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Advances in auditing and business continuity: A study in financial companies

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ABSTRACT

This paper delves into the integration of Intelligent Process Automation within the domain of business continuity auditing, with a focus on the Portuguese banking sector. In an era marked by rapid technological advancement, organizations are increasingly leveraging automation to reinforce operational efficiency and realize substantial cost savings. Concurrently, auditors play a pivotal role in ensuring seamless transitions amid technological transformations to safeguard business continuity. This research endeavors to bridge the realms of business continuity and intelligent automation, culminating in a comprehensive application that streamlines the audit process. The implemented solution encompasses the automation of critical audit activities, including communication, information requests, and final report submissions, liberating auditors from the chains of repetitive tasks. The incorporation of business intelligence augments this automation framework, enabling a meticulous analysis of key performance indicators within the audit department. This ensures a continuous evaluation of the efficacy of the Annual Audit Plan. Empirical validation of this initiative was achieved through surveys conducted with audit teams from four prominent Portuguese banks. The results unequivocally affirm the potential benefits of this implementation, extending invaluable support to management in the decision-making process, while concurrently alleviating auditors of routine tasks inherent to the audit process. This study not only underscores the transformative potential of intelligent process automation in the audit domain but also offers a replicable framework for organizations seeking to fortify their business continuity efforts through technological integration. The findings hold implications for businesses navigating the dynamic intersection of technology and audit practices, providing a blueprint for harnessing automation for enhanced operational resilience.

1. Introduction

Technological advancements have greatly increased information accessibility and are continuously reshaping information systems to meet future demands This dynamic environment compels organizations to adopt open innovation strategies to streamline operations, enhance efficiencies, and fortify fraud prevention measures. The COVID-19 pandemic has accelerated the shift towards remote work, emphasizing the importance of process automation. In auditing, technology has become essential in ensuring compliance, assessing risks, and improving operational efficiencies, promoting transparency and accountability. The shift from manual to automated and continuous auditing is driven by emerging technologies like Artificial Intelligence (AI) and blockchain, significantly affecting the banking sector. Despite these advances, the transition to fully digital auditing practices remains gradual, with many institutions still reliant on traditional methods.

The auditing process has evolved from traditional manual audits of paper documentation to computer-based auditing, progressing towards a paperless, electronic, real-time continuous auditing environment (Rezaee et al., 2002). The banking sector has faced numerous challenges in recent years, responding to incentives and imperatives related to technological advances, market volatility, and increasing regulatory and

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public scrutiny. Since the 2007 financial crisis, known as the subprime crisis, the audit function in banking institutions has become significantly more crucial. Its primary mission is to mitigate the risk of potential or actual losses, thereby enhancing the institution's risk profile (Zinca, 2016). Internal Audit (IA) departments are under increasing pressure to leverage technology for automating the identification of exceptions and/or anomalies and for control testing (The Institute of Internal Auditors, 2019).

Despite the pervasive integration of digital tools into daily life and advancements in various sectors, the application of digital technologies in auditing is still in its nascent stages (Vasarhelyi et al., 2012). Internal Audit Functions (IAFs) predominantly adhere to traditional auditing approaches, and the transition to the continuous audit paradigm has not yet been fully realized in most organizations (AUDITBOARD, 2018; Skantze, 2017).

In the dynamic landscape of technological advancement, businesses find themselves in a race against time to implement automated systems and harness cutting-edge technologies (Mamede et al., 2023). This not only amplifies operational efficiency but also amplifies service effectiveness and drives substantial cost savings, all while ensuring the uninterrupted flow of critical services (J. Brás et al., 2023). Simultaneously, auditors stand as vigilant sentinels, poised to navigate the currents of global change (Murphy, 2020) and scrutinize the orchestration of business continuity processes (Wojciechowska-Filipek, 2019; J. C. Brás et al., 2023; Brás and Guerreiro, 2016).

Sophisticated algorithms employed by modern systems offer a proactive enhancement to banks' capacities for safeguarding operations and reputation. This strategic adoption facilitates navigation through the volatile business landscape, preemptively identifying vulnerabilities before they escalate into significant threats (V-Soft Consulting, 2020). Financial institutions harness such tools for predictive credit risk analysis, leveraging extensive data to forecast market risks and potential loan defaults. Such initiatives underscore the institutions' commitment to risk management, providing a competitive edge in strategic foresight (Anagnoste, 2017; Steinhoff et al., 2018).

Robotic Process Automation (RPA) exemplifies the forefront of technological integration in business processes, augmenting human capabilities and redefining audit procedures without replacing human roles (Devarajan, 2018). RPA, building on the technological innovations of the 1990s, including screen scraping and AI, is transforming into a formidable force (Issa et al., 2016; Javatpoint, 2021). When combined with Intelligent Automation to create Intelligent Process Automation (IPA), RPA significantly raises the quality of auditing, enhancing anomaly detection and insight discovery (Chambers, 2020; Handoko et al., 2021a; Lievano-Martínez et al., 2022; Minnaar and Smith, 2018; Mittal, 2021).

The advancement toward automation-intensive auditing, propelled by open innovation, suggests a diminishing role for manual processes. Collaborative efforts in technology development and knowledge sharing can further streamline audit methodologies (Lu and Chesbrough, 2021; Peñarroya-Farell et al., 2021). Effective utilization of automation in auditing, bolstered by open innovation strategies, can yield outstanding results. Encouraging broader collaboration and external inputs ensures that decisions regarding its implementation are made with discernment, leveraging diverse expertise for enhanced decision-making. (Bedard et al., 2006; David Audretsch and Belitski, 2022; Julka, 2021; Majchrzak et al., 2023). With the automation technology market expected to grow exponentially, the incorporation of automation in strategic planning is imperative. (Agoglia et al., 2010; Devarajan, 2018; Raval and Smith, 2020). Projections indicate that the global automation technology market is poised to attain a substantial valuation of $25.66 billion by 2027, characterized by a robust compound annual growth rate of 40.6 percent (Sikora et al., 2019).

Auditors are tasked with discerning the tasks suitable for automation, mitigating risks associated with automation, and ensuring robots' behavior aligns with societal norms and human preferences (Alles and Kogan, 2008; Moffitt et al., 2018a). Future auditors must transcend traditional roles, integrating mature automated processes, standardized definitions, and adept management to add value and competitive advantage (Bharadhwaj, 2021; Griffiths and Pretorius, 2021; Moffitt et al., 2018a; Vasarhelyi et al., 2004).

RPA's implementation extends beyond technological deployment, involving process optimization and the integration of cognitive capabilities into machines (Syed et al., 2020; Appelbaum and Nehmer, 2017; Vlăduţ et al., 2018). Despite RPA and AI's benefits, it's crucial to acknowledge and navigate the associated challenges and risks to prevent systemic lapses and ensure continued accuracy and efficiency in response to business process changes (Aksoy and Hacioglu, 2021; Gotthardt et al., 2020; Issa et al., 2016; Mandal et al., 2017).

In resume, RPA introduces various risks despite its efficiency benefits, including security vulnerabilities as bots access sensitive data, which may lead to breaches if not securely managed (J. Brás et al., 2023). Operational risks also arise from potential software bugs and maintenance issues, particularly when RPAs are not updated in line with evolving business processes, leading to failures and disruptions. Additionally, compliance risks are significant, as improper programming or oversight might result in regulatory breaches, inviting leg (Deloitte, 2018; Joshi, 2019; Mennen and Van Tuyll, 2015; Szalony et al., 2019), and penalties and reputational damage. Scaling RPAs can compound these issues, making bot management increasingly complex and challenging (Durst and Henschel, 2020; KPMG, 2018a; Olson and Wu, 2021; Pluzhnikov, 2020; Violino, 2020). Over-dependence on automation can reduce human oversight, critical in decision-making processes, potentially affecting operational integrity if RPAs fail. Furthermore, job displacement from automation can impact employee morale and lead to resistance, necessitating careful management and retraining programs to ensure workforce adaptation and acceptance. Effective risk mitigation requires robust governance, continuous monitoring, and integration of RPAs into broader Information Technology (IT) and business strategies to balance benefits against potential downsides(Deloitte, 2020; ELEKS, 2022; Hugo Ciopages, 2016; Namchoochai et al., 2020).

With the imperative to automate audit operations as a guiding principle, this study embarks on a mission to mechanize manual and repetitive activities within the audit process (Nunes et al., 2020). This endeavor promises to underpin a more effective business continuity management, facilitating the identification of optimal solutions while mitigating potential risks (Bharadhwaj, 2021; J. C. Brás et al., 2023; Handoko et al., 2021a). In essence, this reconfiguration of the auditor's role envisages a pivot toward the assessment facet of audit procedures, liberating valuable time from the clutches of routine tasks (Huang and Vasarhelyi, 2019; Moffitt et al., 2018a).

This research aims to rigorously assess whether RPA and IPA can refine the audit process and if active monitoring of audit plans can bolster decision-making. Hence, this article aims to focus on two main research questions:

1. Can RPA and IPA improve the audit process?
2. Can active monitoring of audit plans improve decision-making?

2. Research methodology

In the pursuit of this study, a research approach founded on the principles of the Design Science Research Method (DSRM) is adopted. This method is instrumental in addressing complex issues through the creation of novel artifacts, evaluating their designs, and effectively disseminating the findings to pertinent stakeholders (Hevner et al., 2004; Peffers et al., 2006).

The DSRM framework encompasses five key stages, delineated as follows:

1. Problem identification and motivation: This initial phase involves the discernment of a specific research conundrum and the elucidation of the inherent value in proffering a solution. This serves to engender motivation, both for the researcher and the wider research community, to ardently pursue the resolution of said problem.

