INSTITUTO
UNIVERSITÁRIO
DE LISBOA

Intelligent Process Automation: Application in the audit process

Micaela Margarida Freitas da Fonseca

Master in Computer Engineering

Supervisor:
PhD Rúben Filipe de Sousa Pereira, Assistant Professor
ISCTE - Instituto Universitário de Lisboa

Co-Supervisor:
MSc José Manuel Catarino Barreiros Cascais Brás, Invited Professor
ISCTE - Instituto Universitário de Lisboa

November, 2022

TECNOLOGIAS
E ARQUITETURA

Department of Information Science and Technology

Intelligent Process Automation: Application in the audit process

Micaela Margarida Freitas da Fonseca

Master in Computer Engineering

Supervisor:
PhD Rúben Filipe de Sousa Pereira, Assistant Professor
ISCTE - Instituto Universitário de Lisboa

Co-Supervisor:
MSc José Manuel Catarino Barreiros Cascais Brás, Invited Professor
ISCTE - Instituto Universitário de Lisboa

November, 2022

To all women in engineering. I'm grateful I can make my contribution.

Acknowledgments

Words cannot express how grateful I am to my family, especially my sister, my godson Salvador and Alexandre. They were the source of my strength and motivation throughout this process. Their faith in me meant a lot, and I will never forget it.

I also want to thank my professors for their patience and constant feedback. This journey would not have been possible without their critical thinking and recommendations.

Finally, I would like to thank ISCTE - Instituto Universitário de Lisboa for the opportunity and for introducing me to people I will keep for the rest of my life.

Resumo

Nos dias de hoje, as empresas encontram-se a implementar tecnologias que lhes permitam garantir eficácia dos serviços e uma consequente redução de custos. Complementarmente, os auditores desempenham um papel fundamental no que concerne à avaliação dos processos que se encontram a ser reestruturados devido aos avanços tecnológicos, para garantir que a continuidade de negócio não é comprometida.

Esta dissertação tem como principal objetivo o desenvolvimento de um trabalho académico relacionado com a área de continuidade de negócio e as componentes de automação inteligente de processos.

A componente aplicacional permite dar auxílio ao processo *end-to-end* de auditoria no que respeita à automatização das atividades de comunicação de auditoria, pedidos de informação e envio de relatório final. O objetivo da implementação é permitir que a avaliação realizada pelos auditores aos processos é desprovida de atividades repetitivas e otimizada pela aplicação de automação.

Este desenvolvimento é complementado com a aplicação de inteligência empresarial no tratamento de indicadores de performance do departamento de auditoria, para garantir uma análise contínua da efetividade do Plano Anual de Auditoria.

Para avaliar o trabalho desenvolvido, foram realizados inquéritos a equipas de auditoria de 4 bancos portugueses. Os resultados demonstraram que a implementação seria benéfica em contexto empresarial e permitiria apoiar a gestão no contexto de tomada de decisão, assim como eliminaria tarefas repetitivas que se encontram atribuídas aos auditores durante o processo de auditoria.

Palavras-Chave: Automação Inteligente de Processos, Inteligência Artificial, Automação Robotizada de Processos, Auditoria

Abstract

Nowadays, companies are implementing technologies that enable them to guarantee service efficiency and consequent cost savings. In addition, auditors play a key role in assessing processes that are being restructured due to technological advances, so that business continuity is not compromised.

The main objective of this dissertation is the development of an academic work related to the area of business continuity and the components of intelligent process automation.

The application component supports the end-to-end audit process by automating the activities of audit communication, information requests, and final report submission. The purpose of the implementation is to enable the assessment performed by the auditors to be devoid of repetitive activities and optimized by the automation application.

This development is complemented by the application of business intelligence in the treatment of key performance indicators of the audit department, to ensure continuous analysis of the effectiveness of the Annual Audit Plan.

To evaluate the work done, surveys were conducted with audit teams from 4 Portuguese banks. The results showed that the implementation would be beneficial in companies and would allow supporting management in the decision-making context, as well as eliminating repetitive tasks that are assigned to auditors during the audit process.

Keywords: Intelligent Process Automation, Artificial Intelligence, Robotic Process Automation, Auditing

Contents

CHAPTER 1

Introduction

Due to rapid technological advancements and the coronavirus (COVID-19) outbreak, companies are under pressure to build automated systems and implement technologies that increase efficiency, service effectiveness, and cost savings, while employees strive to maintain business as usual across all essential services [1]. Meanwhile, auditors have had an essential role to remain aware of global changes [2] and in evaluating how business continuity processes are being managed.

Applying automation tools in audit processes enables companies to conduct proactive business process audits and forecast risks, allowing the organization to take the appropriate precautions to minimize them [3]. Robotic Process Automation (RPA), as a robotic technology-based automation method, can be used to replace human tasks in a variety of repetitive activities [4] of business processes, such as audit processes. However, RPA is not intended to take the place of humans in the workplace; rather, it aims to improve employee outcomes so that robots can become more effective and powerful assistants [5].

Despite the term RPA being coined in the early 2000s, the initial development took place in the 1990s. According to its history, screen scraping, workflow automation and management tools, and Artificial Intelligence (AI) are three key predecessors of RPA [6]. All these technologies come together to make RPA a powerful technological platform.

When implementing Intelligent Process Automation (IPA) while auditing business processes, by combining RPA and IA, auditors can use more resources to examine potential anomalies, resulting in improved audit quality [7]. Therefore, there is a growing belief that manual auditing is no longer effective, which means that concise and simple audits can produce high-quality outcomes using robots [8].

To maximize the influence on company performance and return on investment, it is critical to make a conscientious and well-informed decision about how and where automation will be deployed [7].

This chapter includes an overview of the thesis structure which introduces the audit process and the applicability of RPA and IA in these areas. This chapter also introduces the problem characterization as well as a research topic, research method, and main objectives for this thesis.

1.1 Motivation

There has been exponential technological progress to generate more automated and intelligent processes in recent decades. Continuous improvement and automation are top priority items in research studies across all industry domains on strategic agendas for their businesses [5]. The global market for automation technology is expected to reach $25.66 billion by 2027, growing at a compound annual rate of 40.6 percent each year [7].

For business professionals, especially auditors, it is crucial to erase barriers now that automation is implemented. One barrier to RPA implementation is determining which tasks to automate. Auditors must identify the right issue, as research reveals that many bot implementations fail [7]. Ensuring that robot behavior does not result in catastrophic failures and establishing how compliant the robot is with social standards and human preferences are two important necessities [9].

The future auditor is expected to be more proactive and forward-thinking, breaking the conservative ideal of financial auditing. To make this happen, mature automated processes, definitions, standards, and management must be implemented in their functions to provide value and competitive advantage. Auditors will also need a solid and realistic intelligent automation approach for success.

RPA implementation entails more than just putting technology in place. RPA automates business processes and allows companies to identify inefficiencies in those processes and simplify/standardize them, as more capabilities from human brains are being added to machines daily.

1.2 Objectives

Even though RPA and AI applications in businesses are recent, there are a variety of problems and risk factors that can be identified, each with its own set of consequences [10]. Because RPA actions are consistent, any error becomes a systemic and pervasive problem throughout the business process and data set. Alternatively, if a business process changes but the robot is not updated to reflect the change, the robot may fail to execute or introduces inaccuracy [11].

Given the necessity to automate audit operations, as previously said, this study aims to automate manual and repetitious activities from the audit process that will guarantee a more effective business continuity management, by helping to identify the right solution to implement and removing potential risks. In essence, the auditor's position would be repurposed, with a focus on the assessment component of audit procedures rather than wasting time with repetitive tasks [12].

As shown in Figure 1, this prototype is projected to (1) reduce the risk of human error, (2) optimize production and time, (3) access information easily, and (4) decrease expenses.

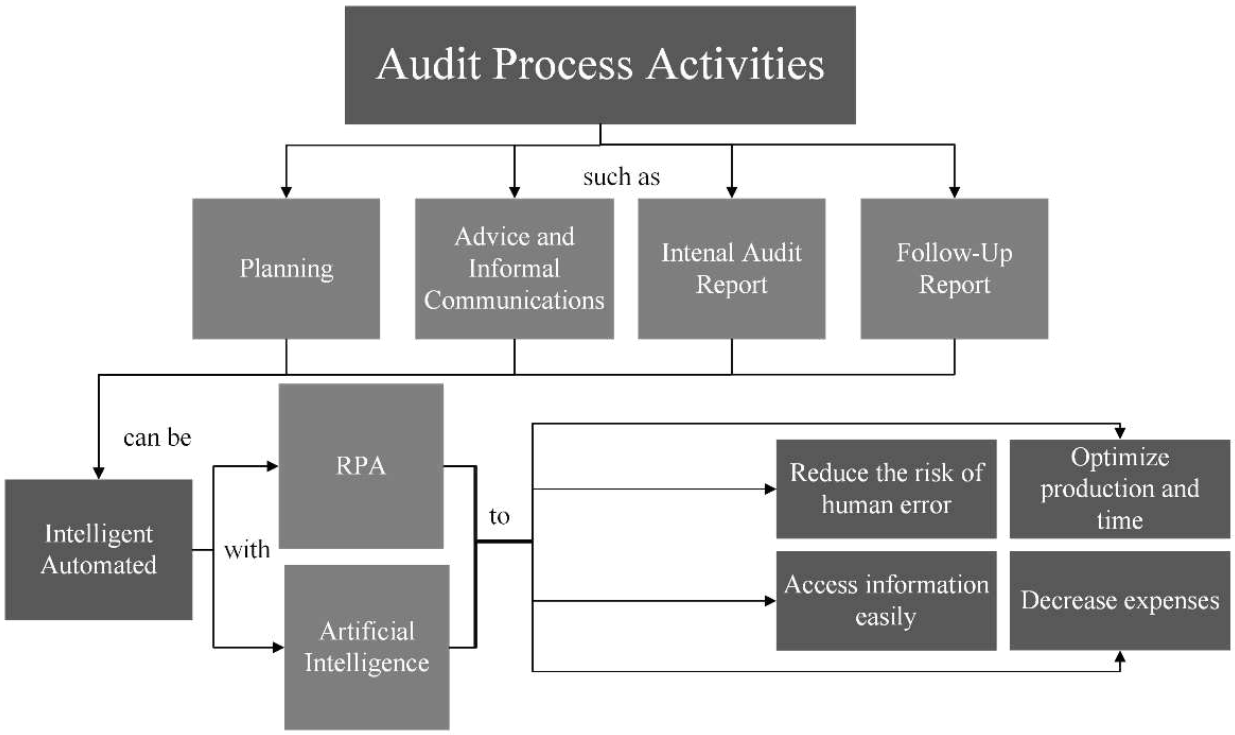

Figure 1 - Conceptual Map

Hence, this thesis aims to focus on two main research questions:

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

1.3 Dissertation Structure

This dissertation is divided into six chapters, which are listed below:

1. The first chapter includes an overview of the thesis structure, the problem characterization, as well as a research topic, the research method, and the main objectives.
2. The second chapter contains the literature review and provides a full picture of the risks, benefits, and challenges of automating audit processes.
3. The third chapter describes the problem we will solve and demonstrates the activity where the solution is applied, either in the real field or in simulations.
4. The fourth chapter demonstrates the design and the development made to meet solution's objective.
5. The fifth chapter evaluates the obtained results from the demonstration concerning the settled objective.
6. Chapter sixth finishes this thesis with the conclusion, communication, limitations, and future work.

