients of budget funds. Since the territorial divisions of the Treasury are located in almost every significant settlement, this information on the movement of budget funds can be obtained almost everywhere. And each control and accounting authority must ensure the provision of this data within the framework of agreements with the bodies of the Treasury. Auditors, monitoring the movement of budgetary funds, can identify the most suspicious operations, for which it remains to request confirming primary documents when entering the object of control.

In addition to the government audit body and accounting authorities, control structures also operate at the state and local level of the executive branch of government. The creation of a united information portal in the field of the government

audit (control) will make it possible to analyse the composition and value of the identified violations and to take measures to optimise budget spending. It would be wonderful if the results of the state audit (control) could be taken into account when drawing up the budget for the next period. In the future, it will be possible to link the determination of the value of budget subsidies with the results of the state audit, if the transparency of the control results is ensured by using information digital technologies and the mechanism of identifying violations.

Thus, the main challenges of Government Digital Auditing are:

Cybersecurity posture of the government audit body;

Practical Trainings of the government auditors;

Close Interaction between the treasury, government audit body and other government ministries/agencies;

United portal of general control data.

5. Technique of Government Digital Auditing

Technique can be defined as a set of actions and procedures that are subordinate to the practical implementation of specific tasks. With regard to government auditing, the technique is that which serves to achieve the final result, namely the verification of the targeted and effective use of budget funds. Based on this, the government audit technique can be defined as a set of verification procedures that correspond to the methodological foundations of government auditing and which make it possible to determine compliance with both the principles of using budget funds and the legal grounds determined when allocating these funds. In essence, a technique is a sequence of actions for verifying the utilisation of budget funds by a particular public sector entity/budgetusers.

The organisation and implementation of a digital audit should be guided by the fact that any audit of the use of state and local government funds should have concrete results that can contribute to

- increase responsibility, transparency and accountability in the work of the authorities and those using the budget

- Solve major social issues and problems;

- Improvement of the efficiency of government agencies and budget users, including the introduction of modern working methods in their activities;

- A more efficient use of the budget funds in all the regions of a given country.

Using digital audit in government audit system makes it easier for analysing and evaluating public bodies' functionality and efficiency, identifying ways for using budget resources prudently and optimising budget relations within state government.

In order to carry out government digital auditing technique, it is necessary to perform five main procedures that represented in five paragraphs below.

5.1. Determination of organizational, legal status and capacity (block I in Table 2)

To determine the legal status, it is necessary to study the charter (regulation) of the organization, all its registration documents in state bodies. As a rule, these documents are located in one folder and are stored in a safe at the head or chief accountant. It is also necessary to take into account that only originals need to be studied.

As a result of determining the legal status, the introductory part of the audit report is formed.

The introductory part of it should contain the following information:

date and place of compilation of the results of the audit;

by whom and on what basis the audit was carried out;

the audit period and the terms of the audit;

the full title and details of the audittee, the identification number of the taxpayer (TIN);

departmental affiliation and name of a higher organization;

information about the founders;

the main goals and types of the audittee activities;

whether the audittee has a license for the implementation of certain types of activities;

list and details of all accounts in credit institutions, including deposit, as well as current accounts opened in the treasury bodies;

who in the audited period had the right to the first signature in the audittee and who was the chief accountant;

by whom and when the previous audit was carried out, what was done in the audittee over the past period to eliminate the identified shortcomings and violations.

In case creating of united portal of general control data above mentioned information will be automatically provided.

5.2. Checking the state of accounting and reporting (block II in Table 2)

When checking the state of accounting and reporting, it is necessary to find out:

◊ Is there a properly approved order on the accounting policy. If a schedule of workflow and a working plan of accounts is attached to the accounting policy, the verification is much simplified.

◊ whether the provision on the accounting service is properly approved and how it is carried out;

◊ whether the chief accountant is fulfilled by the obligation to organize accounting and control of ensuring the safety of funds and material values;

◊ whether the chief accountant order the official duties for accounting workers;

◊ whether all the necessary documents are presented by audittee workers for accounting and control in a timely manner;

◊ whether all the accounting registers are carried out by the law and instructions of the Ministry of Finance; the correctness, timeliness and accuracy of the records of operations in these registers;

◊ compliance of the remains at the beginning of the year in accounting registers with data for the previous year;

◊ the availability of genuine documents confirming transactions, timeliness and compliance of primary documentation with the established forms;

◊ whether the established procedure for correcting errors in the primary documents entering the accounting department is observed;

◊ whether the registers are correctly designed and compiled;

◊ whether the total sum and leftovers of registers correspond to the total sum and leftovers of Ledger Registers;

◊ whether proposals are made based on the results of previous checks of the state of accounting and reporting;

◊ whether the established storage rules are respected in the accounting of primary documents, accounting registers and other accounting documents.