2. Objectives of a solution: After the delineation of the problem, this stage demands the establishment of precise goals for the envisaged solution. These objectives are logically derived from the foundational problem definition, anchoring the subsequent development process.

3. Design and development: This pivotal stage entails the actualization of the solution. Here, the desired functionality and architectural attributes of the artifact are meticulously delineated, culminating in the construction of the artifact itself.

4. Demonstration: In this conclusive phase, the efficacy of the artifact in addressing the identified problem is validated. This entails subjecting it to rigorous experimentation, simulations, or other pertinent evaluative activities, thereby substantiating its effectiveness.

5. Evaluation: This critical phase entails a comprehensive assessment of the created artifact's efficacy in resolving an authentic problem and its practical utility. This involves subjecting the artifact to rigorous testing, simulations, or real-world applications to gauge its performance, reliability, and applicability in practical scenarios. The evaluation process serves as a pivotal validation of the artifact's real-world relevance and its potential to address genuine issues in practice. Fig. 1 presents a description of the research strategy using a DSRM process and summarizes the design and development of the artifact under analysis.

By adhering to the systematic rigor of the DSRM framework, this research endeavors to navigate the intricate terrain of problem-solving, thereby yielding insights that contribute substantively to the body of knowledge in the field.

The adoption of the DSRM approach in the realm of engineering and related themes offers significant advantages, primarily in terms of practical applicability (Peffers et al., 2007). Furthermore, this methodology exhibits a commendable degree of adaptability. Although the model is ostensibly structured in a sequential manner, researchers possess the flexibility to initiate their efforts at any juncture within activities one, two, three, or four. This adaptability caters to individual researchers' specific approaches and requirements (Maria Gonçalves Martins et al., 2018).

The main objectives of the proposed solution include strict compliance with and timely updates to the Annual Audit Plan. It aims to simplify routine tasks such as scheduling meetings and sending emails, thereby freeing up resources for more strategic activities. Additionally, the solution will evaluate auditor performance, providing insights that help pinpoint opportunities for improvement and refinement (Dabthong et al., 2021). Fig. 2 illustrates the six key activities facilitated by the potential automation solution.

Next, the IPA system will issue timely alerts to auditors, informing them of upcoming audits and requesting their permission to proceed. This enhances the efficiency of the audit initiation and ensures better time management.

The system will also automate the creation of emails and meeting requests, which are recurrent tasks within the audit process, thus enhancing operational efficiency.

After an audit is completed, the final report is meticulously analyzed using CV techniques again. This analysis provides critical data necessary for developing Key Performance Indicators (KPIs), which will be further discussed.

Given these activities, choosing the right RPA tool is crucial. As shown in Table 1, UiPath stands out for its cost-effectiveness and extensive support and learning community, making it the preferred tool for developing the automation framework.

In addition to the UI Path tool, integrating a Business Intelligence (BI) tool like Power BI is essential for enhancing the internal audit function's effectiveness and aligning it with organizational goals. This integration is crucial for assessing audit performance, which is increasingly scrutinized by regulators and investors concerning an organization's operational integrity. Power BI will be used to visualize KPIs identified by leading research institutions and regulatory bodies,

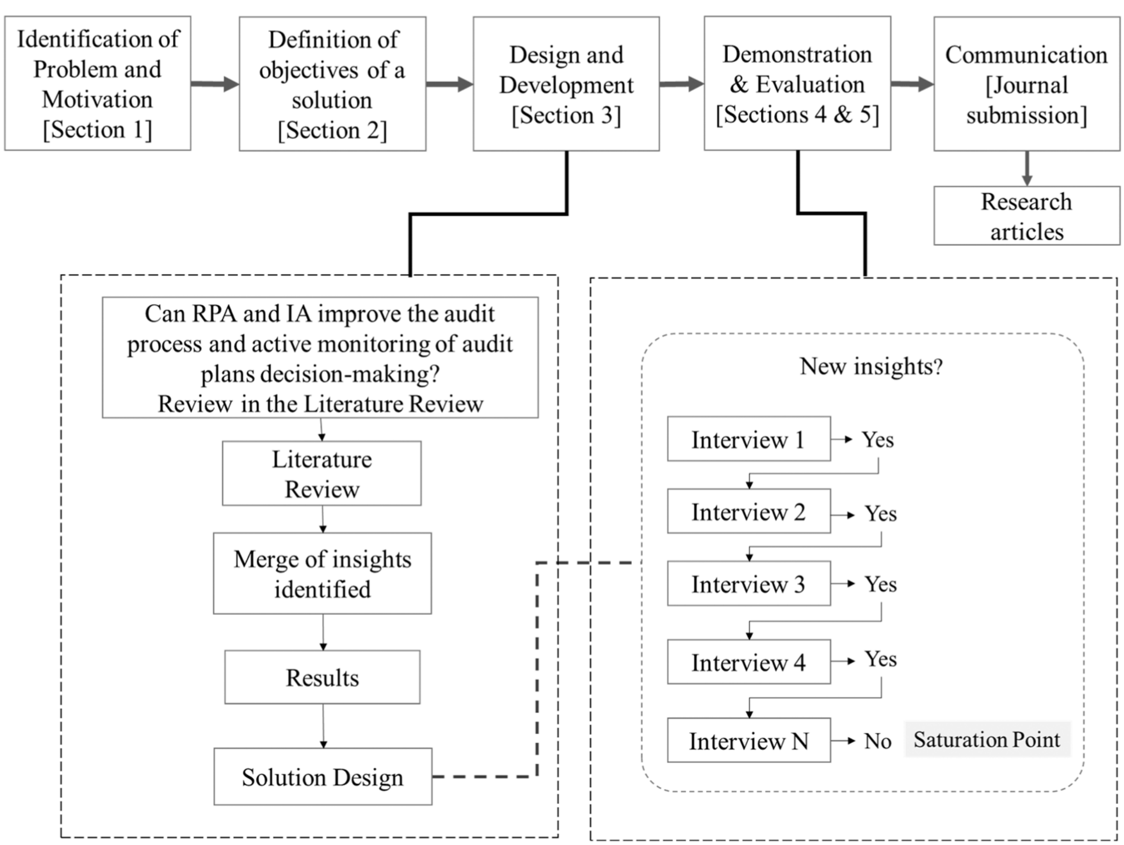


Fig. 1. DSRM workflow diagram.

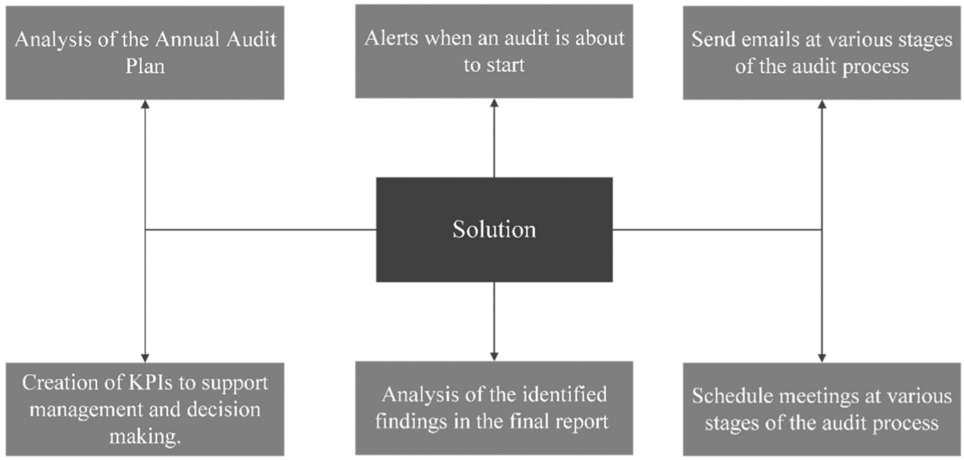


Fig. 2. Objectives of a solution.

Table 1
Top 5 best RPA tools (Adapted from (Software Testing Help, 2023)).

	Keysight's Eggplant	Blue Prism	UiPath	Automation Anywhere	Pega
Cost	Contact them for pricing.	$ 15,000 to$ 18,000 annually.	Free	Contact them for pricing details.	Start from $ 200/month
Maintenance and support services by the company	Documentation, Videos, FAQs, Tickets, etc.	Help Guide, Online-portal, Email, Contracts, & Training's	Training, Video tutorials, Community forum, & Implementation support	Training & Certifications	Training & Certifications, Community forum, Installation guide
Scalability	Extensible & can meet new challenges.	N/A	Can handle any process, in any number irrespective of its complexity	Yes. Scalable.	Scalable to Enterprise level.
User-friendliness	Process experts.	Yes. Developers	Yes. Even for non-developers	Yes. For anyone.	Yes. It supports low-code development.
Industry size	Small to large	MediumLarge	SmallMediumLarge	MediumLarge	MediumLarge

which include audit effectiveness, feedback on findings, audit duration and timeliness, and the value added by internal audit functions (Metricstream, 2023). These KPIs, such as the percentage of completed audits, number of planned audits, findings categorized by severity, and hours spent per audit, are vital for demonstrating the alignment of audit activities with management's expectations (AuditBoard, 2019). Power BI's intuitive interface allows for the creation of detailed dashboards that facilitate data-driven decision-making, thereby enhancing the analytical capabilities of the automation framework and ensuring that internal audit functions meet their objectives effectively.

3. Design and development

This section outlines the third step of the DSRM, which involves the creation and detailed description of the artifact's functionality. It breaks down the process into specific sections, each illustrating the steps taken and the main outcomes. A focus is also placed on the dependencies identified in the project, crucial for its execution.