CHAPTER 2

Related Work

Multivocal Literature Review (MLR) is a type of Systematic Literature Review (SLR) that incorporates both published and grey literature (GL). It is gaining traction among Software Engineering (SE) students and researchers, who believe that its content can compensate for the lack of practitioner evidence in traditional literature [13].

Table 1 - Differences between White and Grey Literature (Adapted) [14]

White literature	Grey literature
Books	Blog posts
Journal and Conference papers	White papers
	Audio-Video media

This process, as the SLR process, is divided into three steps: planning the review, conducting the review, and reporting the review conclusions.

The following topics are discussed during the MLR planning phase:

1. **Identifying the need for an MLR:** There is a need to capture current perspectives about automation in audit because GL provides "extremely current" insights and compensates for gaps in the formal literature.
2. **Ensuring that the planning process is useful:** The main goal of this MLR is to be able to carefully decide what and how to use RPA and AI to guarantee business continuity.
3. **Defining MLR's objectives and posing review/research questions (RQs)**: A significant number of research difficulties emerge when the audit paradigm evolves toward the integration of automation tools.

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:

Table 2 - 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

When it comes to grey literature, Filter 2 changes. In this case, instead of Query Abstracts, Query Title is used.

Selection criteria were set at the protocol definition phase of the MLR's planning phase to limit the risk of bias. Inclusion and exclusion criteria are used to express the criteria, as represented in Table 3.

Table 3 - Inclusion and Exclusion Criteria

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

The research results are shown in Table 4, with a total of 71 documents obtained – 35 white papers and 26 grey literature. Snowballing resulted in 17 white papers, which refers to the additional papers identified on our reference list.

Table 4 - Review conclusions

Database	**Filter 1**	**Filter 2**	**Filter 3**	**Filter 4**	**Filter 5**	**Filter 6**
IEEEXplore	25	16	16	3	2	
ACM Digital Library	437	2	2	2	2	
webofscience	100	30	30	0	0	+17
Scopus	3,329	104	61	55	14	
Google	16 500 000	479	41	26	26	
Total	**16500565,33**	**631**	**150**	**86**	**44**	**61**

2.1 Audit

The word audit comes from the Latin word *audire*, which means to listen [15]. The main goal is to gather sufficient evidence to establish with reasonable certainty that the auditable statements are free of fraud and/or material misstatement and then to report the findings to stakeholders [16].

An audit serves to obtain an assessment or evaluation of the company's performance, products, or systems and can take a long time in practice. Furthermore, when the audit process was done manually [17]. Even though each audit process has its particularities, most audits follow a similar pattern and include four stages, as described in Table *5*.

Table 5 - Audit Processes (Adapted)

[18]

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.

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 [19]. 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 [20].

2.2 Robotic Process Automation

The Institute of Electrical and Electronics Engineers (IEEE) Standards Association defines RPA as:

‘‘*A preconfigured software instance that uses business rules and predefined activity choreography to complete the autonomous execution of a combination of processes, activities, transactions, and tasks in one or more unrelated software systems to deliver a result or service with human exception management”* [21]

The impact of replacing jobs in human-based workflows is represented in Figure 2. By assuming that panel A illustrates low-level jobs in the extremities and high-level jobs in the middle, panel B shows that robots will replace more low-level jobs than higher-level skilled positions.

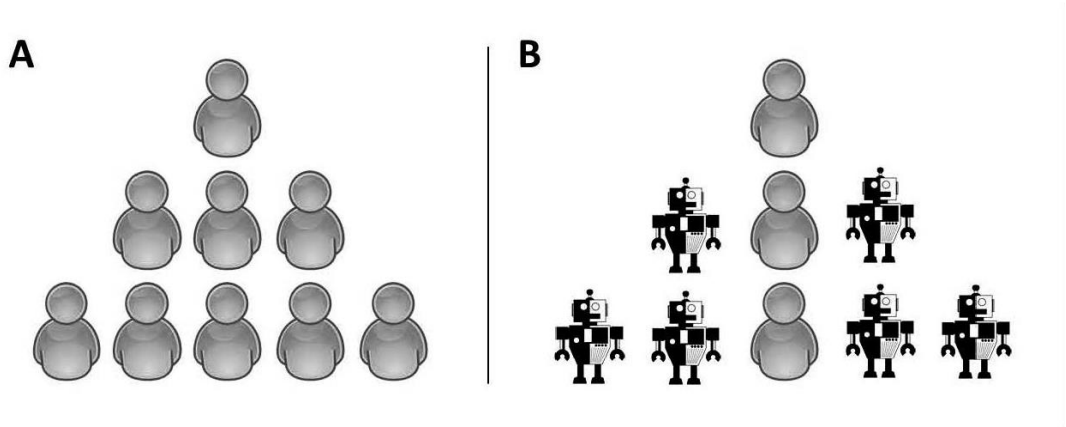

Figure 2 - Insertion of RPA into Human Processes [12]

Apart from savings in human efforts, there are several benefits associated with implementing RPA in audit processes. The benefits can be seen in the table below:

Table 6 - Benefits of RPA in Audit

Benefits	References
Savings in human efforts	[4], [8], [10]–[12], [22]
Increased value-add talent	[4], [8], [11], [12], [22]
Increased agility for transformation	[22]
Reduced errors	[12], [22]
Increase in speed of delivery	[8], [11], [22]
Customer satisfaction/advocacy	[8], [11], [22]

RPA technology is visible in everyday life. RPA implementation results in a reduction in Full-Time Equivalent (FTE) and manual work [4], [8], [10]–[12], [22]. Because of close interaction between humans and robots, companies will be able to provide better service [8], [11], [22] and employees will have more time to do more valuable things [4], [8], [11], [12], [22].

RPA improves task speed [8], [11], [22] and accuracy, resulting in increased productivity and reduced errors [12], [22]. RPA can also run nonstop for 24 hours a day, seven days a week, resulting in higher work quality and increased agility for transformation [22].

2.2.1 The benefits of embedding automation

Although RPA is ideal for repetitive and labor-intensive audit tasks (such as reconciliations, internal control testing, and detail testing), its auditing application has lagged due to risk and regulatory concerns [23]. The risks can be seen in the table below:

Table 7 - Risks of RPA in Audit

Risks	References
Privacy and Security	[11], [12], [24]–[26]
Compliance risks	[11], [24], [27], [28]
Selecting the wrong tool	[8], [11], [12], [24], [27], [28]
Costly maintenance	[24], [27]

RPA has implications for governance, control, and risk management in the organization. Before any RPA implementation, governance structures should be in place [29]. Concerns about privacy and security have an impact on the risk environment because the collection of digital evidence during auditing may expose sensitive [11], [12], [24]–[26]. 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 [19]. Controls that ensure the confidentiality, integrity, authenticity, and reliability of data used by RPA software should be implemented [26].

Using the wrong sourcing model [8], [11], [12], [24], [27], [28] can result in exorbitant costs [24], [27]. This occurs frequently when organizations decide to do everything internally, lacking the necessary skills to govern, develop, and implement without relying on external advisory, choosing inexpert advisors, or bringing them in after a key decision has been made.

On the other hand, implementing RPA in the process of disclosing information that is a banking secret to authorities has been found to reduce the risk of non-compliance in areas such as information security and meeting statutory obligations [26]. By reducing errors in critical processes, RPA may also provide a way to address some compliance threats [11], [24], [27], [28]. To ensure that strategic objectives are met, organizations must consider the various applications of RPA and their effects on business [30].

Table 8 - Identified targeted risk categories for implementing a program with RPA and AI (Adapted) [11]

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

2.2.2 Intelligent Process Automation

AI can be defined as the "ability of a system to correctly interpret external data, learn from those data, and use those learnings to achieve specific goals and tasks through flexible adaptation" [31]. When combined with AI and cognitive automation, RPA becomes more effective, giving rise to the new IPA technology. RPA and IPA differ from one another fundamentally in terms of the tasks that are involved. Routine tasks are faced by RPAs, whereas judgment and decision-related tasks are faced by IPAs. RPA executes commands; IPA makes decisions and provides recommendations [32].

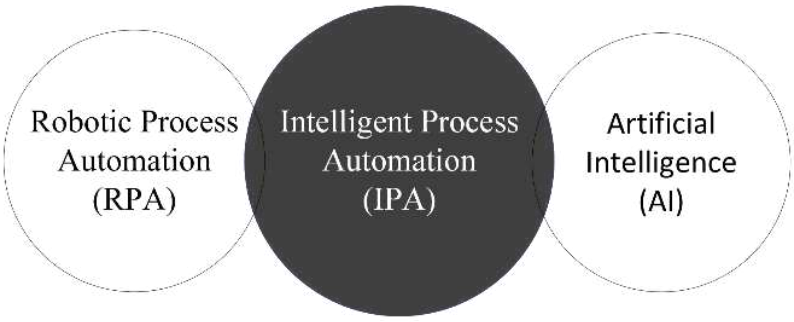

Figure 3 - Intelligent Process Automation

Computer vision (CV) is a field of AI that enables computers and systems to extract useful information from digital images, videos, and other visual inputs and to take actions or offer recommendations in response to that information [33]. We have relied on human descriptions to be able to understand what images contain. These are referred to as metadata. However, some metadata can't fully convey the value of all the information present in those images. We require computers that can perceive images similarly to humans and comprehend their content to obtain that value [34].

Processing invoices is one typical application where computer vision is already being used to power intelligent automation, as previously said. Invoices can appear in a variety of unstructured data forms, such as images saved as PDF files, and come in all different shapes and sizes, through all different channels. The entire process of what was formerly a time-consuming, manual task can be automated using intelligent automation that makes use of computer vision to recognize all the important content, extract it, and process it using AI-based rules.

2.2.3 Automation Tools

Enterprises that want to roll out RPA on their own face several challenges. Most businesses intend to collaborate with RPA solution providers to avoid launching poorly designed RPA-powered digital workers that frequently frustrate customers and employees. A technology vendor specializing in RPA solutions should be sought in the same manner as any other technology or sourcing procurement strategy [27]. Table 8 lists several open-source and vendor-provided tools that can help with automating audit tasks (including RPA).

Table 9 - Comparison between Automation Tools for Audit Tasks
[11], [35]

Tools	Tool Execution	Audit Task
Excel Macros	Rules-Based Functions	Reconciliations
IDEA	Calculations	Analytical Procedures
		Internal Control Testing
		Detail Testing (Attribute Match)
Python	Rules-Based Functions	Reconciliations
R	Calculations	Analytical Procedures
	Web Scraping	Internal Control Testing
RPA Vendor Tools (UiPath and Blue Prism, for example)	Importing Data	Detail Testing (Attribute Match)
	Exporting Data	Input: Collection of Data
		Output: Compilation of Audit Test Results

The above scenario assumes the use of multiple tools in parallel. However, another option would be to use RPA tools to complete all the tasks. RPA vendors such as UiPath and Blue Prism provide similar automation capabilities as Excel, IDEA, Python, and R, but without the need for programming in the user interface.