Usually government audit bodies (Supreme Audit) prefer to check financial statements for whole fiscal year because it is clearly seen how to executed year budget. That is all of budget money that was received by budgetary entity yearly must be spent during fiscal year and this spending must be reflect in annual financial statements. In www reality auditors can check statements in electronic format but they must verify them with stamped paper version.

When checking the correctness of the audittee' reporting, one should determine (authoring):

o The guidance of international and domestic accounting rules.

o Completeness and timeliness of reporting. Completeness means that all requirement statements (see Table 1) are presented.

The composition of public sector financial reporting is established in international regulations such as GFS, IPSAS and others. Forms for public sector reporting that required by IMF are shown in Table 1.

Table 1. The required forms for public sector reporting

GFSM 2014
Statement of Operations
Statement of Other Economic Flows
Balance Sheet
Statement of Sources and Uses of Cash
Statement of Total Changes in Net Worth
Summary Statement of Explicit Contingent Liabilities and Net Implicit Obligations for Future Social Security Benefits

Source: Author's compilation based on [11].

Timeliness depends on the end of the reporting period [10]. Usually, financial statements must follow a strictly defined deadline, for example in 20 days after the end of the reporting period or fiscal year. In addition, according to the budgetary rules, all transactions of public sector entities must fit into the fiscal year. Different countries have fiscal years which end in different dates, complicating data comparability by comparing statements between those countries.

o Whether all transactions with budget funds are accounted for the fiscal year.

o The availability of authentic primary documents, timeliness and accuracy of recording, reflected into the accounts.

o Whether the total amount on the accounts equal the sum their detailed transcript.

o Compliance with the instructions of the Ministry of Finance on the accounting and registers.

o Compliance with established procedure for correcting errors in primary documents received by the accounting department in the accounting records, as well as printouts.

o Whether considered the results of previous audits of accounting and reporting.

5.3. Checking Revenue and Expenses (block III in Table 2)

During Government Digital auditing, key reported elements, such as revenue, and expenses are analyzed and checked [10]. These elements are reflected mostly in the Statement of Operations (see Table1).

The *Statement of Operations* presents details of transactions in revenue and expense. Revenue minus expense equals the *net operating balance*, reflecting the total change in net worth due to transactions with financial assets and liabilities (GSFM 2014, 4.16, 4.17). Since the *net operating balance* equals Revenue minus Expense, it becomes necessary to control the Revenue and Expense.

Any of budget revenues can be classified as all proceeds from transactions that result in an increase in the value of assets. But the detailed classification of revenue for operations statement purposes is significantly different depending on the regulations ordered by Ministry of Finance from country to country. So, compliance factual revenue with classification needs to be controlled in the audit.

First of all, control starts with checking the completeness and correctness of

the reported amounts of revenues and expenses.

Revenue is an increase in net worth resulting from a transaction [11, 4.23]. **Expense** is a decrease in net worth resulting from a transaction [11, 4.24].

A key point when checking revenue and expense is the recording bases because the amount of revenue and expense depend on applicable recording bases. Broadly, the time of recording could be determined on **four bases**: the accrual basis, the commitments basis, the due-for-payment basis, and the cash basis. In practice though, many variations on these bases of recording may exist. [11, 3.61].

In the course of checking **revenue**, the auditor pays particular attention to:

- The completeness and correctness of recording and reporting all revenue;
- A contract between the government/state and the contractor, the definition of contractual compliance with applicable laws;
- The presence of an integral part of the contract between the customer (the state) and the performer - budget programs and activities justifying the targeted use of budgetary funds; special attention in the implementation of this complex work should be focused on coming budgetary allocations to finance capital (current assets) and operating costs;
- The nature of the receipt of funds - if the entity is a budgetary entity or state budget funds, the budget comes to exercise their statutory activities within the estimates of revenues and expenses.

If the budget comes in the form of grants, subsidies and other transfers, it is necessary to examine the contract for their provision; especially attentively one must check the performance of all the essential conditions of the contract.

The main thing in this block is the control over the use of finance, which should confirm the reasonable assertion that the budget users achieve the goals set in their outcome.

To check **expenses**, the auditor performs the following procedures [10]:

1. Check the distribution of the sum of debit turnover of the account "Expenses", taking into account the formation of the cost of the transaction log.

2. Check the completeness, accuracy and timeliness of the entries in the transaction logs.

3. Verify the resulting amount of expenses of primary documents with a total transaction log on the account "Expenses" for a month, and then - with a total of the general ledger for the month, two, three, six or nine months a year. Then compare the results of the general ledger with a total cost in the Statement of Operations.

4. In the event of discrepancies in the amounts of analytical and synthetic accounting, find out the cause.

5. Pay attention to the procurement procedure because it is known that during public procurement some officials have enriched.