4. Multivocal literature review

The Multivocal Literature Review (MLR) (Garousi et al., 2019) is similar to the Systematic Literature Review (SLR) (Garousi et al., 2016; Kitchenham and Charters, 2007) and aims to incorporate the so-called "grey literature" to supplement the published (formal) literature. MLRs are SLRs that include both scholarly writing (also known as academic writing or formal writing) and the (informal) grey literature (GL). Scholarly writing is the genre of writing used in all academic fields. GL is a multisource of information, which may exist in the form of blogs, videos, webpages, and white papers that are produced outside academic forums and are not subject to any quality control mechanism (e.g. the peer review process) before publication.

By including information that normally would not be considered due to its "grey" nature (Garousi et al., 2019), MLRs are important for the completeness of the research. An MLR in each subject field is essentially a combination of the sources that would be studied in an SLR and a Grey Literature Review (GLR) in the same field. Thus, an MLR is, in principle, expected to provide a more complete picture of the evidence in a given field. Figure 3 represents the relationship between SLR, GLR and MLR.

In the swiftly evolving domain of auditing, and IT, several researchers have recognized the value of incorporating GLR to enhance the comprehensiveness and applicability of their studies. This approach not only enriches the research by broadening the knowledge base but also ensures the credibility of the information remains uncompromised. Evidence of the successful integration of the MLR in the audit field can be found in several key studies referenced in (Van den Oever, 2020; Amaro et al., 2022; Pokhrel et al., 2020), and (Kamei et al., 2018). These studies confirm the practical utility of the MLR methodology, which we have adopted in our current research to draw upon a diverse array of knowledge sources. These sources provide various perspectives and

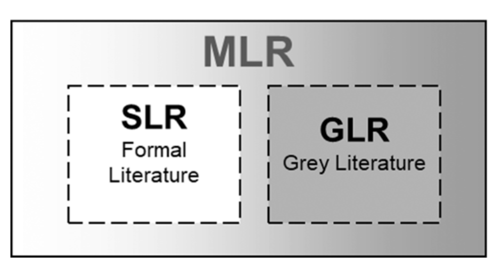


Fig. 3. The relationship between SLR, GLR and MLR.

objectives that are currently available, enriching the scope and depth of the audit literature (Ogawa and Malen, 1991).

In Table 2 of the study, we differentiate between "White" and "Grey" literature sources, where the aggregation of both forms the basis of the MLR. It is pertinent to note that to maintain the credibility of the data, literature including ideas, concepts, thoughts, and communications through social networks, tweets, and emails have been excluded (Garousi et al., 2019).

This MLR aims to identify and thoroughly examine the primary risk factors associated with the implementation of automated auditing tools, as reported by various auditing professionals. This involves exploring whether there exists a consensus among experts on the most effective strategies to mitigate these risks during implementation. The use of MLR allows the study to transcend the confines of conventional scientific literature by incorporating a wider spectrum of knowledge, thus enhancing the analysis process while maintaining rigorous quality standards (Garousi et al., 2019; Ogawa and Malen, 1991).

In the domain of auditing and the integration of RPA, the MLR process is depicted in Fig. 4 and unfolds in three phases. The initial phase of the research, titled "Planning the MLR," consists of two fundamental steps:

- Determining the necessity of conducting an MLR for auditing and RPA.
- Defining the objectives of the MLR and formulating specific research questions relevant to RPA in auditing.

While numerous guidelines exist for conducting an SLR, the MLR incorporates phases that diverge from traditional SLRs, particularly in the process of assessing the quality of information sources and their thorough investigation. Consequently, we will adapt the SLR guidelines to facilitate the execution of this MLR. As illustrated in Fig. 4, the structure of these guidelines for the MLR encompasses the planning, conducting, and reporting phases, as proposed by Garousi et al. (Garousi et al., 2019).

With the implementation of this model, it is anticipated that the inclusion of grey literature will furnish critical insights regarding the risks associated with implementing RPA in auditing processes. However, incorporating such literature introduces new challenges, primarily because it often relies on the practical experiences and opinions of professionals actively engaged in the field. To address these challenges and ensure robust data collection, this research will employ systematic guidelines to conduct the MLR (Garousi et al., 2016). This approach will allow for the application of specific inclusion and exclusion criteria, akin to those used in SLRs, to filter the results obtained through the world's leading search engine, Google. This methodology aims to provide a structured and comprehensive aggregation of both academic and grey literature, thereby enhancing the depth and applicability of the findings.

During the conducting review, the search string defined above was searched via Scopus, Web of Science, IEEE Xplore, ACM digital library, and Google - the last one for grey literature:

- (("robotic process automation" OR rpa OR "intelligent process automation") AND (audit*))

After acquiring potentially relevant primary sources, the following filters were established as illustrated at Table 3.

Regarding grey literature, Filter 2 undergoes modification; specifically, the Query Title is utilized instead of Query Abstracts. During the protocol definition stage of the MLR's planning phase, selection criteria were established to minimize the risk of bias. These criteria are articulated through inclusion and exclusion parameters, as detailed in Table 4.

The limitation associated with using Google Search, particularly regarding the replicability of searches at specific times, was acknowledged. Nonetheless, some scholars contend that methodologies for website searches can vary, emphasizing the importance of a well-thought-out rationale tailored to the specific goals and objectives of each review. This perspective suggests flexibility over adherence to a single methodological approach. Thus, careful planning and execution of the research, systematic screening of results, and the establishment of effective management structures are essential to ensure the robustness of this methodology (Stansfield et al., 2016).

Consequently, it is recommended to perform an extensive search of grey literature using at least one standard search engine (e.g., Google, Yahoo, or Bing) and to consider the first 12 pages of results instead of limiting the review to just the first 5 pages. Additionally, it is advisable to conduct a detailed examination of academic databases that are closely related to the research topic. This comprehensive approach ensures that all relevant literature, both grey and academic, is considered, thereby supporting the development of more thorough and substantive conclusions (Bellefontaine and Lee, 2014; Coleman et al., 2020).

The outcomes of the research are presented in Table 5, which lists a total of 61 documents: 18 white papers and 26 pieces of grey literature. The technique of snowballing yielded an additional 17 white papers, identified through references cited in our initial set of documents.

5. Audit

The term 'audit' originates from the Latin 'audire', meaning 'to listen', and aims to assure that financial statements are free of significant fraud or errors before reporting to stakeholders (Financial Reporting Council, 2023; Hayes et al., 2014). An audit evaluates a company's performance or systems, often lengthy when performed manually (Widuri et al., 2019). Typically, audits follow a four-stage pattern detailed in Table 6.

Regardless of the client's IT or accounting complexity, auditors are required to carry out audits within the criteria of the regulations. The client is likely undergoing processes involving advanced analytical techniques and new data sources. The increasing use of Big Data and the subsequent application of more advanced analytics by clients are the most recent challenges facing auditors (D. Appelbaum and Nehmer, 2017). That is why automation is so present in audits nowadays.

According to the research, there is no agreement on which activities should be automated. However, there is a requirement to automate highly structured and repetitive processes (Griffiths and Pretorius, 2021).

6. Robotic process automation

The results of the MLR examining the integration of RPA in audit practices yield compelling insights into its benefits. This review, encompassing a diversity of perspectives and sources, provides a nuanced understanding of how RPA can enhance audit procedures. The systematic analysis reveals advantages, from operational efficiencies to strategic enhancements, that RPA contributes to the audit process. Table 7 summarizes the benefits found, serving as a testament to the transformative impact of RPA on auditing.

As with any technological implementation, the adoption of RPA in

Table 2
Spectrum of the "White", "Grey" and Excluded literature (adapted from (Garousi et al., 2019)).

"White" literature	"Grey" literature	"Black" or other types of literature (excluded)
Papers published in journals.Conference ProceedingsBooks	Preprints; e-Prints; Lectures; Datasets; Gouvernement documents Standards; White papers; Technical reports; Blogs;Audio-video media	IdeasConceptsThoughts

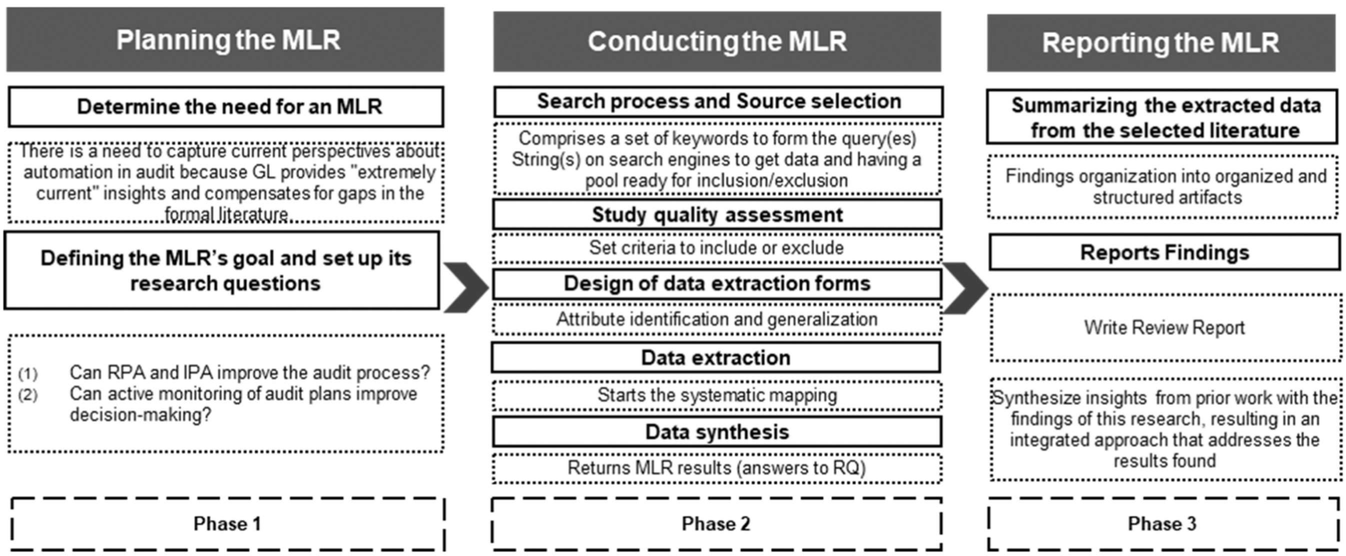


Fig. 4. Process stages for MLR: planning, conducting, reporting.