2.3 Related Work

For more than three decades, auditing has used automation technology [36]. Vasarhelyi and Halper proposed the concept of continuous auditing (CA) in 1991, which the CICA/AICPA defines as:

"*Methodology for issuing audit reports simultaneously with, or within a short period of time after, the occurrence of the relevant events*"
[37]

Later, CA and continuous monitoring (CM) became examples of automation technology applications [38]. In 2008, as part of a pilot project, CA/CM was applied to an internal IT audit process. They create guidelines for formalizing audit procedures into a computer-executable format and determine which procedures can be automated and which need to be re-engineered.

Accounting firms have implemented audit management systems such as electronic work papers to improve audit effectiveness and efficiency even further. Electronic systems allow auditors to directly link information between documents, and managers/reviewers to remotely access files and communicate with their audit teams [39], [40].

The Automated Contract Analysis System (ACAS) framework, proposed by Zhaokai and Moffitt in 2020, is based on auditing standards with contract-specific requirements. They demonstrate the feasibility of incorporating text mining into contract audit procedures, using the proposed ACAS framework, to automate contract analysis in the audit stages of risk assessment, and substantive tests and to provide auditors with contract data that can be used to identify audit risk and generate audit evidence. Recent literature, as shown in table 10, emphasizes recent work on automation and audit.

Table 10 – Related work about automation and audit

Related Work	**References**
Automates the confirmation process, which validates that the bank account balances directly with a third-party intermediary.	[23]
Automates OS Security Audit Platform, which consists of 3 modules: Integrity Proofs, Import Test Case, and Report and Logs.	[41]
RPA Implementation Framework in Audit and Fraud Control	[20]
Studies based on a review of the literature about the concept of RPA in accounting and/or auditing.	[4], [10]–[12], [17], [25], [42]

Every automation mentioned above adheres to/creates a framework for some specific problem. The main limitations found are mostly the need for constant upgrades of software and libraries since RPA was programmed using modular structure and software that performs only routine tasks and makes decisions based on explicit rules. To confirm their effectiveness, all frameworks should also be evaluated by auditors and revised based on their feedback and comments.

2.4 Challenges

Throughout the literature review analysis some challenges in automating auditing activities were identified. One of the difficulties when associating automation with the audit is deciding which activities to automate [8], [12]. Would RPA be beneficial to which audit activities? Is it possible to apply RPA to distinct phases of the audit model?

Forrester surveyed RPA customers as part of its research for UiPath and the result is represented in Figure *4*. The issues demonstrate the difficulties of maintaining bots while processes change, and the last three issues indicate customers' dissatisfaction with the RPA solution they selected.

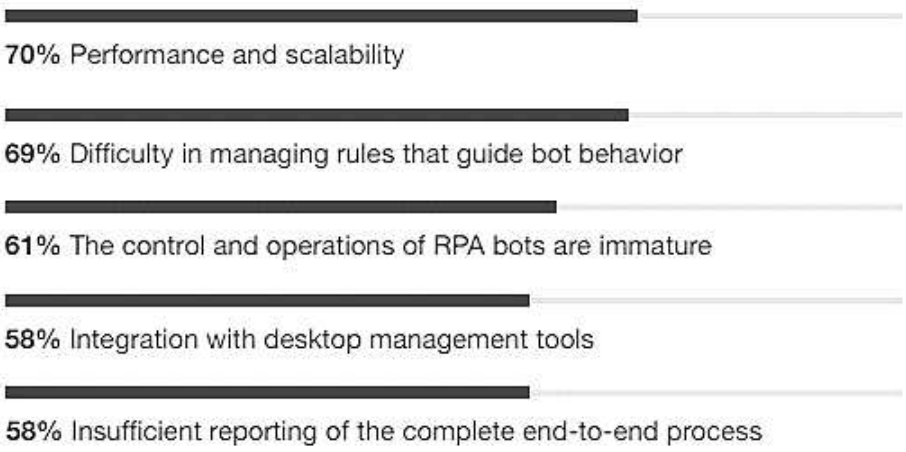

Figure 4 - Technical and deployment issues when it comes to RPA technology [28]

Another difficult challenge is the resistance of traditional auditors, who may believe that the presence of RPA is a threat. As manual work can be replaced by robots, the presence of RPA is frequently interpreted as a reduction of auditors in companies.

Although RPA has the potential to significantly improve auditing practice, one of the software's current limitations is that it can only perform routine tasks and make decisions based on explicit rules. As a result, current RPA software is incompatible with audit procedures that require professional judgment and cannot be converted into structured instructions [23].

However, RPA technology is undergoing a significant transformation as it integrates AI, Machine Learning, and other cognitive technologies. Cognitive Automation, Intelligent Process Automation, Smart Process Automation, and other terms are used to describe RPA that is integrated with these technologies [5].

CHAPTER 3

Research Methodology

To develop this thesis, a research method based on the Design Science Research Method (DSRM) is used. It is used to solve issues by contributing to research, evaluating the designs, and communicating the results to relevant audiences [43].

DSRM consists of four main steps and can be described as follows:

1. Problem identification and motivation: Identify a particular research problem and clarify the value of a solution that will motivate the researcher and the research audience to pursue it.

2. Objectives of a solution: Determine the goals of a solution based on the problem definition. The objectives should be deduced logically from the problem definition.

3. Design and development: Produce a solution. This activity entails identifying the artifact's desired functionality and architecture and building the artifact itself.

4. Demonstration: Demonstrate that the artifact is effective in solving the problem. This would require putting it into experiments, simulations, or other appropriate activities.

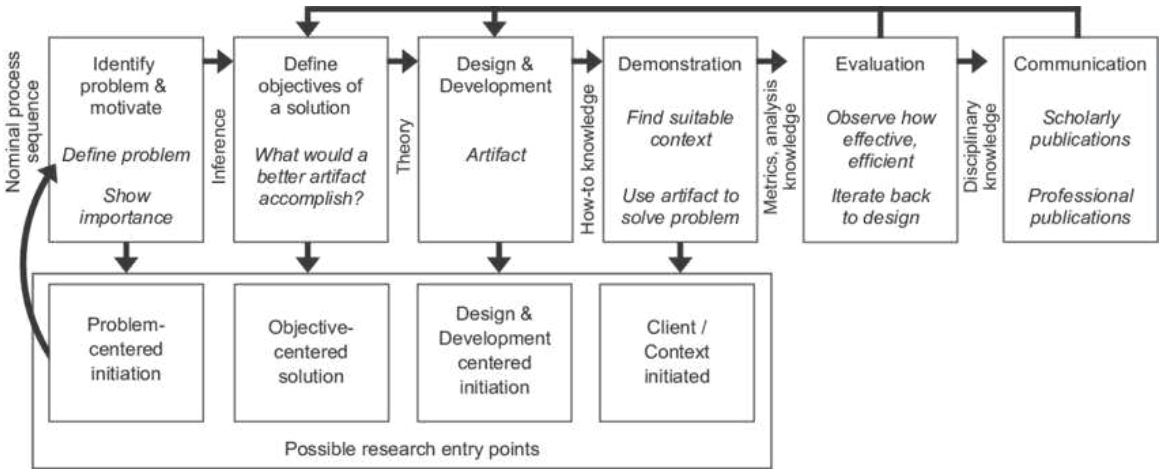

Figure 5 - Design science research process (DSRP) model [44]

Given the many works related to engineering and this theme in general, using Design Science as a research approach gives benefits of practical applicability [45]. Another benefit of employing this methodology is its adaptability: while the model is organized in nominally sequential order, researchers can start at any point in activity one, two, three, or four, depending on their approach and need [46].

3.1 Problem identification and motivation

The previous research work consisted of studying the main risks and benefits of applying RPA technology to the audit process. It was possible to verify that the application of automation in audit has several benefits, such as savings in human efforts, increased value-add talent, increased agility for transformation, and increased speed of delivery, mostly. However, there are still limitations in RPA implementations, such as software being able to perform only routine tasks and to make decisions based on explicit rules because they are not applying other technologies such as IA, and finally, choosing the right activities to automate.

The motivation of this theme is to implement RPA throughout the audit process, in order to overcome the difficulty of identifying the best activities to automate. Applying RPA to the entire audit process will not only include the main benefits of using automation in auditing, as listed above but also indicate through Key Performance Indicators (KPI) where the biggest problems can be found.

Every company has different risks as well as needs. The possibility of implementing an IPA that tracks audits from the Annual Audit Plan (initial phase) to the submission of the final report (final phase) will allow the company to identify audit automation needs in a consolidated manner. After the analysis of the indicators taken from the proposed automation, the decision-making process will be facilitated, and the value added to the company will be considerably visible.

In addition, the main repetitive tasks of emailing and scheduling meetings will be automated, allowing the act of communication between auditor and auditee to be streamlined and ensuring that the auditor has a more central focus on fieldwork.

This paper focuses on the banking industry where auditing increasingly plays a key role. Not only the presence of regulators is growing, but also the need to report data that reflects the overall and succinct view of the business.

3.2 Objectives of a solution

The main objectives of the proposed solution are to ensure that the Annual Audit Plan is adhered to and updated, to perform repetitive tasks such as scheduling meetings and sending emails, and to analyze the auditors' work performance to allowing identify opportunities for improvement. Figure *6* summarizes the six major activities that will be conducted by the automation robot.

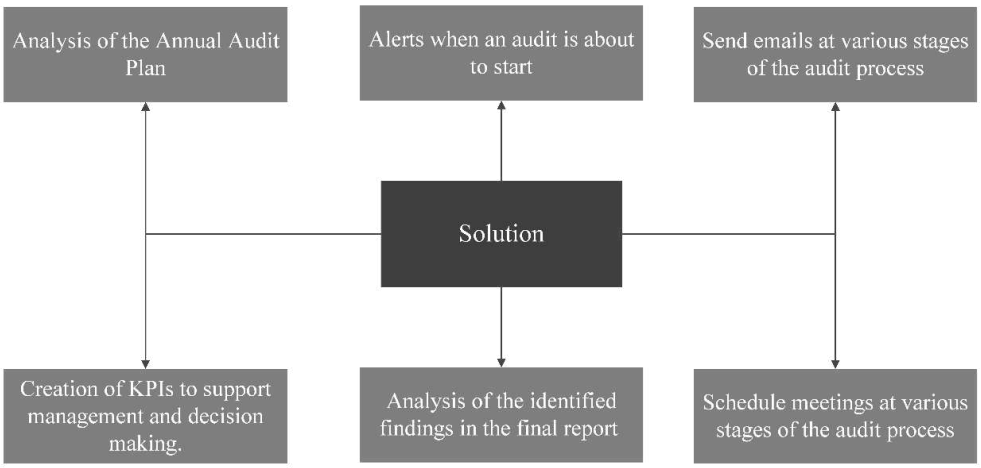

Figure 6 - Objectives of a Solution

The first major activity is the Annual Audit Plan analysis. This should be done using CV techniques since it is fundamental to have an AI tool to scrutinize the plan that supports information about all audits about to start.

Secondly, IPA will send alerts to the auditor regarding the closest audit, expecting to have the approval to initiate it. Then, several emails and meetings request will be sent to cover repetitive actions of the audit process.

Finally, the final audit report will be examined using CV, and data will be extracted to support KPIs. The importance of this activity will be explained later.