6. Control for whether government activities are operating in accordance with the principles of economy, efficiency and effectiveness.

7. Control of Social Spending.

By checking revenue and expenses, only those documents that have been properly approved are accepted as evidence.

5.4. Checking Assets (block IV – V in Table 2)

During Government Digital auditing, key reported elements, such as assets and liabilities are analyzed and checked. These elements are reflected mostly in the Balance Sheet (see Fig.3).

Table 7.1 Balance Sheet					
Assets	Opening balance	Closing balance	**Liabilities and net worth**	Opening balance	Closing balance
Nonfinancial assets[1]			Liabilities[1]		
Financial assets[1]			Net worth		
Total assets[1]			Total liabilities and net worth		
Memorandum items					

[1]Classified by categories of assets and liabilities as needed.

Fig. 3. Balance Sheet.
Source: [11].

A **balance sheet** is a statement of the values of the stock positions of assets owned and of the liabilities owed by an institutional unit or group of units, drawn up in respect to a particular point in time [11, 3.56]. In accordance with **a double-entry system,** each transaction gives rise to at least two equal-value entries, traditionally referred to as a credit entry and a debit entry [11, 3.54]. In other words, balance sheets consist of a left side which reflects all assets' leftover and right side which reflects all liabilities' leftover.

Asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the resource over a period of time. It is a means of carrying forward value from one reporting period to another. [11, 3.42].

According to GFSM, Assets classified as Nonfinancial and Financial assets in general (see Fig.3).

When controlling Nonfinancial and Financial assets, auditors need to ensure:

1) The accuracy and completeness of elements provided in the forms of reporting, and the coordination of related elements presented in separate forms and the balance.

2) Compliance with the actual performance on the reporting date (end of the financial year).

3) That all assets actually existed at the reporting date; in case of doubt an inventory should be conducted.

4) Whether the same analytical and synthetic accounting data. If any discrepancies exist, the deviation of each of the accounts should be calculated. The magnitude of the deviation should indicate the amount of distortion of financial statements.

5) The correctness of the assets' amount.

6) Controlling of the operation with different debtors and creditors. To do this, auditors must check the reasons for the formation of receivables and payables; the terms of the debt of each debtor and creditor, the reality of receivables and payables.

Only those documents that have been successfully verified are accepted as evidence.

5.5. Checking Liabilities

Liability is established when one unit (the debtor) is obliged, under specific circumstances, to provide funds or other resources to another unit (the creditor). [11].

When controlling the liabilities, auditors need to ensure [10]:

1) That all liabilities actually existed at the reporting date; in case of doubt an inventory should be conducted.

2) Whether the same analytical and synthetic accounting data. If any discrepancies exist, the deviation of each of the accounts should be calculated. The magnitude of the deviation should indicate the amount of distortion of financial statements.

3) The correctness of the liabilities' amount.

4) Controlling of the operation with different debtors and creditors. To do this, auditors must check the reasons for the formation of receivables and payables; the terms of the debt of each debtor and creditor, the reality of receivables and payables.

The most important blocks of the aforementioned procedures as Government Auditing Technique present in Table 2.

Table 2. The main blocks of Government Auditing Technique

№	Audit stages	Test procedures	Verified documents
I	Determination of organizational, legal status and capacity	1. Review the Charter (Regulations) of the audittee. 2. Determine whether the audittee is a legal entity 3. Review the statutory activities of the audittee 4. Investigate the structure of the audittee. 5. Determine those responsible for financial and economic activities.	Memorandum/Articles of Association /Charter /Regulations; All constituent documents; Local acts (orders, instructions of the head)
II	State-of-the-art of audittee' accounting and reporting	1. Check the availability of accounting policies and document flow schedules 2. Review the accounting policies 3. Determine the methods and methods of accounting 4. Check the compliance of accounting with current legislation. 5. Review the structure of the accounting service 6. Verify that all audittee' transactions have been duly recorded within the relevant accounting and reporting registers. 7. Determine the timeliness of reporting 8. Check for the presence of Treasury marks on the reporting 9. Check the availability of estimates of income and expenses approved by the chief manager (manager)	Accounting policy; Document flow schedule; Working chart of accounts; Accounting Regulations; Job descriptions of accounting employees; General Ledger; Ledgers; Registers; Financial statements
III	Checking Revenue and Expenses	1. Make an analysis of the Statement of Operations. 2. Check the total amount of Revenue in all forms of reporting and accounting registers. If it does not match, then calculate the amount of deviations. 3. Check the total amount of Expenses in all forms of reporting and accounting registers. If it does not match, then calculate the amount of deviations. 3. Investigate the causes of the aforementioned deviations.	Financial Statements; General Ledger; Registers; Primary documentations
IV	Checking Financial Assets	1. Request a certificate of availability of bank accounts 2. Check the availability of a book for recording bank expenses. 3. Reconcile the total amount of cash expenses in the ledger and in the financial statements. If there are discrepancies, determine their cause. 4. View and analyze bank source documents. 5. Check the existence and execution of contracts specified in the purpose of payment in payment orders	Financial Statements; General Ledger; Bank account book; Bank statements; money orders; check books, book of accounting of contracts, contracts for the supply of goods, works, services;