Table 3
Filters used in the literature review.

Filter **1**	Query All Metadata, All documents
Filter **2**	Query Abstracts, All documents
Filter **3**	Relevant (inclusion/exclusion criteria)
Filter **4**	Erase duplicates
Filter **5**	Out of Scope
Filter **6**	Snowballing

Table 4
Inclusion and Exclusion Criteria.

Inclusion Criteria	**Exclusion Criteria**
Written in English	Unidentified author
Since the 2000 s	Irrelevant topics such as medicine
Pdf's Document	Conference Review

Table 5
Review conclusions.

Database	**Filter 1**	**Filter 2**	**Filter 3**	**Filter 4**	**Filter 5**	**Filter 6**
IEEEXplore	25	16	16	3	2	+17
ACM Digital Library	437	2	2	2	2	
webofscience	100	30	30	0	0	
Scopus	3 329	104	61	55	14	
Google	16,500,000	479	41	26	26	
Total	**16,503,891**	**631**	**150**	**86**	**44**	**61**

auditing is accompanied by inherent risks that necessitate careful consideration. The outputs of the MLR offer not only a lens through which the benefits can be viewed but also shed light on the potential pitfalls and challenges. Table 8 distills the associated risks identified during the MLR, providing a comprehensive overview that auditors and decision-makers can reference to preemptively address and navigate these complexities.

RPA has implications for governance, control, and risk management in the organization. Before any RPA implementation, governance structures should be in place (Steinhoff et al., 2019). Concerns about privacy and security have an impact on the risk environment because the collection of digital evidence during auditing may expose sensitive (KPMG, 2018b; Mandal et al., 2017; Moffitt et al., 2018b; Syed et al., 2020b; Wojciechowska-Filipek, 2019b). To put it another way, the risk of organizational cybersecurity breaches may be on the rise.

These risk areas will require changes to the organization's risk assessment and may necessitate changes to auditing standards (D.

Table 6
Audit Processes (Adapted from (Chicago State University, 2023)).

Processes	**Description**
Planning	The auditor notifies the client of the audit, meets with organization management to discuss the scope and objectives of the examination, gets information on critical processes, analyzes current controls, and plans the remaining audit stages.
Fieldwork	Transaction testing and informal communication are the focus of the fieldwork. The auditor assesses whether the controls identified during the preliminary review are functioning effectively and, in the way, stated by the client during this phase. The fieldwork stage ends with a list of important findings from which the auditor will construct the audit report's final draft.
Audit Report	The final report, in which we document our audit findings and recommendations for improvement, is our main product. This also includes the response and implementation plan from management, as well as the completion timeline and responsible individual(s). Internal Audit discusses the rough draft with the client before issuing the final report to facilitate communication and guarantee that the recommendations written in the final report are practical.
Follow-up review	The client response documentation is examined, and the actions taken to address the audit report findings may be put to the test to ensure that the desired outcomes were achieved. In the follow-up report, all unresolved findings will be discussed.

Table 7
Benefits of RPA in Audit.

Benefits	References
Savings in human efforts	(Anagnoste, 2017; Gotthardt et al., 2020; Handoko et al., 2021b; Herrera et al., 2020; Mandal et al., 2017; Moffitt et al., 2018b)
Increased value-add talent	(Anagnoste, 2017; Handoko et al., 2021b; Herrera et al., 2020; Mandal et al., 2017; Moffitt et al., 2018b)
Increased agility for transformation	(Herrera et al., 2020)
Reduced errors	(Herrera et al., 2020; Moffitt et al., 2018b)
Increase in speed of delivery	(Handoko et al., 2021b; Herrera et al., 2020; Mandal et al., 2017)
Customer satisfaction/ advocacy	(Handoko et al., 2021b; Herrera et al., 2020; Mandal et al., 2017)

Table 8
Benefits of RPA in Audit.

Risks	References
Privacy and Security	(KPMG, 2018b; Mandal et al., 2017; Moffitt et al., 2018b; Syed et al., 2020b; Wojciechowska-Filipek, 2019b)
Compliance risks	(Deloitte, 2020; KPMG, 2018b; Mandal et al., 2017; The New Frontier Of Automation: Enterprise RPA, 2017)
Selecting the wrong tool	(Deloitte, 2020; Handoko et al., 2021b; KPMG, 2018b; Mandal et al., 2017; Moffitt et al., 2018b; The New Frontier Of Automation: Enterprise RPA, 2017)
Costly maintenance	(Deloitte, 2020; KPMG, 2018b)

Appelbaum and Nehmer, 2017). Controls that ensure the confidentiality, integrity, authenticity, and reliability of data used by RPA software should be implemented (Wojciechowska-Filipek, 2019b).

Opting for an inappropriate sourcing model may incur significant financial implications (Deloitte, 2020; Handoko et al., 2021b; KPMG, 2018b; Mandal et al., 2017; Moffitt et al., 2018b; The New Frontier Of Automation: Enterprise RPA, 2017). Such fiscal burdens often arise within organizations that elect to internalize all operations without the requisite expertise in governance, development, and implementation, or those that select inexperienced advisors or engage them after crucial decision-making junctures.

Conversely, the integration of Robotic Process Automation in the confidential information disclosure processes to banking authorities has demonstrated a decrement in the risk of non-compliance regarding information security and statutory mandates (Wojciechowska-Filipek, 2019b). RPA's reduction of procedural errors presents a potential solution to compliance-related challenges (Deloitte, 2020; KPMG, 2018b; Mandal et al., 2017; The New Frontier Of Automation: Enterprise RPA, 2017). It is incumbent upon organizations to meticulously assess the varied deployments of RPA to align with strategic objectives and mitigate business impacts (Hale et al., 2020). A comprehensive analysis of the associated risks of adopting RPA and Intelligent Process Automation within the audit function is presented in Table 9.

7. Solution design

The project utilized UiPath Studio Community, selecting appropriate project types and templates which influenced the dependencies in the Studio. Key dependencies integrated into the project include *UiPath.DocumentUnderstanding.ML.Activities* for machine learning features in document processing, *UiPath.PDF.Activities* for comprehensive document management, *UiPath.Mail.Activities* for email operations, *UiPath-Team.OutlookCalendar.Activities* for managing Outlook calendar events, and *UiPath.Excel.Activities* for handling Excel operations. These dependencies were critical in enabling functionalities like machine learning-based document reading, email handling, and meeting scheduling, highlighting UiPath's capacity to facilitate complex tasks with minimal development expertise. The subsequent sections will delve into the development stages of the solution.

Table 9
Identified targeted risk categories for implementing a program with RPA and AI (Adapted) (Mandal et al., 2017).

Business Risks		Automation Risks	
Executive	Who designs control systems?Who will manage the framework and promote efficiencies?	License Compliance; Automation strategy and governance.	Proof of Concept
Functional	Who designs control systems?Are any scalability limitations in RPA and core systems?	Adapting schemes of existing systems with new features;Legacy systems for simultaneous and unified operations across technical testing and rollout.	Backward Compatibility
Technical	How will the data quality and accuracy be ensured?	Incident management and business continuity;Regulatory compliance.	Implementation
Operational	Which controls need to exist to monitor performance?How will the business comply with regulatory requirements?	Data leakage and privacy;Cyber threats.	Business Case

8. Annual internal audit plan

The annual internal audit plan serves as a key document outlining the audit engagements scheduled for the upcoming year, tailored to the specific needs of each organization (AuditNet, 2023). Initially, defining essential attributes for the audit plan is critical, as these characteristics form the basis of the development process and are instrumental in automating routine tasks such as email correspondence. Key elements include the email addresses of the auditor and the auditee, the audit's name, and the start date, all crucial for operational effectiveness. A thorough review of existing audit plans from public entities ensures alignment with these criteria, although some plans may show structural inconsistencies such as poorly formatted tables or imprecisely noted dates. Effective collaboration between development and business teams is essential to address any potential modifications that might impact the development process. This collaborative approach aids in maintaining a robust audit plan that supports automated functions like scheduling and sending alerts for upcoming audits, thereby enhancing the efficiency and accuracy of the internal audit function.