Before that, as previously stated, there are numerous tools to automate processes. Considering the former activities, a RPA vendor tool should be selected. As we can see in Table 11, UIPath has multiple advantages such as having free cost and a large support and learning community, when compared to the other 4 RPA tools. Therefore, this tool will be used in this prototype.

Table 11 - Top 5 best Robotic Process Automation Tools (Adapted) [47]

	Keysight's Eggplant	Blue Prism	UiPath	Automation Anywhere	Pega
Cost	Contact them for pricing.	$ 15000 to $ 18000 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	Medium Large	Small Medium Large	Medium Large	Medium Large

As a complement to the solution created in the UI Path tool, a business intelligence tool will be added. It is known that measuring internal audit performance can be critical to organization's overall business performance. Furthermore, regulators and investors are demanding greater scrutiny of an organization's operations. Leading research institutes and a few regulators have identified the following key performance measurement benchmarks [48]:

1. Audit effectiveness in covering areas;
2. Feedback of audit findings;
3. The audit's duration and timeliness; and
4. Internal audit functions add value.

To ensure that the internal audit function involves the management's expectations and achievements, it is crucial to formally report to the board KPIs. Metrics in audit projects can help auditors to meet project goals and demonstrate how internal audit activities align with company objectives. The most common KPIs include [49]:

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

Regarding data analysis and KPI demonstration, it will be used Power BI to easily create visualizations and intuitive dashboards. This Business Intelligence tool is widely used in companies across the world; therefore, it will be used to connect and combine data from IPA databases, providing accurate data-driven audit decisions.

CHAPTER 4

Design and Development

This chapter aims to demonstrate step three of the Design Science Research Method which is to produce the solution and identify the artifact's functionality. For a better demonstration, it is divided into various sub-sections that describe the process developed and show the main outputs of each activity. The identified process dependencies will also be demonstrated.

4.1 Project dependencies

As previously mentioned, to achieve the development's goal it is used UIPath tool, specifically UiPath Studio Community. Depending on the project type, compatibility, or template used to create the project, Studio's dependencies change. To use additional functionality, the main dependencies listed above had to be added:

1. *UiPath.DocumentUnderstanding.ML.Activities*: Machine Learning Document Understanding features, such as the Machine Learning Extractor and the Machine Learning Classifier are enabled by this activity package;
2. *UiPath.PDF.Activities*: IntelligentOCR, DocumentUnderstanding.ML, PDF, AmazonTextract, OCR.Activities and OmniPage packages are included;
3. *UiPath.Mail.Activities*: Email and Exchange protocols are used to retrieve and send emails;
4. *UiPathTeam.OutlookCalendar.Activities*: This package allows to manage Outlook Calendar events. It enables users to send meeting requests and make appointments. Users can easily export calendar events for a specific time period to .ics (format for iCalendar); and
5. *UiPath.Excel.Activities*: Use the Open Office XML format (XLSX) or Excel.Interop to carry out Excel-related operations.

The addition of the above dependencies was necessary to use the features of reading documents with Machine Learning techniques, sending emails, and scheduling meetings. The wide variety of available packages demonstrates that UIPath is a user-friendly tool that can perform quite complex tasks without requiring much development, allowing anyone to learn how to implement an RPA and supervise it. Now that all dependencies are associated with the project, it is time to develop the solution. The main development stages will be explained in the following sections.

4.2 Annual Internal Audit Plan

The annual internal audit plan (hereafter audit plan) is a list of audit engagements that will be performed throughout the year [50]. Each organization should develop an audit plan that fits its specific and unique needs [51].

In the first stage, while ensuring compliance with the above mentioned, it is necessary to define which attributes should be included in the audit plan, as this is the core document of the development. To answer this first question, it is required to research audit plans of public entities to find an audit plan that could serve as an example and meet the needs.

As the goal is to collect as much information as possible from the audit plan, it is essential to define the choice's criteria so that the plan does not have to be changed later for lack of information. Since the goal of the development is to eliminate routine tasks such as sending e-mails, it is known that 3 variables are needed right from the start: both emails from the auditor and audited area, and the audit name. When we think about the more concrete tasks, such as knowing what audit is about to start, it is essential to have the start date of the action represented in the audit plan.

Now that we have the 4 main variables, it is time to look at public entities' audit plans and verify if any of them satisfy our needs. After the research, some audit plans met the defined criteria. However, many of them did not have a fluid structure. Plans were found to have the table unformatted or to identify dates by semester. To achieve a successful development, the development and business teams must understand each other's document formats as any changes in the data or in the table itself can affect the entire development.

It is possible to check in Table *12* an adaptation of an audit plan table taken from a public entity that corresponded to the basic criteria.

Table 12 - Attributes of Annual Audit Plan Table (Adapted)
[52]

Internal Audit	Audit Number	Start Date	Audited área	Scope	Audit team
Example1	1	dd/MM/yyyy	Auditedarea1@company.com	Ambit1	auditor@company.com

As mentioned above, it is essential that the audit plan has at least the attributes listed above and follows some rules, which will be listed thereafter. To send emails and schedule meetings, the robot must have access to the auditor's and auditee's email, so the plan must keep the emails of all auditors and auditees that will participate in the process up to date. In case there is more than one auditee and/or auditor, the emails must be separated by the ";" symbol so that all emails are considered.

The robot will also use the date assigned to the audit to compare with the system date and send alerts when it is about to start, so it must be realistic and in dd/MM/yyyy format.

Attributes such as Internal Audit (name), Audit Number, and Scope are important to unify each communication made. The audit number will also be used to link all databases created in development as a primary key. Table *13* presents the data attributes dictionary used in an audit plan.

Table 13 - Audit Plan - Data dictionary

Attribute	Data Type	Description
Internal Audit	Text	Audit name.
Audit Number	Integer	Unique ID value for every input.
Start Date	Date	Audit start date.
Audited área	Text	Email of the people responsible for the area to be audited.
Scope	Text	Brief description of what will be evaluated in the audit.
Audit team	Text	Email of the auditors who will perform the audit action.

It is possible to assign more data to the audit plan, however, it is important to note that any changes in the column's order will mean changes in the development. The reason why will now be explained.

CV techniques will be used to read the audit plan. As companies can use .pdf and .xlsm versions for the audit plan, it will be readable for both.

CV eliminates dependence on selectors while maintaining familiar labor flows for RPA developers. We can perform more automatic processes as the number of elements that can be seen on the screen increases. In other words, when the CV technique is applied, the errors associated with reading documents are substantially reduced. In this case, the CV Screen Scope activity is used to read the table containing the audit plan, as we can see in Figure *7*.

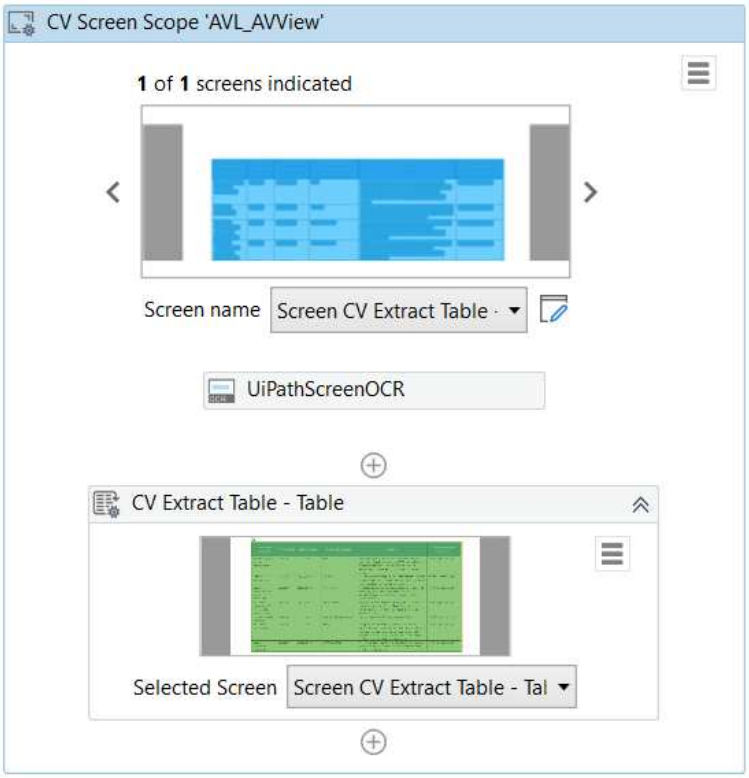

Figure 7 - CV Screen Scope activity

In the CV Screen Scope activity, it is first asked to identify the screen that contains the table with the audit plan. Later, it is necessary to use the CV Extract Table activity to, as the name speaks, extract the entire table into a data table variable.

After the CV activity finishes the table reading process, it is used Write Range activity to extract to an excel file the variable containing the audit plan. It is important to note that this step only happens if the document is in .pdf format. If the audit plan is already in excel format, this step is skipped.

Then, a condition is used to scroll through all the dates that are in the audit plan to compare them with the system date plus the 7 days advance. If the robot identifies an audit to be started in 7 days, the line corresponding to the audit will be stored in a new variable. To ensure the effectiveness of this step, it is necessary to make sure that the columns do not change position. This is because the columns of the audit plan will be stored in a variable of type object[], which means that each variable in the table will be stored in order in an array of length 5.

After saving the audit data in the new variable, the robot confirms that there is no folder with the assigned audit name. This verification ensures that the audit has not been started yet and that the next steps should be taken.

This search can be done both at the network folder level and the cloud level, however, it will always be necessary to ensure that the robot searches the URL that the company uses to store audit information. To ensure the effectiveness of this step, the variable used to identify the URL must be up to date.

When the robot ensures that there is no folder/document with the audit name, the robot sends an alert to the auditor telling him that an audit is about to start. The output can be seen in Figure *8*.

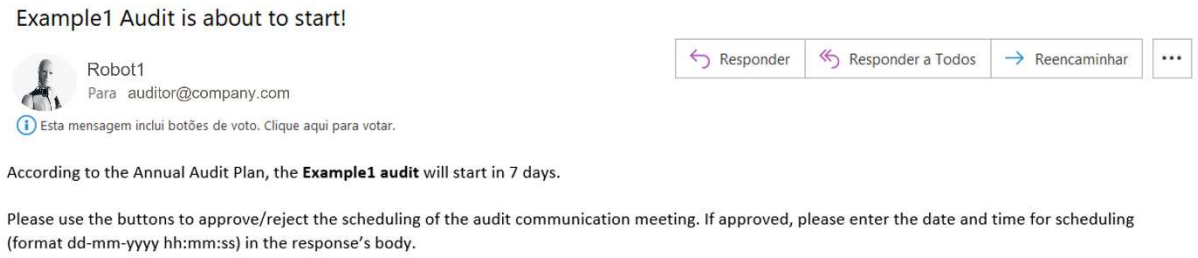

Figure 8 - Output alert email

Not only this email allows to inform the auditor that he is associated with an audit that will start in the next few days, but also allows him to prepare and organize his work. The email will not only serve as an alert to avoid delays in starting the audit, especially in large companies that manage an exhaustive audit plan, but also collect information such as the date for scheduling the meeting, in case of the auditor approves the start of the audit. If the auditor doesn't approve, the robot returns to the first step to see if audits will start the next day, repeating every step of the process.