		6. Check the completeness of the receipt of funds received from the bank at the cash desk	Primary documentations.
V	Checking Non-financial Assets	1. Check the compliance of the amount of Non-financial Assets in the balance sheet and accounting registers. 2. Check the correctness of registration of the non-financial assets (availability of Acceptance certificate) 3. Check compliance with the rules for accounting and storage of fixed assets 4. Check the validity of writing off fixed assets (availability of permission) 5. Check that inventories are carried out correctly 6. Check the compliance of the actual balances of fixed assets with accounting data (conducting an inventory). 7. Check that depreciation is calculated correctly.	Financial Statements; General Ledger; Ledgers; Acceptance certificates; Acts on write-off; Inventory cards and lists; Inventory reports; Primary documentation
VI	Verification of Liabilities	1. Verify that all liabilities actually existed at the reporting date; in case of doubt an inventory should be conducted. 2. Whether the same analytical and synthetic accounting data. If any discrepancies exist, the deviation of each of the accounts should be calculated. The magnitude of the deviation should indicate the amount of distortion of financial statements. 3. The correctness of the liabilities' amount. 4. Controlling of the operation with different debtors and creditors. To do this, auditors must check the reasons for the formation of receivables and payables; the terms of the debt of each debtor and creditor, the reality of receivables and payables.	Financial Statements; General Ledger; Ledgers; Primary documentations

Source: Brief Excerpts from Author's insights and practical experience.

As shows in Table 2, the audit process comprises several stages, each of which is subject to specific test procedures.

Government Digital Auditing should be led to ensure the issuance of reliable financial information and to deter fraud, waste, abuse and others violations of public resources. The most common violations in the Public Sector are: abuse, fraud, waste, bribery, and kickbacks. However, unfortunately these kinds of violations are really difficult to reveal, because such violations very often do not have documentary proof and are made as a result of face-to-face agreements in cash (black) or virtual money, and so are not reflected in the financial statement. This is caused by the appearance and prosperity of the shadow economy, and some senior officials became oligarchs due to these non-revealed and non-identified violations [10].

6. Conclusion

Despite the fact that government auditors have many types of instructions, there are still not enough really workable, clear and easy manuals for beginners and students. Given the author's significant practical experience as a chief accountant, government auditor, and Professor of Accounting and Auditing, this article has shed light on the professional view of government auditing process to present a workable, clear and simple manual for carrying out some government procedures.

It is undoubtedly true that Government Digital Auditing involves a multitude of intricate nuances and details, making it challenging to disseminate this information online to those who could benefit from it. However, the author hopes that the results of this work might enhance the skills and competencies of auditors in conducting Government Digital auditing.

This article presented the main blocks of Government Digital Auditing Technique that carries out in audittee: Determination of organizational and legal status and legal capacity; Checking the organization of accounting and reporting; A review of the budget execution process; Checking bank transactions; Checking cash transactions; Checking operations with fixed assets.

The author's future direction is to organise training centres for government auditors and to publish more detailed techniques for each block separately with specific test procedures.

Moving auditors to new and evolving techniques will modernize Government Digital Auditing by making full use of current and emerging technologies to overhaul traditional sampling-based auditing approaches and fully leverage technology to digital auditing. Digital Auditing allows leveraging sophisticated tools, such as online analytical processing to analyze large populations of both manual and automated journal entries from the financial management system. In doing so, it will enable the auditor's profession to move into the future and add even greater value to managing the cost of government and providing the highest levels of accountability and transparency to the public [12].

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Aims and Objectives

Published online by Institute of Cited Scientists, Cyprus, two times a year, Journal of Digital Science (JDS) is an international peer-reviewed journal which aims at the latest ideas, innovations, trends, experiences and concerns in the field of digital science covering all areas of the scholarly literature of the sciences, social sciences and arts & humanities. The main topics currently covered include: Digital Economics, Education, Engineering, Finance, Health Care.

The main goal of this journal is the effective dissemination of original incites/results generated by the human brain and presented/reflected in articles using modern information/digital technology.

This current Issue divided on two equal parts: 1. Scientific view on digital technology implementations (the first three articles) and 2. Economics scientific view (the last two articles) with multidisciplinary approach on adoption of Digital technology/knowledge in modern reality.

Contact information