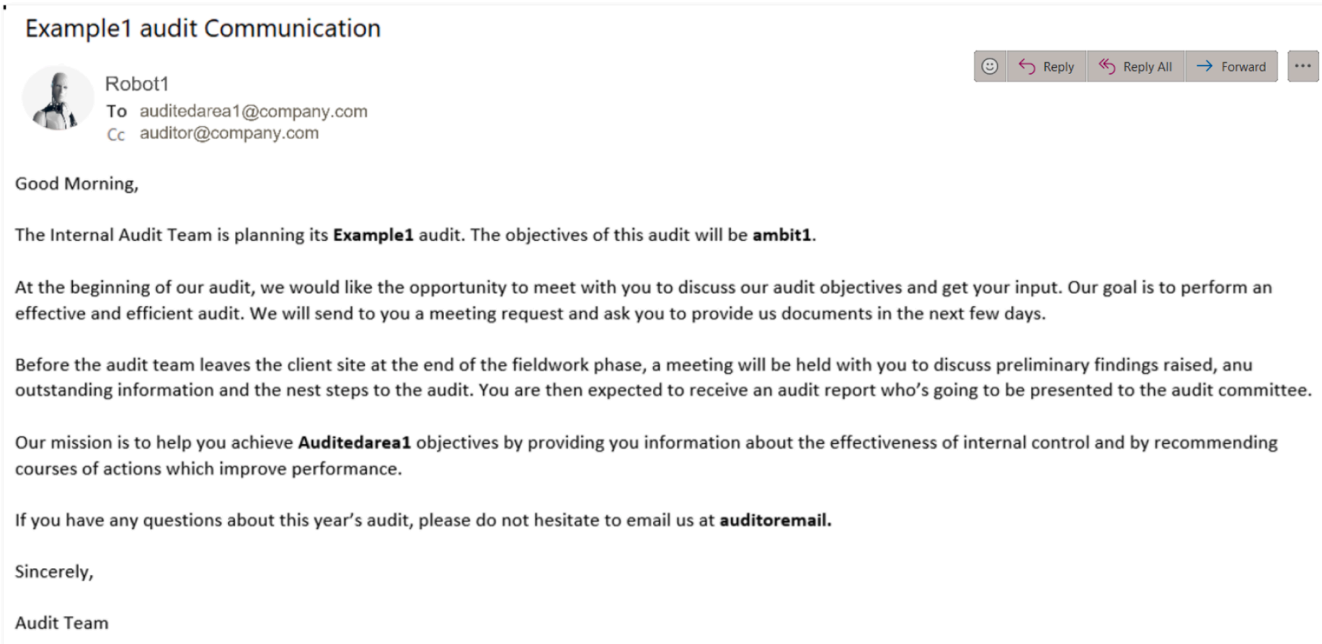
9. Launching the audit process

In the second stage of the audit initiation process, the automation system plays a pivotal role. Upon determining which new audit is about to start, the robot begins by creating the necessary organizational structure. This involves setting up designated folders for different phases of the audit, specifically for communication, execution, and reporting, at a URL specified by the auditor.

Following the creation of these folders, the RPA then proceeds to facilitate initial communications. It sends an email to notify involved parties of the upcoming meeting and schedules this meeting based on the date previously provided by the auditor during the initial planning phase. The communication email, as illustrated in Fig. 5, leverages data pulled from the audit plan, including the audit name, scope, the email of the audited area, and the auditor's email. Post this communication, the robot does not engage further, leaving any potential meeting cancellations or rescheduling to be handled directly by the auditor.

Subsequently, the RPA verifies the existence of an information request list, an essential artifact for the collection of audit evidence. Acknowledging that this document may not be readily accessible, the system is configured to conduct daily searches for up to five days. Should the document remain undiscovered after this interval, the robot dispatches an email notification to the auditor, indicating the necessity for manual intervention in the document transmission process. Conversely, if the document is located within the prescribed period, the robot immediately forwards it to the auditee, as illustrated in Fig. 6.

This automation of evidence requests and communication significantly streamlines the auditing process, making it more efficient by reducing delays and manual intervention. These steps, along with the entire audit plan analysis process, are summarized in the Information Flowchart shown in Fig. 7. This flowchart provides a visual overview of the sequence and interactions of the tasks involved in this audit initiation stage.



Example1 audit Communication

Reply Reply All Forward

Robot1
To auditedarea1@company.com
Cc auditor@company.com

Good Morning,

The Internal Audit Team is planning its **Example1** audit. The objectives of this audit will be **ambit1**.

At the beginning of our audit, we would like the opportunity to meet with you to discuss our audit objectives and get your input. Our goal is to perform an effective and efficient audit. We will send to you a meeting request and ask you to provide us documents in the next few days.

Before the audit team leaves the client site at the end of the fieldwork phase, a meeting will be held with you to discuss preliminary findings raised, anu outstanding information and the nest steps to the audit. You are then expected to receive an audit report who's going to be presented to the audit committee.

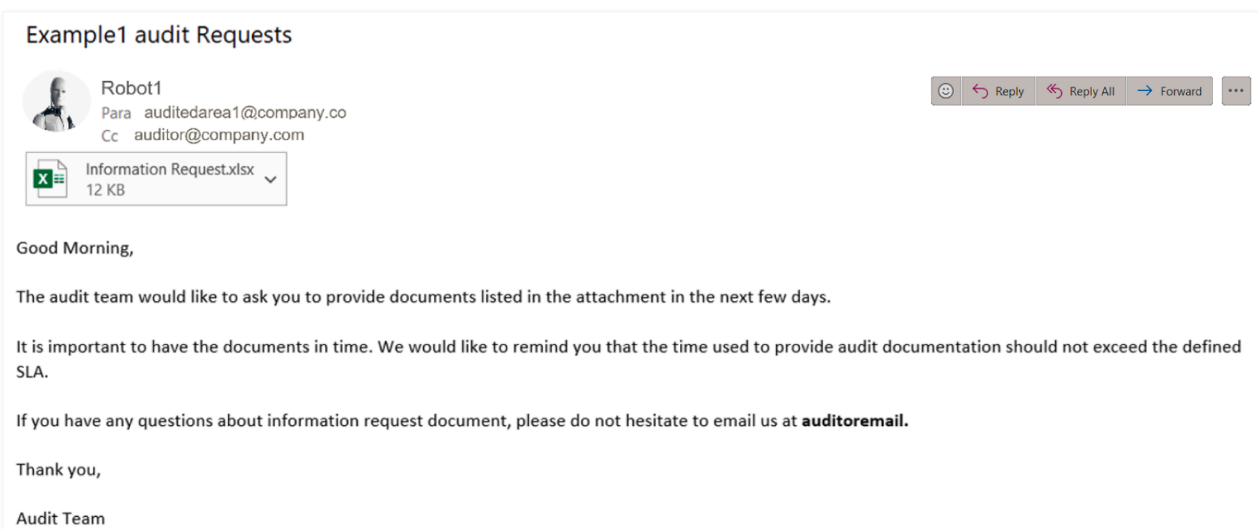
Our mission is to help you achieve **Auditedarea1** objectives by providing you information about the effectiveness of internal control and by recommending courses of actions which improve performance.

If you have any questions about this year's audit, please do not hesitate to email us at **auditoremail.**

Sincerely,

Audit Team

Fig. 5. Communication email output.



Example1 audit Requests

Reply Reply All Forward

Robot1
Para auditedarea1@company.co
Cc auditor@company.com

Information Request.xlsx
12 KB

Good Morning,

The audit team would like to ask you to provide documents listed in the attachment in the next few days.

It is important to have the documents in time. We would like to remind you that the time used to provide audit documentation should not exceed the defined SLA.

If you have any questions about information request document, please do not hesitate to email us at **auditoremail.**

Thank you,

Audit Team

Fig. 6. Information request email output.

9.1. *Reporting tool*

The third phase of the audit process culminates in scheduling the final meeting and dispatching the final report, following a 15-day period allocated for fieldwork. This duration may be adjusted depending on the actual time spent in fieldwork. Should the final document not be present in the designated folder after this period, the robotic system initiates daily checks for up to five days. Failure to locate the document prompts the robot to notify the auditor to take over the document-sending phase. Conversely, if the document is located, the robot seeks the auditor's approval to send it and to schedule the final meeting, requesting the meeting date in the format dd/MM/yyyy. Approval from the auditor triggers the robot to execute these tasks. The format for the final report email is derived from a template used by The University of Texas at Dallas, as illustrated in Fig. 8. This automated process ensures efficiency and timeliness in the final stages of the audit.

The robot then moves on to the activity where it reads the report and takes the information from the findings table, with the CV technique's help. The CV activities used for reading the audit plan are used again for analyzing the final audit report. However, as the final audit report is usually a longer document, additional steps had to be added to ensure that the table summarizing the findings status is read.

To ensure the robot locates the required table, the Send HotKey activity is used following the CV Screen Scope activity to perform a page down if the "Finding Status" table isn't initially found. This part of the process, which involves the robot methodically reading each screen element, may take a few seconds.

Additionally, a final audit report template closely mirroring real-world business formats is utilized, sourced from The Internal Auditor's website, which offers resources to enhance audit effectiveness (The Internal Auditor, 2023). Table 10 in the final report displays this "Finding Status" table, showcasing the practical application of these templates.