The approval/rejection of the audit will be done through voting buttons inserted in the email. It is expected that the auditor will reply to the email in the next few days after the email is sent and, if he approves the start of the audit, inserts the most satisfactory date to schedule the communication meeting in the body of the email. The date must be entered in the dd-mm-yyyy hh:mm:ss format without any other words.

The process of scheduling a meeting will take place in the next phase, where it is already guaranteed that an audit will be started. However, these activities as the entire process of analyzing the audit plan, are summarized above in Figure *9*.

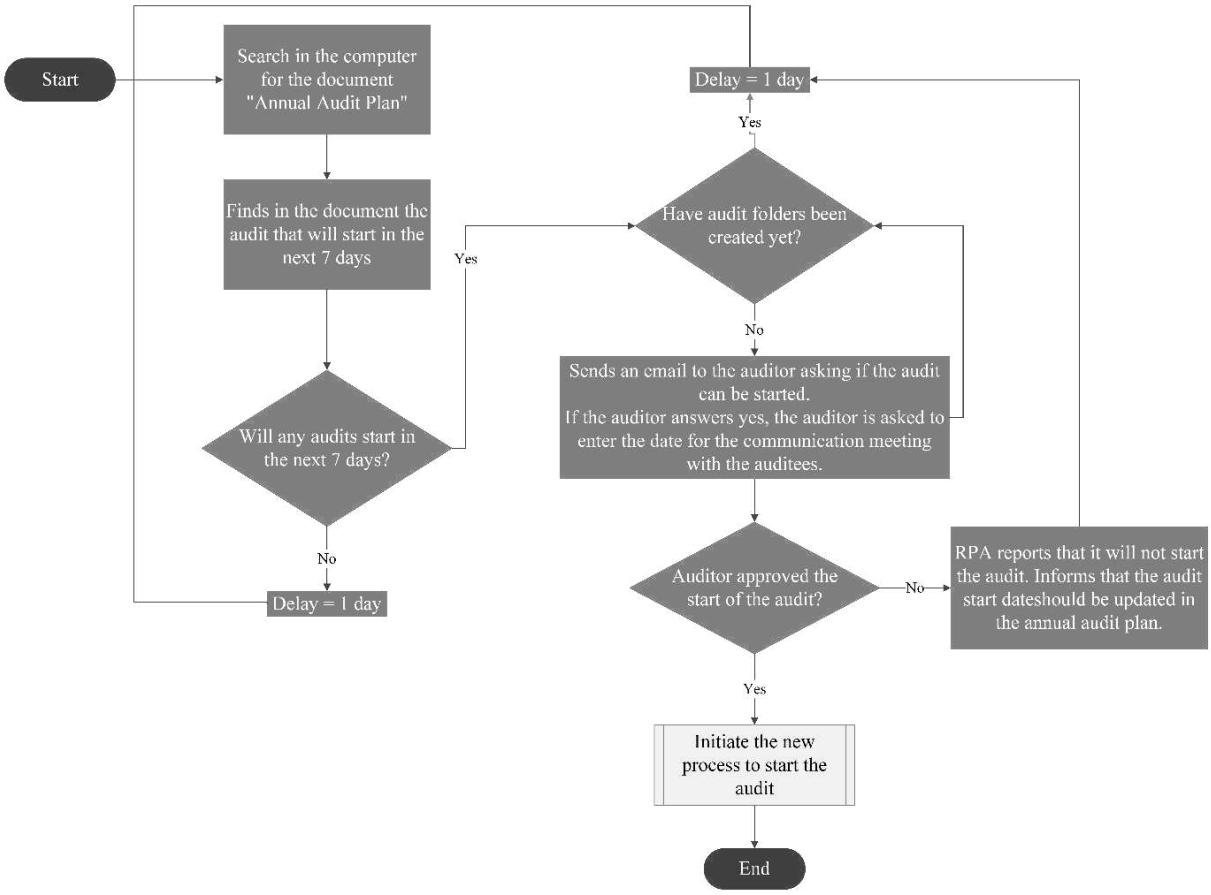

Figure 9 - "Start Process" Flowchart

4.3 Initiate Audit

In this second stage, the robot already knows which new audit is about to start. Therefore, it starts by creating all the necessary folders for the various steps of the audit: Communication, execution, and report.

After completing the folder creation activity at the URL set by the auditor, the robot sends an email to communicate the meeting and schedules the meeting based on the date sent by the auditor in the first phase. To create the communication email, as we can see in Figure *10* - Communication Email Output, it is fundamental to use various variables from the audit plan such as audit name (Example1), scope (ambit1), Audited area email (Auditedarea1), and auditor's email. The robot will not intervene further in this communication phase, so any future cancellation of the meeting will have to be resolved by the auditor.

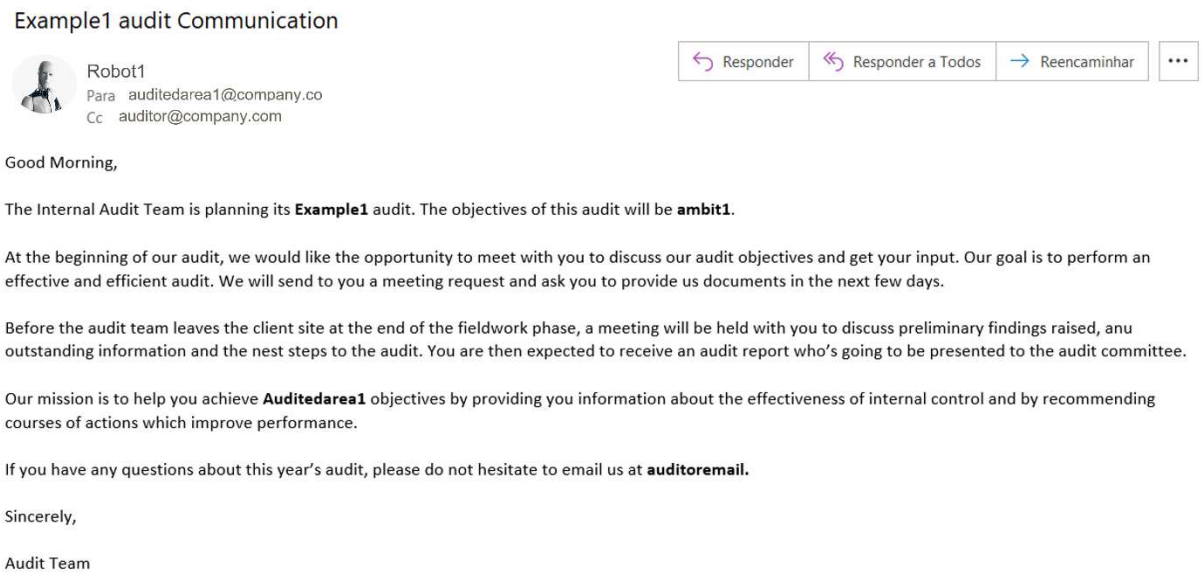

Figure 10 - Communication Email Output

Now, it is analyzed if the information request list has been created. Of course, this may not be instantaneous after the communication, so a delay is implemented to search every day for the document until the count of the day is 5. If the document is not found within 5 days, an email will be sent informing the auditor that he/she will oversee the document-sending phase. In case it founds the document, the robot sends the document to the auditee. The email output can be seen in Figure *11*.

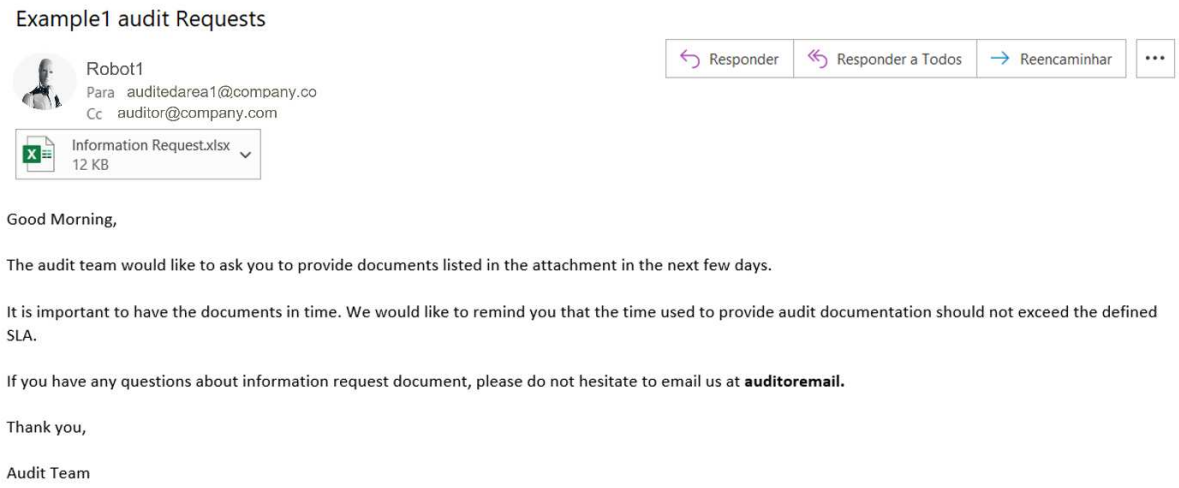

Figure 11 - Information Request email Output

This phase is widely used in auditing. Auditors always need a set of evidence to do their analysis work and the fact that the request is automatic speeds up the process. These activities, as the entire process of analyzing the audit plan, are summarized above in Figure *12*.

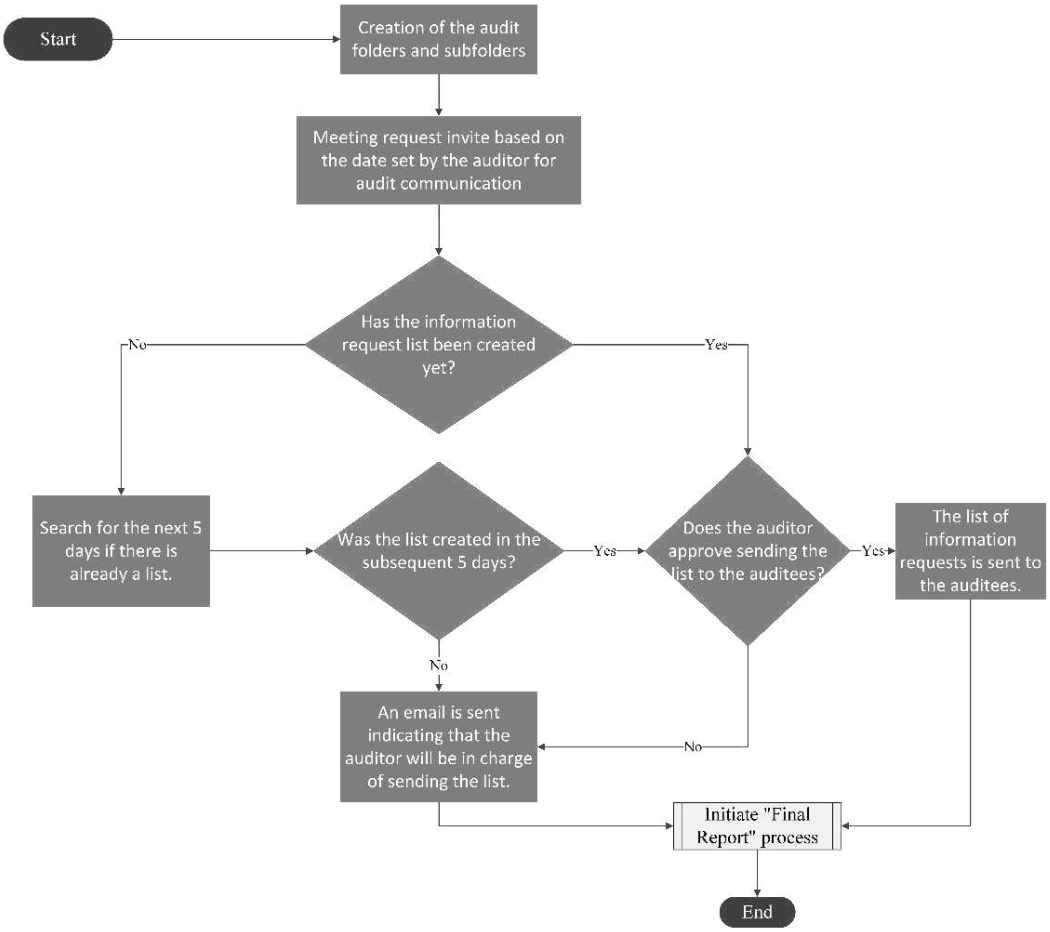

Figure 12 - Information Flowchart

4.4 Audit report

The third phase demonstrates the last activity of the audit process, specifically scheduling the final meeting and sending the final report. This phase starts after an interval between the information requests phase (second phase) and the report phase (third phase), identified in a 15-day delay that can be changed according to the time the audit team spends in fieldwork.

After the 15 days dedicated to fieldwork, the robot will analyze whether the final document is already in the corresponding folder. If it does not find the document, it will scan the folder daily to see if the document has already been created. If the document is not found within 5 days, an email will be sent informing the auditor that he/she will oversee the document-sending phase.

In case it founds the document, the robot asks the auditor if it can send the document and asks for the meeting's date in dd/MM/yyyy format if approved. If not approved, the same email that is sent when the document is not found will be sent also in this case.

When the auditor approves the scheduling of the meeting and the sending of the final report, these activities are performed by the robot. The output from the final report email was based on a template from The University of Texas at Dallas and can be seen in Figure *13*.

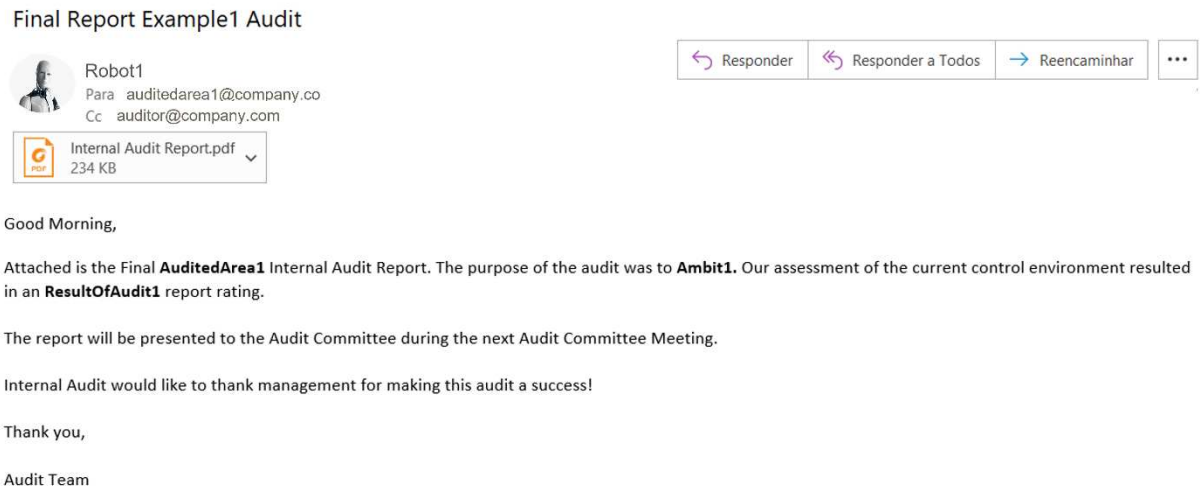

Figure 13 - Output Final Report email (Adapted)

[53]

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 that the robot finds the table, it is necessary to use the Send HotKey activity after the CV Screen Scope activity. During this analysis, the robot reads the screen, and if it does not find a table with the title "Finding Status", it will use the Send HotKey activity to do a page down. This process can take a few seconds, as CV reads every element on the screen to try to find the table.

Since a final audit report is required to complete this step, templates had to be researched on internal audit websites to ensure that they had the closest format to the one used in business reality. In this way, it is used a report template that can be found on an interactive website established to share ideas, templates, and documents to enhance the effectiveness of the internal audit department [54]. Table *14* presents the finding status table that is considered in the final report.

Table 14 - 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**

After the CV activity finishes the table reading process, it is used the Write Range activity to extract to another excel file the variable (data table) containing the finding status table. It is important to note that this step only happens if the document is in .pdf format.

Once the robot extracts the table into an excel sheet, the robot finishes its paper in this development. These last activities, as the entire process of analyzing the audit plan, are summarized above in Figure *14*.

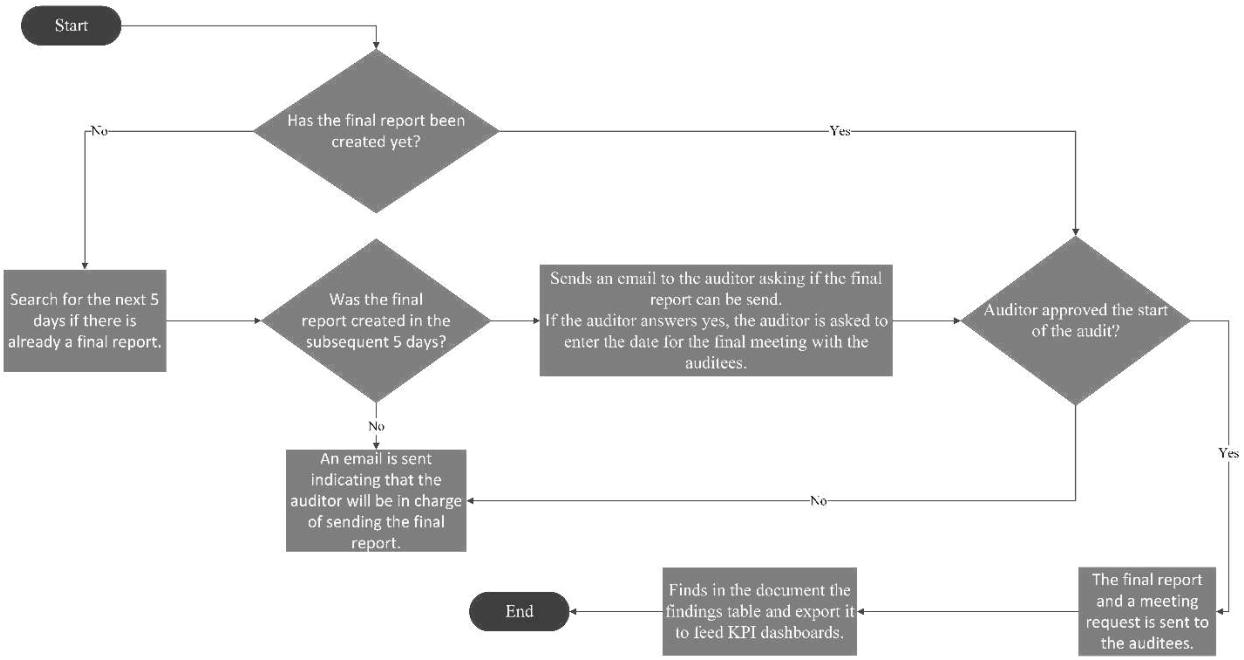

Figure 14 - Final Report Flowchart

It is important to note that both at the beginning and the end of the development, 2 variables were defined to indicate the actual date that the audit started and the date it ended. Both variables will be extracted to an excel to calculate key performance indicators, a topic that will be explained in the next section.

4.5 Key Performance Indicators

As previously mentioned, it will be used Power BI to combine data provided by IPA databases to create accurate data-driven audit decisions and demonstrate how audit activities support the strategic goals of the company. The most common key performance indicators include [49]:

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

From the previously explained, 3 excel workbooks were created during IPA development with the data tables corresponding to (1) the audit plan, (2) finding status of the audits performed and (3) the actual audit start and end dates. These excel workbooks will be loaded into the Power BI dashboard to support visual elements. The scheme is identified in Figure *15*.

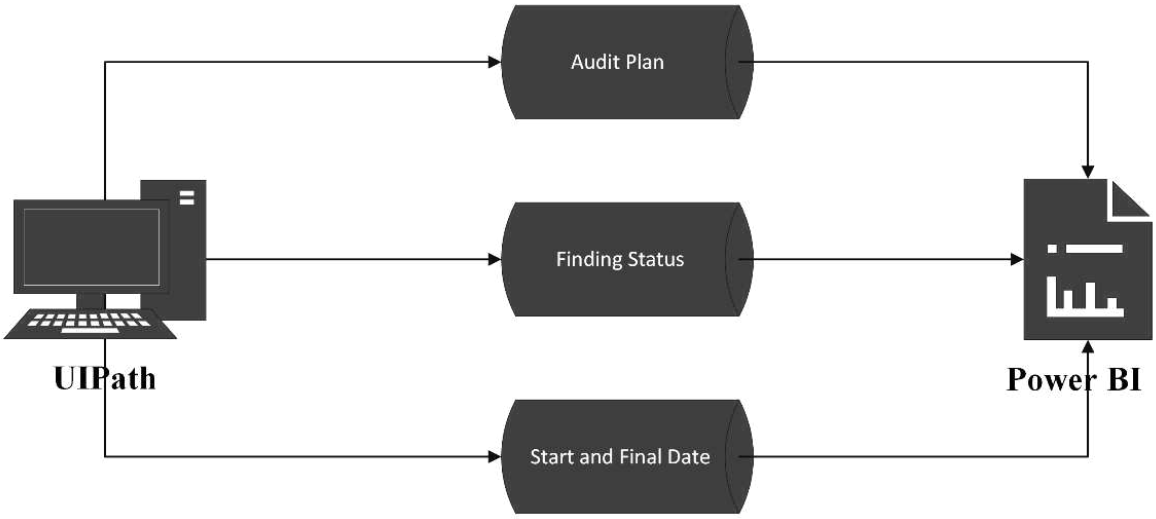

Figure 15 - Data Bases scheme

To create a visualization that incorporates all the KPIs identified above, a report was created in the Power BI tool with 3 iterative and 3 informative visual elements. It was crucial that the report created is user-friendly and have all the information on a single page so that the manager has an overview of the work in the area. To create this visualization, a Zebra BI matrix visual was used. Zebra BI is one of the most powerful tables in Power BI that creates spectacular reports capable to show what's going on in business with a few simple clicks [55].