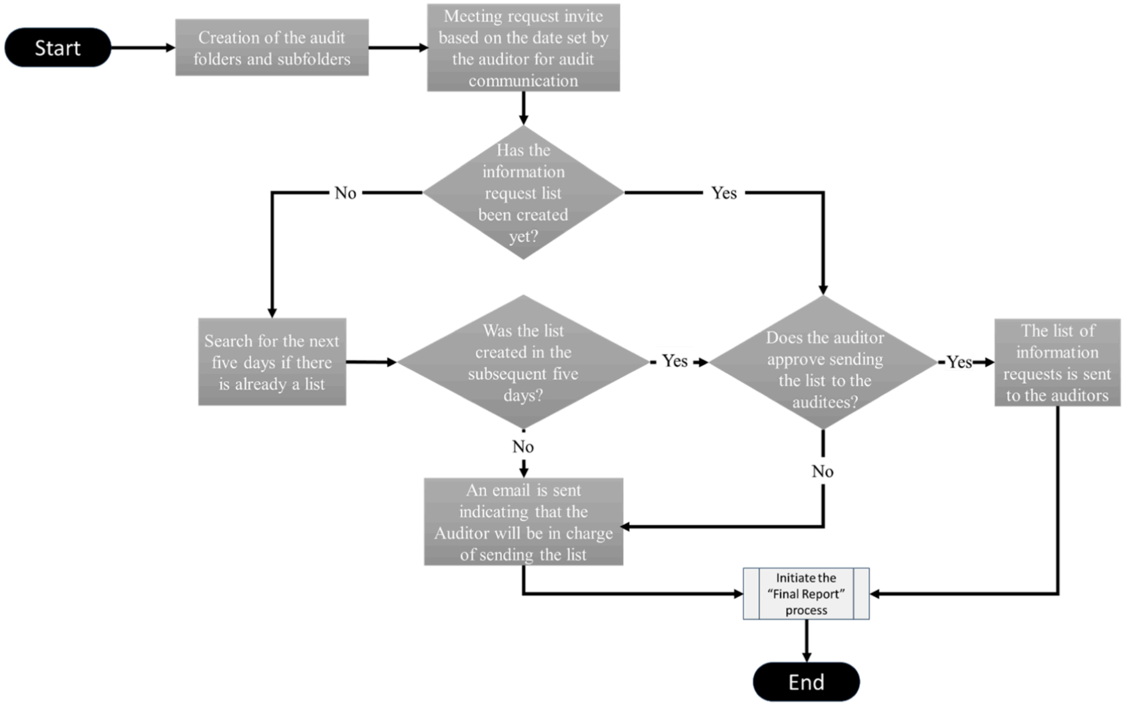


Fig. 7. Information flowchart.

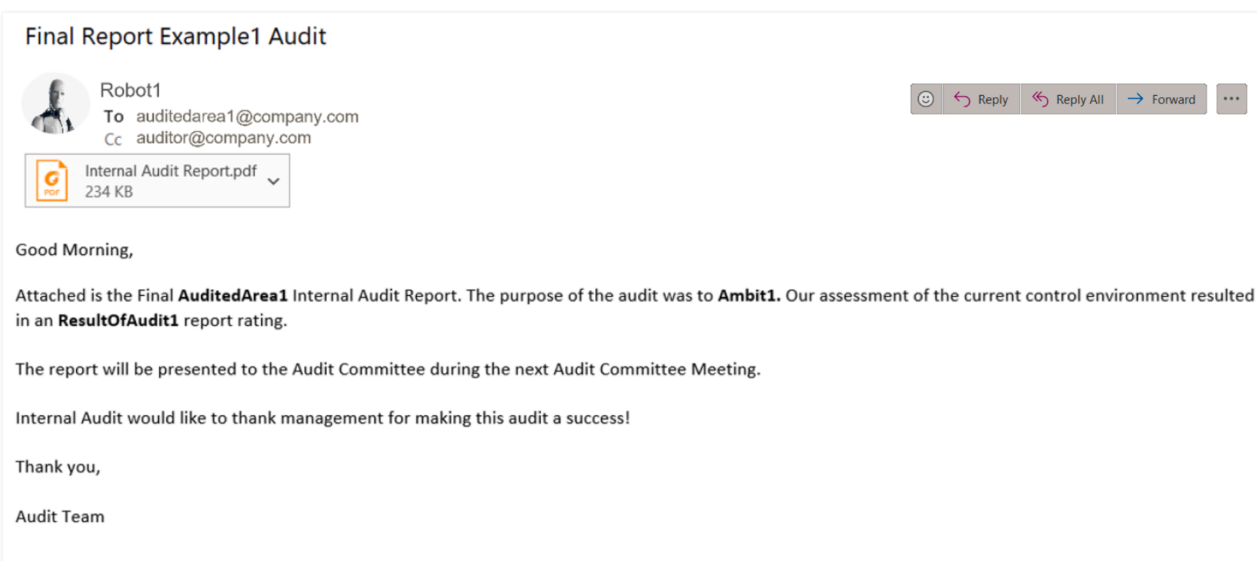


Fig. 8. Output Final Report email (Adapted) (Stephen S., 2020).

Table 10
Findings Status (example).

Findings Status	Critical	Significant	Less Significant	Minor	Total
Number of Findings	0	4	1	5	10
Cleared Findings	0	0	0	0	0
Findings to clear	0	4	1	5	10

Upon completion of the table reading process via the Computer Vision (CV) activity, the Write Range activity is employed to transfer the data table, which contains the finding status table, to another Excel file. It is noteworthy that this step is undertaken exclusively when the document is in PDF format.

Following the extraction of the table into an Excel sheet, the robot concludes its role in this development phase. These final activities, along with the entire process of analyzing the audit plan, are succinctly summarized in Fig. 9.

It should be noted that at both the commencement and conclusion of the development, two variables are designated to record the actual start and end dates of the audit. These variables are subsequently extracted to an Excel file to calculate KPIs, a topic that will be elaborated upon in the following section.

10. Key performance indicators

As noted earlier, Power BI will be employed to integrate data from

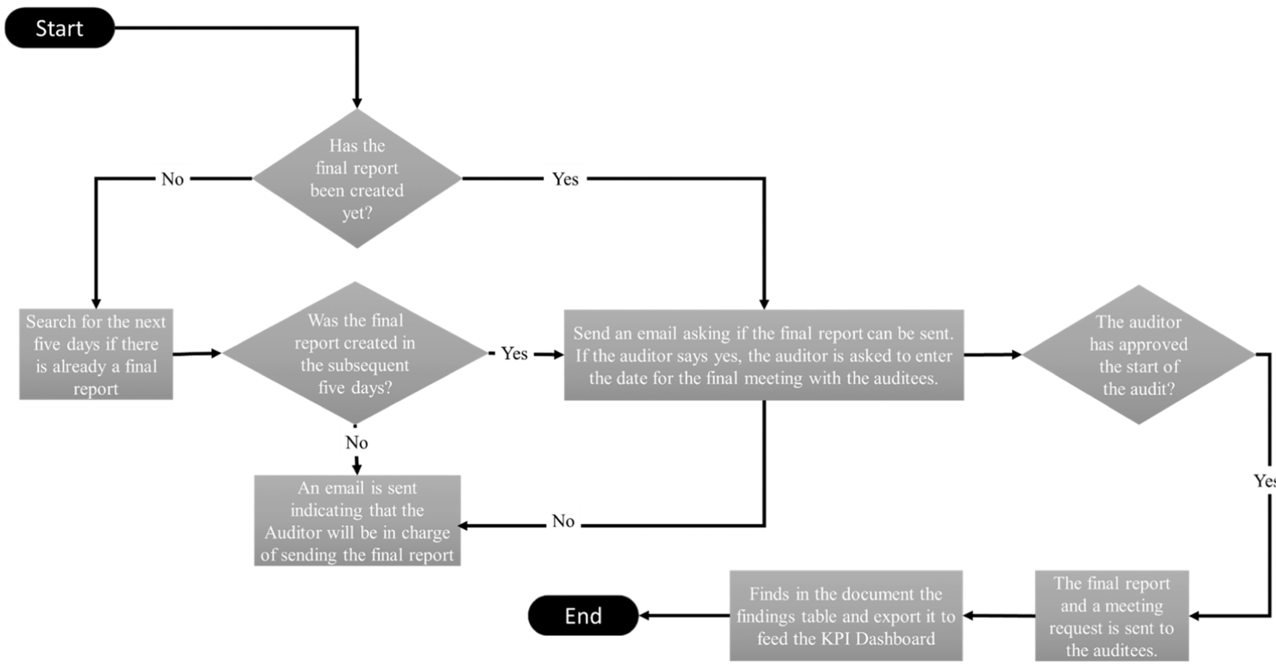


Fig. 9. Final Report Flowchart.

IPA databases to facilitate precise, data-driven audit decisions and illustrate how audit activities align with the strategic objectives of the company (Lu and Chesbrough, 2021). The KPIs commonly used include (AuditBoard, 2019):

1. Percentage of completed audits;
2. Count of planned audits;
3. Count of findings found per gravity; and
4. Hours spent per audit;

Correspondingly, three Excel workbooks have been developed during the IPA process containing data tables for (1) the audit plan, (2) the finding status of completed audits, and (3) the actual start and end dates of the audits. These workbooks will be integrated into the Power BI dashboard to enhance the visual representation of the data. This integration is depicted in Fig. 10.

A comprehensive visualization was developed using the Power BI tool, incorporating all identified KPIs into a single-page report for a managerial overview. The report features both iterative and informative visual elements, employing the Zebra BI matrix visual - a highly effective Power BI table that enables the creation of detailed and visually appealing reports (Zebra BI, 2023). This tool allows for dynamic filtering of data by auditor, audited department or area, and year, providing a segmented analysis of each KPI. Additionally, it supports the comparison of current findings with previous audits and checks if the actual time spent on an audit aligns with the estimated time. The report, in Fig. 11, is designed to be user-friendly and continuously updated, aiding management in evaluating audits, managing team performance, and informing decisions related to resource allocation, future audit planning, and scope improvements. This ensures that management decisions are well-supported by timely and relevant data insights.

In conclusion, the final stage is critical as it allows management to evaluate real data without human interference, identifying audits that may need more time or have issues. This data-driven insight helps in making informed decisions about enhancing the IPA system, ensuring effective reporting to the board while preventing unnecessary expenditures and automation failures.