Figure *16* represents the created report. Due to the potential of Power BI, this solution provides a report that filters data by the auditor who performed the audit action, by the audited department/area, as well as for the year, giving a more segmented view of each of these KPIs.

It is also possible to verify the variation from findings identified in previous audits by comparing them with the status of the same audit in the current year and to validate if the time spent during audit action corresponds to the estimated time.

This information will be always up to date, so that information gathered from the data segmentation helps management, not only to evaluate the audits created but also to manage the team's work. This solution helps to support management's decision-making regarding the management of resources, the creation of the next audit plans, and improvements to be made within the scope of the work.

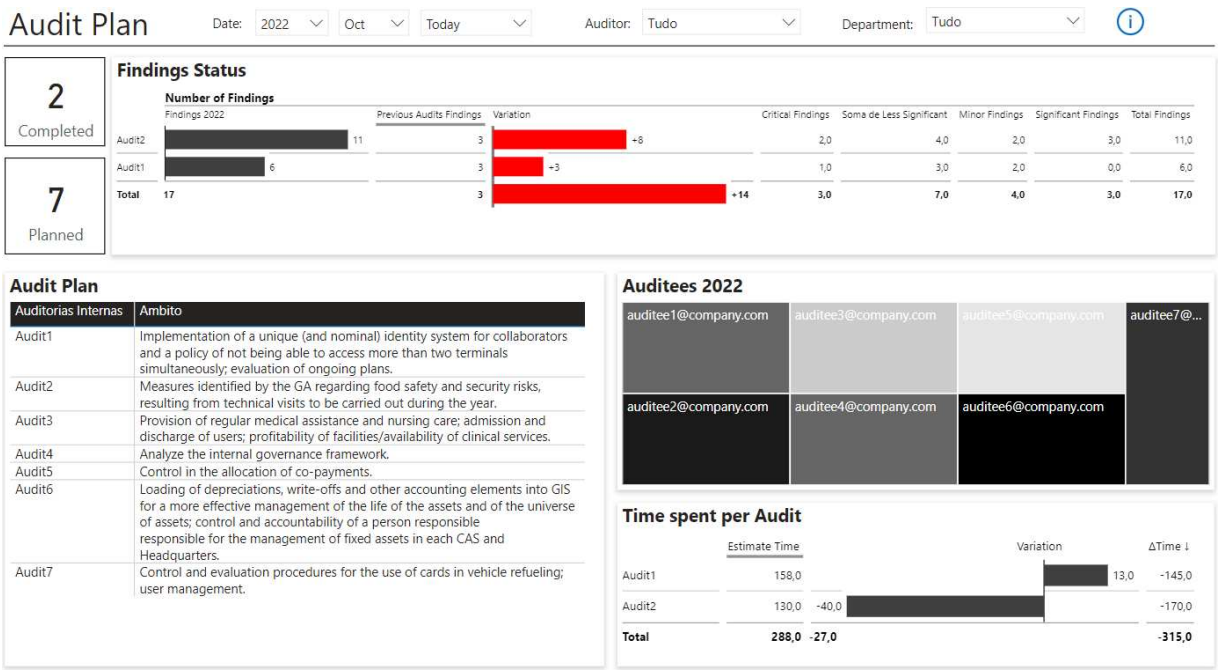

Figure 16 - Power BI dashboard

In conclusion, this final stage is considered the most important of the development because it allows management to evaluate information based on real data without human interference. It allows to verify when some audit requires more time and/or more failures are identified so that later, a decision can be made to add more automated modules to the developed IPA. In this way, besides formally reporting to the board the KPIs, it is guaranteed that there are no unnecessary expenses or failed automation developments.

CHAPTER 5

Demonstration and Evaluation

This chapter 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 opinion about the implemented 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.

5.1 Survey questions

To have conclusive answers, it was necessary to identify the right questions to ask the respondents. In addition to more personal questions such as age, gender, education, field of study, profession, and company, questions involving their experience with automation were asked.

The first question asked was if the auditors were aware of any automated auditing activities/processes in their company. If so, it was asked if they think that the automation of the process/activity had a positive impact on the Management. These questions were important to assess their resistance to automation and their knowledge of implementing process automation in their area, to be able to validate the subsequent questions.

The next questions had the main purpose of asking for an evaluation of the created solution. To have these answers, it was asked to evaluate on a scale from totally agree to totally disagree the following activities:

1. Sending an alert (email) to the auditors when the robot identifies, in the Annual Audit Plan, an audit action to be started in the next 7 days;
2. Automatic scheduling of the audit communication meeting with the audited area;
3. Automatic sending of an email with information requests to the audited area;
4. Automatic scheduling of the closing audit meeting and sending of the final report;
5. Creation of a Power BI report, based on the information collected from the final report (findings identified) and the hours spent since the beginning of the audit, which will support key performance indicators.

To verify the auditors' satisfaction with the implementation of the activities, they were asked to evaluate from 0 to 5 the added value of implementing the automation in the Audit Department, considering 1 as not very useful and 5 as very useful.

Lastly, two optional open-text questions were created to collect feedback. The first was intended to collect feedback from auditors on activities in the audit process that they felt necessary to be automated. The second asked them to identify points for improvement in the development. The survey can be seen in Appendix A.

5.2 Respondent Universe

The universe of answers corresponded to 17 auditors from 4 Portuguese banks, of which 2 are considered large companies and the other 2 small medium-sized companies. It was verified by the survey that they had quite distinct academic backgrounds, as shown in Figure *17*. Most of the respondents have a bachelor's degree, specifically 53%, and about 42% have a master's degree completed. The remainder has post-graduate degrees as their academic background.

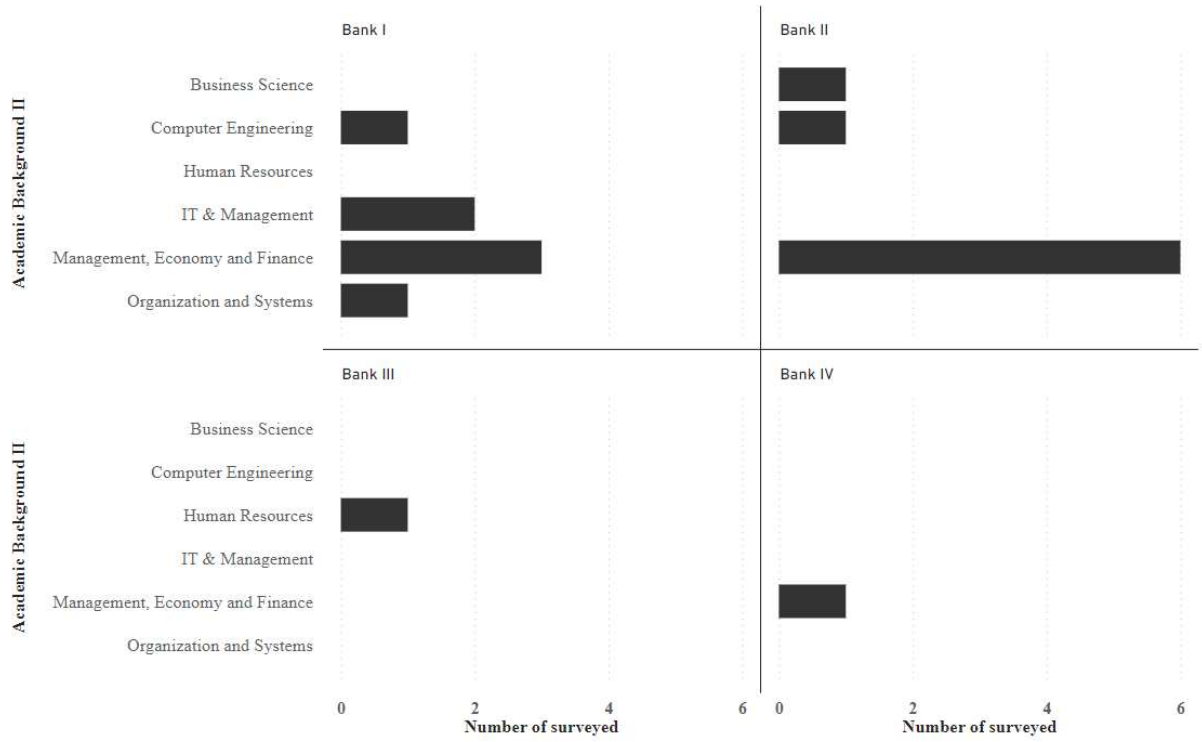

Figure 17 - Academic Background of surveyed auditors

When it comes to ages, as shown in Figure *18*, 47% have between 30 and 39 years, 23% have between 40 and 49 years and 18% have less than 29 years. The other 12% have more than 50 years.

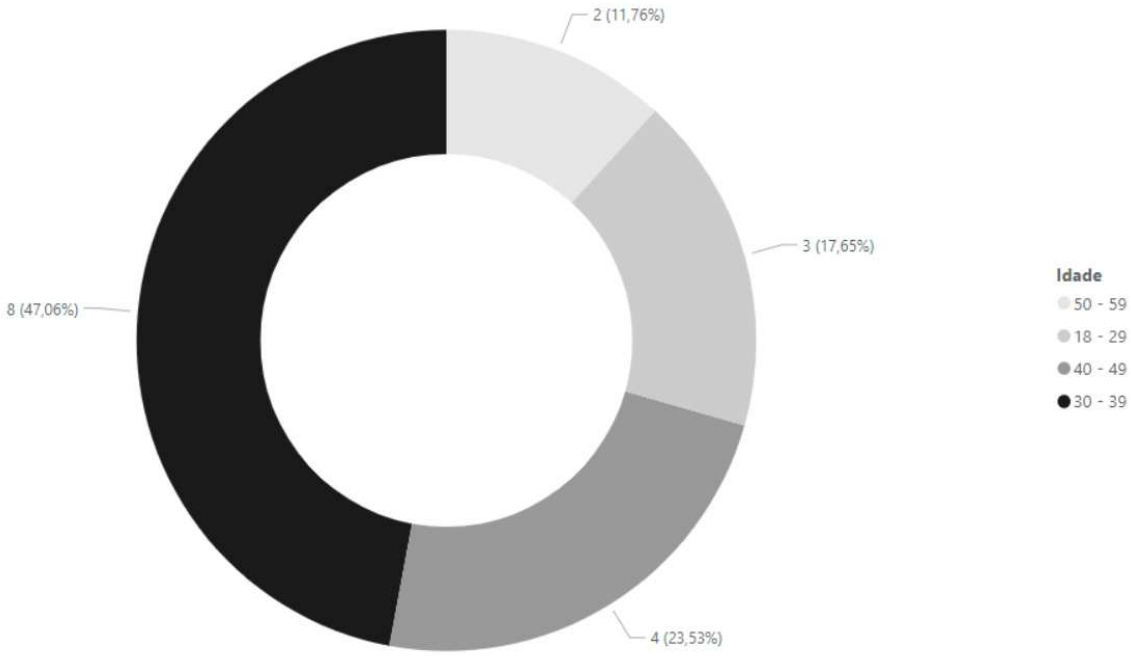

Figure 18 – Respondents' ages

About 82% of respondents are technicians, 12% are coordinators and 6% have a director role, which corresponds to 1 auditor – important to note that all of them work in an audit department. Also, it is possible to verify that about 58% are male, which shows that gender disparity in auditing areas was not experienced in this study.