11. Demonstration and evaluation

This section aims to demonstrate step four of the DSRM which is to demonstrate that the artifact is effective in solving the problem. To respond to this important step, some auditors from the banking sector in Portugal were asked to give their opinions about the implemented

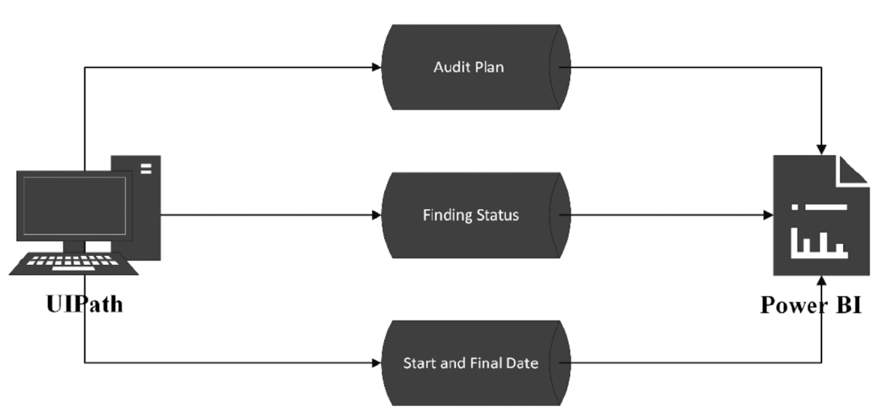


Fig. 10. Data bases scheme.

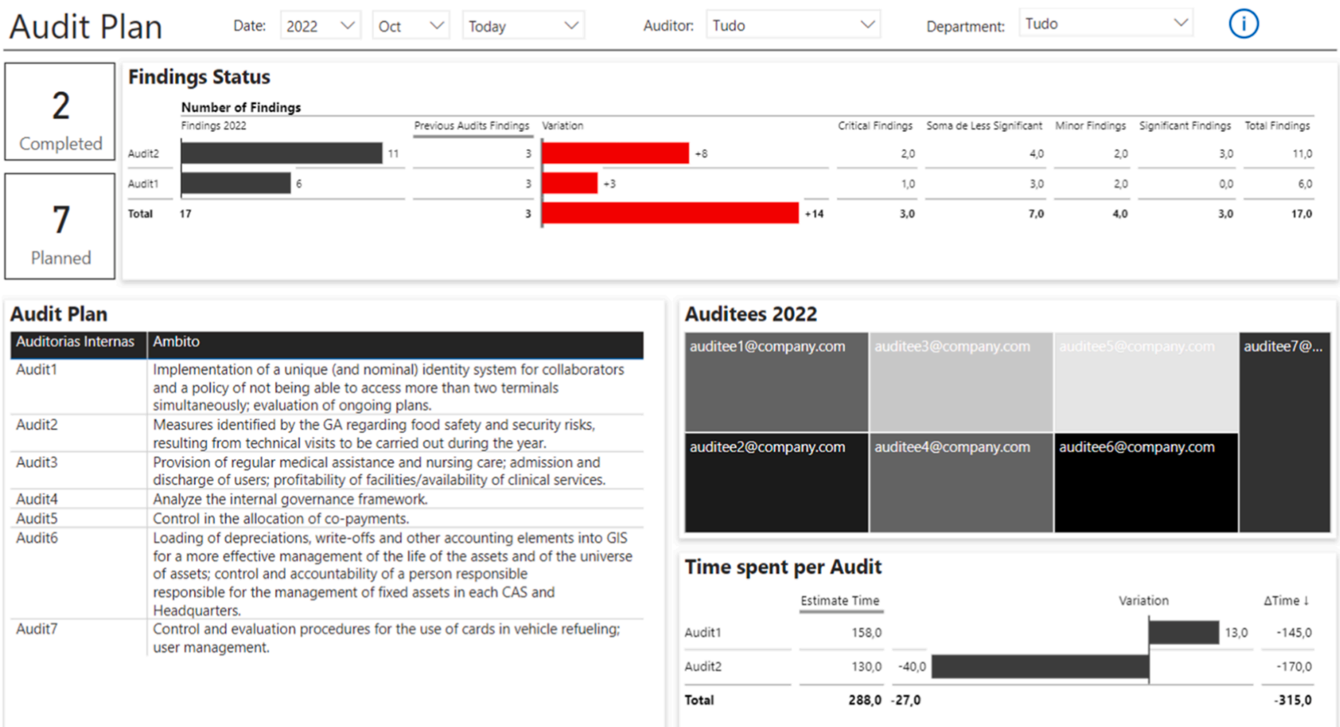


Fig. 11. Power BI dashboard.

solution. The response from auditors turns out to be one of the most important in understanding the need for the solution developed in this area since they are the ones facing the changes in the process with the implementation of IPA.

To evaluate the proposed artifact, numerous interviews were conducted with experts and professionals from both fields. Interviews are a fundamental component in social science research, extensively discussed in various publications on research methodology (Eisenhardt, 1989; Hollweck, 2015). The objective of these interviews is to draw inferences about a broader population by analyzing a sample from that population. This approach stands in contrast to a census, which seeks to gather observations from the entire population and is another method employed for evaluating artifacts. Consequently, for this study, a semi-structured questionnaire was utilized to assess the proposed artifact.

In this study, the artifact underwent evaluation based on its construct and model using specific principles. These included completeness, ease of use, fidelity to real-world phenomena, internal consistency, level of detail, simplicity, understandability, importance, accessibility, and suitability, as delineated by March and Smith (March and Smith, 1995) and Rosemann and Vessey (Rosemann and Vessey, 2008). Guided by these principles, a semi-structured questionnaire was developed, as detailed in Table 11.

As emphasized earlier, assessment is crucial within the DSRM. To evaluate the artifact effectively, professionals from both the BC and Audit sectors were selected, who possessed various levels of experience and expertise. This approach was intended to deepen the rigor of the evaluation and ensure the artifact's practical applicability.

12. Interview questions

To gather conclusive data, it was essential to ask respondents the right questions, covering basics like age, gender, and professional background, as well as their experience with automation. Initial questions gauged auditors' awareness and perceptions of automated processes in their company and their impact on management. Subsequent inquiries sought evaluations of specific automated activities, such as alerting auditors of upcoming audits, scheduling meetings, sending informational emails, and generating a Power BI report to support KPIs. Auditors rated the value of these automations on a scale from 0 (not useful) to 5 (very useful). Finally, two optional open-ended questions were posed to collect feedback on desired automation and potential improvements in the development process.

Table 11
Semi-structured questionnaire for evaluation of the purposed artifact.

	Criterion	Statement
1	Completeness	The introduction of automation into the audit process contains all the rules and standards of both realms.
2	Ease of use	The introduction of automation into the audit process is well-described and easy to verify and implement in both contexts.
3	Fidelity with real-world phenomena	The proposed artifact corresponds to possible solutions.
4	Internal consistency	The findings to introduce automation into the audit process use adequate terminology, are well-written, and are justified by the theory.
5	Level of Detail	The proposed artifact contains a sufficient level of detail in each mechanism for each area.
6	Simplicity	The proposed artifact contains the necessary practices and it is easy to implement.
7	Understandability	The proposed artifact is easily understood as a good practice for both BC and Audit practitioners.
8	Importance	The proposed artifact is important for both practitioners and academics.
9	Accessibility	The proposed artifact has an understandable terminology with a practical perspective, not only a theoretical one.
10	Suitability	The proposed artifact of practices is applicable in the practice of both realms.

13. Population and sample

The population under consideration comprises auditors from four Portuguese banks and offers insightful details about the composition of audit teams in terms of qualifications, age, roles, and gender. Table 12 provides an overview of the characteristics of the sampled population for the study.

Educational background:

A majority of the auditors (53%) hold bachelor's degrees, indicating that this level of education is sufficient for most auditing roles within these banks.

The significant portion (42%) with master's degrees suggests a high level of expertise and possibly a preference or requirement for higher education in more complex audit functions.

Only a small fraction (5%) has post-graduate qualifications, reflecting perhaps that such advanced degrees are not typically necessary for the roles filled by the respondents.

Age Distribution:

Nearly half (47%) of the auditors are between thirty and thirty-nine years old, suggesting a mature workforce with substantial professional experience.

The representation across other age groups (23% between forty and forty-nine, 18% younger than twenty-nine, and 12% over fifty) shows a broad range of ages, which can contribute to diversity in perspective and approach within the audit teams.

Roles within Audit Departments:

The vast majority (82%) being technicians indicates that the primary need within these audit departments is for hands-on auditing work.

The presence of coordinators (12%) and directors (6%) suggests a structured hierarchy but with relatively few in leadership roles, emphasizing a pyramid structure in staffing.

Gender Distribution:

The gender split shows a slight male predominance (58%) but is relatively balanced (42% female), suggesting no significant gender disparity. This balance may contribute to diverse viewpoints and approaches to auditing, potentially enhancing the effectiveness and comprehensiveness of audits.

Overall, the survey highlights a well-educated, age-diverse audit workforce with a reasonable gender balance, primarily composed of technical staff with a structured, yet minimal, leadership hierarchy. This composition could be indicative of a robust and dynamic auditing environment, capable of addressing various challenges and complexities within the banking sector.

In the context of determining the requisite number of interviews for qualitative research, Myers (2013) contends that the quantity is indeterminate and varies depending on the research question and the nature of the insights sought. The concept of saturation is achieved when no additional insights are garnered that contribute to the understanding of the research question (Myers, 2013; Myers and Newman, 2007). In the current study, which aims to evaluate and refine a model designed to streamline the audit process, saturation was attained after the tenth interview. Subsequent interviews, ranging from the eleventh to the seventh, did not yield any new insights that further elaborated on the proposed model as a possible solution.

Table 12
Profile of Auditors in Portuguese Banks: Qualifications, Age, Roles, and Gender Distribution.

Description	Details
Number of Auditors Surveyed	17
Banks Involved	4 Portuguese Banks (2 Large, 2 Small to Medium-sized)
Academic Qualifications	Bachelor's: 53% Master's: 42% Post-graduate: 5%
Age Distribution	<29 years: 18% 30–39 years: 47% 40–49 years: 23% >50 years: 12%
Job Roles	Technicians: 82% Coordinators: 12% Directors: 6%
Gender Distribution	Male: 58% Female: 42%

14. Data collection

In Table 13 below, we summarize the key findings from a recent survey conducted among auditors across four Portuguese banks. This table presents the auditors' responses to various aspects of automation within their audit processes, illustrating their levels of awareness, acceptance, and resistance to automated activities. The responses are categorized into several key areas of automation implementation and evaluate their impact on the audit workflow. This data aids in understanding the current stance of audit professionals towards automation and highlights areas where further discussion or intervention may be necessary.

The survey results among auditors in Portuguese banks generally show a positive attitude towards automation in audit processes. A significant majority of auditors are aware of and acknowledge the benefits of automation, with nearly unanimous support for an automated alert system and strong approval for Power BI reporting.

However, some resistance remains, notably with routine task automation like email notifications, where about 12% expressed disagreement. This resistance could stem from concerns over job security or the adequacy of automation for complex tasks.

Responses also indicate that perceptions of automation's benefits may vary by role, with less direct involvement leading to more neutral views. Despite some resistance, the overall acceptance suggests a favorable outlook for further integrating automation into audit practices, though continued education and dialogue will be crucial to address lingering doubts and ensure widespread adoption.

15. Discussion

This section critically examines the findings of the study, integrating both theoretical insights and practical implications of deploying IPA within the auditing processes of financial institutions, particularly in the banking sector. While the integration of IPA offers significant enhancements in efficiency and strategic decision-making, it also presents

Table 13
Auditor attitudes towards automation in audit processes.

Survey Aspect	Response	Comments
Awareness of Automated Activities	94% aware	
Resistance to automation	18% reported resistance	Some auditors showed doubts or resistance.
Impact of Automation	88% positive impact	
Support for Audit Alert System	100% support	65% totally agree.
Approval of Automatic Email Notifications	82.35% agree	11.77% disagreed, 5.88% neutral.
Scheduling and Sending of Final Report	58% approval	23.53% neutral, mostly technicians.
Scheduling Audit Communication Meetings	62.5% agree	
Implementation of Power BI Reporting	94% agree	1 neutral auditor identified resistance in audit areas.
Overall Rating of Solution (Scale 0–5)	94% rated above 4	Indicates a positive evaluation despite initial resistance to change.

challenges and raises important considerations for implementation and future development (Gegenhuber and Mair, 2024; Peñarroya-Farell and Miralles, 2021; Yun et al., 2022). Here, we discuss the broader implications of our findings, focusing on their relevance to banking sector policymakers, and delineating the theoretical contributions to the existing literature on business continuity and audit practices (Harsanto et al., 2022). This discussion aims to bridge the observed gaps identified in previous sections and suggests pathways for leveraging IPA to enhance audit effectiveness and organizational resilience. Moreover, it offers recommendations tailored to policymakers and industry leaders who are positioned to influence the adoption and regulation of emerging technologies within the audit domain (Bigliardi et al., 2020).

The integration of IPA within business continuity auditing, as explored in this study, has demonstrated substantial potential to streamline audit processes through the automation of routine tasks such as communications, information requests, and final report submissions. This shift not only enhances operational efficiency but also supports auditors in their critical role during technological transformations.

From a theoretical standpoint, this study contributes to the body of knowledge by bridging the gap between business continuity practices and the application of IPA in the auditing domain. It challenges existing theories that view automation merely as a tool for operational efficiency, proposing instead that automation is pivotal in enhancing the strategic decision-making process within financial institutions. This perspective suggests a paradigm shift where automation is seen as a transformative force that aligns closely with business goals rather than just a means to reduce labor costs.

Practically, the findings from this research have direct implications for banking sector policymakers:

- **Enhanced Compliance and Risk Management:** Automated tools can provide real-time data analysis, which is crucial for maintaining compliance with evolving regulations and managing risks proactively.
- **Strategic Resource Allocation:** By automating routine and time-consuming tasks, resources can be redirected toward more critical analytical and strategic functions. This not only improves productivity but also enhances job satisfaction among audit professionals by reducing monotonous tasks.
- **Decision Support:** With automation, audit data can be processed and presented in ways that support strategic decisions, providing insights that were previously difficult to extract manually.

  The adoption of IPA in auditing represents a transformative opportunity for the banking sector. However, the successful integration of these technologies necessitates supportive policy frameworks and strategic initiatives from regulators and government bodies. These suggestions aim to maximize the benefits while mitigating potential risks associated with IPA, ensuring that the banking sector remains robust, compliant, and competitive in a rapidly evolving digital landscape:
- **Adopting Progressive Regulatory Frameworks**: Policymakers should consider creating and adapting regulatory frameworks that encourage the adoption of automation while ensuring robust data security and privacy standards.
- **Encouraging Investment in New Technologies**: There should be a clear directive from regulators and government bodies encouraging banks to invest in new technologies that facilitate transparency and efficiency in auditing processes.
- **Training and Development**: To overcome resistance to new technologies, comprehensive training programs should be implemented to ensure that the workforce is well-prepared to leverage these new tools effectively.

While the study effectively demonstrates the benefits of IPA in auditing, there remains a lack of discussion on:

- **Integration Challenges:** How do existing systems integrate with new automated tools without disrupting current operations?
- **Long-term Sustainability:** What are the long-term impacts of automation on employment within the banking sector, and how can these be mitigated?
- **Customization and Scalability:** How can these automated solutions be customized to fit different sizes and types of banks or financial institutions?

16. Conclusions

This study aimed to integrate automation within the audit process, thereby streamlining manual and repetitive tasks to enhance the efficacy of business continuity management. This goal was pursued through the identification of optimal automation solutions and the mitigation of associated risks.

A multi-stage methodological approach was utilized, beginning with an extensive literature review to identify the risks, benefits, and challenges linked with the automation of audit processes. This was followed by the application of the DSRM to precisely define the core problem and develop an appropriate solution. Subsequent phases involved the detailed design and development of the proposed solution, culminating in a survey conducted among bank auditors to evaluate how well the solution met their needs.

The findings from this study highlight the pivotal role of IPA in the audit process. Significant advantages were observed, including the implementation of an alert system that notifies auditors of upcoming audits and the use of KPIs to provide a detailed overview of the progress within the audit plan. These tools help identify areas that require refinement in audit management.

The integration of automated tasks, such as email correspondence and meeting scheduling, is expected to reduce the workload of auditors, increase operational agility, and accelerate the delivery of audit outcomes. This paper contributes a novel perspective to the auditing field, particularly in evaluating IT sectors, emphasizing the need to revolutionize auditing practices to allow auditors to focus on more critical tasks. Moreover, the significant reliance on non-peer-reviewed literature highlights the necessity for thorough academic scrutiny of the advancements in implementing technologies like IPA to strengthen business continuity management.

17. Limitations

While analyzing the survey results, a notable limitation emerged related to the diversity of the sample, which comprised four distinct companies varying in size from small to large banks. This variation introduced disparate realities into the data, as large firms often require more extensive automation due to the volume and repetitiveness of their processes. Conversely, smaller companies are typically more conservative in adopting automation strategies, largely due to budget constraints.

This disparity suggests that the solution discussed is optimally suited for larger organizations that manage comprehensive audit plans. Although characterized as low-cost, the implementation of this IPA solution still demands significant resources for continuous evaluation and adaptation to ensure its effectiveness across diverse organizational contexts. This observation underscores the need for tailored approaches in the automation of audit processes to accommodate the specific operational and financial contexts of different-sized institutions.

18. Future work

This study aims to inspire further enhancements in automated audit processes. Auditing plays a critical role in identifying risks and inefficiencies within organizational processes, necessitating the elimination of repetitive tasks. This research has shown the potential for increased agility in audit functions through comprehensive automation.

Although some activities are already automated during fieldwork, it remains essential to evaluate whether automation solutions are effective or merely resource-intensive.

The solution proposed operates continuously and can be implemented in audit departments at a minimal cost. It is also adaptable, allowing customization to meet specific organizational needs. Using KPIs to identify critical gaps (for instance, in annual audits that are time-intensive), helps management to strategically decide on expanding automation across the audit process.

Future initiatives should focus on integrating advanced modules within the existing development framework to cater to specific corporate needs. Feedback from this study has highlighted several potential enhancements. There was significant support for implementing automated alert systems at key stages of the audit process to monitor both the actual and projected timelines, as well as to provide timely updates on the remaining steps. There is also a demand for increased automation in tasks such as data extraction, procedural mapping, characterization of findings, and the regular dissemination of progress reports. These improvements aim to refine the automation process further, enhancing efficiency and effectiveness in audit operations.

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CRediT authorship contribution statement

Ruben Filipe Pereira: Writing – review & editing, Supervision. **Micaela Freitas da Fonseca:** Visualization, Investigation. **José Cascais Brás:** Writing – review & editing, Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Isaias Scalabrin Bianchi:** Writing – review & editing. **Rui Ribeiro:** Validation, Software, Resources.

Declaration of Generative AI and AI-assisted technologies in the writing process

In the preparation of this manuscript, generative AI and AI-assisted technologies were utilized only to enhance the readability and language quality. These technologies were applied under strict human oversight and control. The authors thoroughly reviewed and edited the outputs to ensure accuracy and reliability. Following Elsevier's AI policy, the AI was not listed as an author or co-author, and the responsibility for the manuscript's content lies solely with the human authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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