5.3 Survey responses

As previously said, at an earlier stage of the survey was necessary to ask the auditors' opinion about the existence of automation resistance in their area. It was possible to see that 94% already knew about automated activities in audit, and when questioned about the resistance of auditors to automation, the answer was positive. As presented in Figure *19*, about 82% answered that there is no resistance from the auditors. However, 3 auditors mentioned that they see resistance from auditors to automated activities. 4 auditors answered "maybe", which shows some doubt about the acceptance of automation in their area.

When asked if they considered that the automated activities had a positive impact on their work, about 88% acknowledged the positive impact.

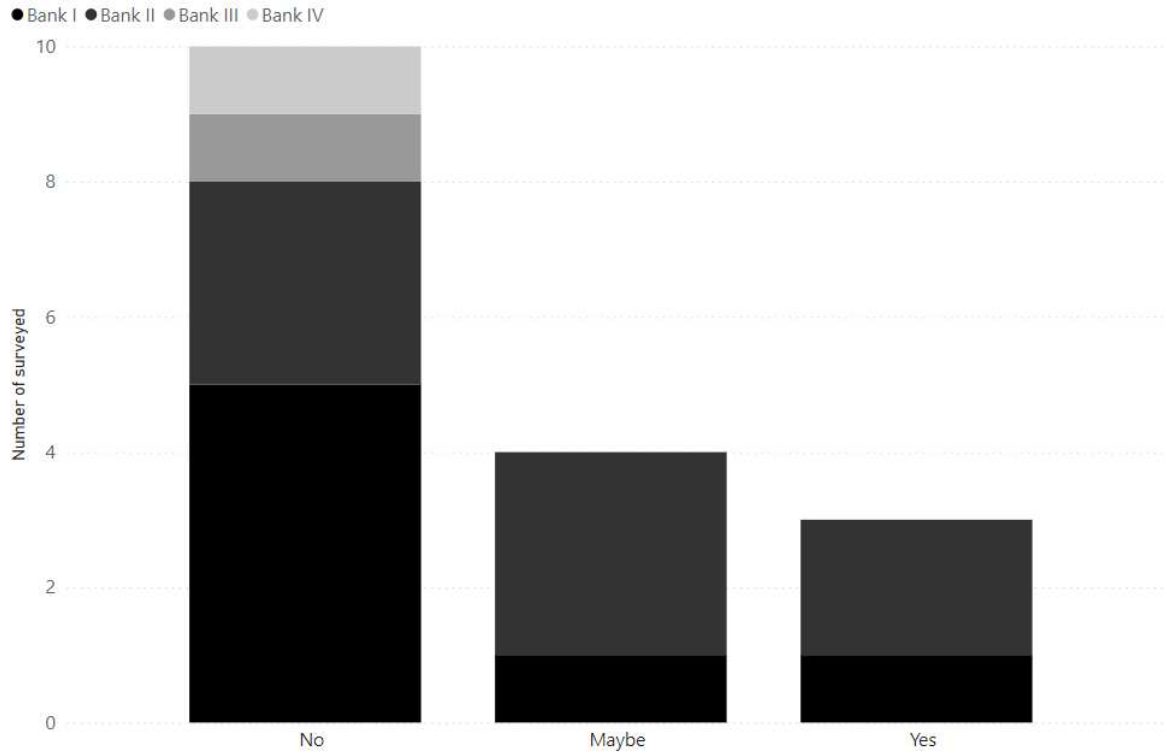

Figure 19 - Responses about the resistance of auditors to automation

Afterward, the auditors were asked to evaluate the activities that were automated with this development, to understand how they would consider the solution in the business environment. When asked about the importance they would give to implementing an alarm system that would inform the auditors whenever they had an audit action about to start, based on the audit plan, the response was very optimistic. About 100% of the respondents agreed with the implementation of the alert, in which 65% totally agreed as demonstrated in Figure *20*.

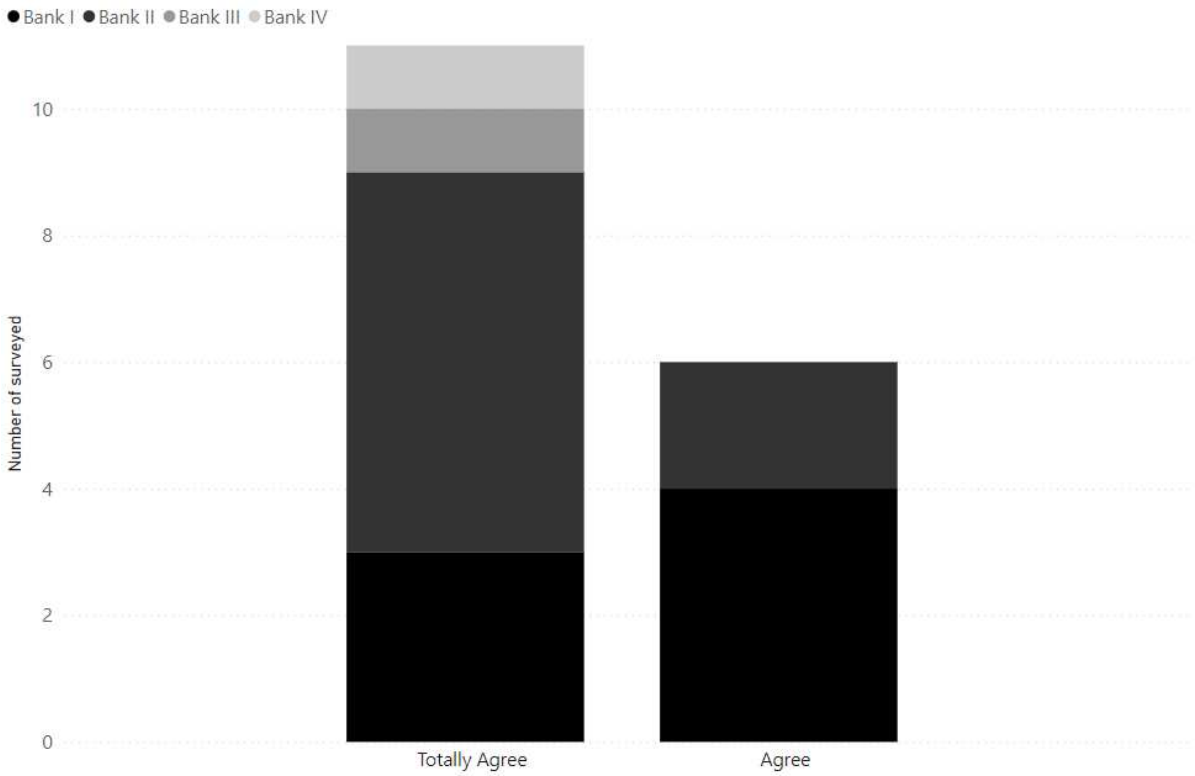

Figure 20 - Responses about the implementation of the alarmistic email

When asked about the sending of emails with information requests, the answers varied a bit more. About 82.35% of the respondents answered that they agree with the implementation of an automatic email sending of information requests, however, 11.77% disagreed, and 5.88% neither agreed nor disagreed.

One of the respondents who disagreed with the implementation of email sending ended up giving the same negative answer on the remaining questions that asked about agreement on the implementation of email automation. When analyzing the answer given by the respondent to the question of resistance by auditors to automation, it was found that the respondent was 1 of the 4 to answer "maybe". This response may be directly correlated with disagreement when it comes to automating routine tasks such as email sendings. It was also verified that this was a coordinator of the audit areas.

The scheduling of the final meeting and the sending of the email with the final report had the approval of 58% of the auditors. About 23.53%, which corresponds to 4 auditors, were neutral on this question. About 3 of these 4 auditors are technicians, and it can validate the neutrality of the answer since it is a task mostly carried out by the directors of the area. Identical answers were found to the question about automatic scheduling of the audit communication meeting with the audited area, which had 62,5% agree on responses.

The implementation of power BI reporting in the area was positively evaluated, as can be seen in Figure *21*, showing that 94% agree with the implementation. The auditor that answered "neutral" corresponds to 1 of the 3 auditors that identified resistance in audit areas, which validates that the responses are directly correlated with an indication of resistance in audit areas.

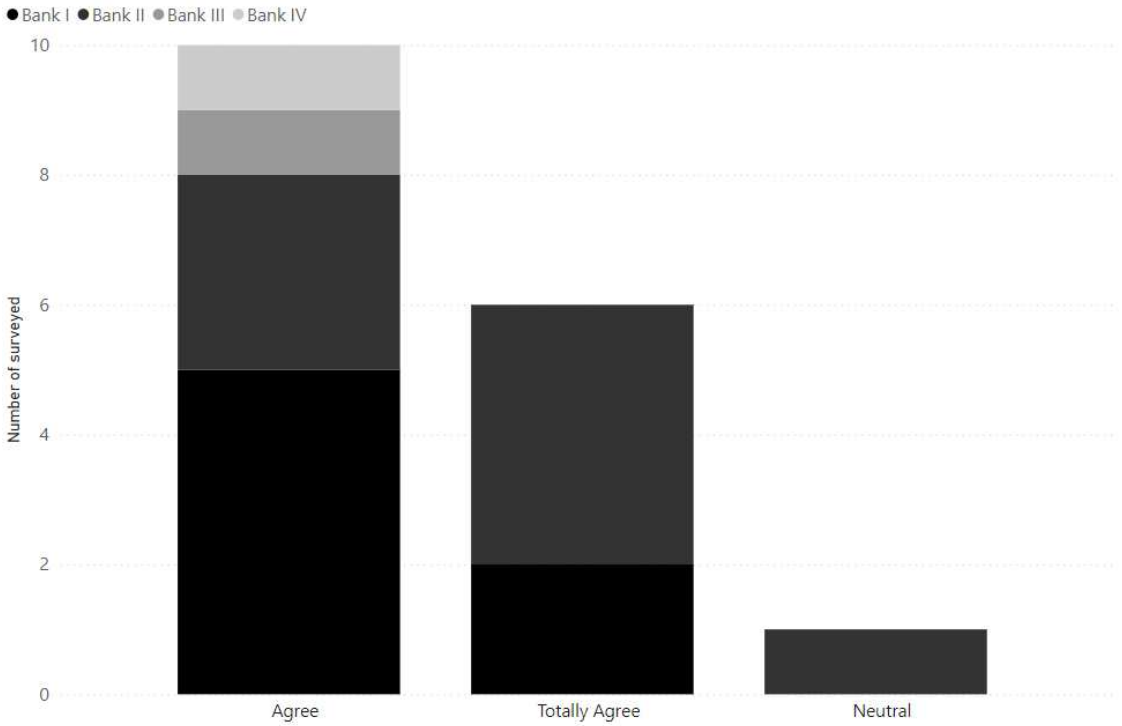

Figure 21 - Response of Power BI report implementation

Finally, it was asked to auditors to rate from 0 to 5 how important it would be to implement the above-rated activities into a single solution for the audit area. Considering that it was possible to verify the resistance of some auditors throughout the various questions, it was expected that there would be some resistance in the final solution evaluation. However, it is possible to verify that 94% of the auditors evaluated the solution with more than 4 points, which indicates a positive evaluation. The results are presented in Figure *22*.

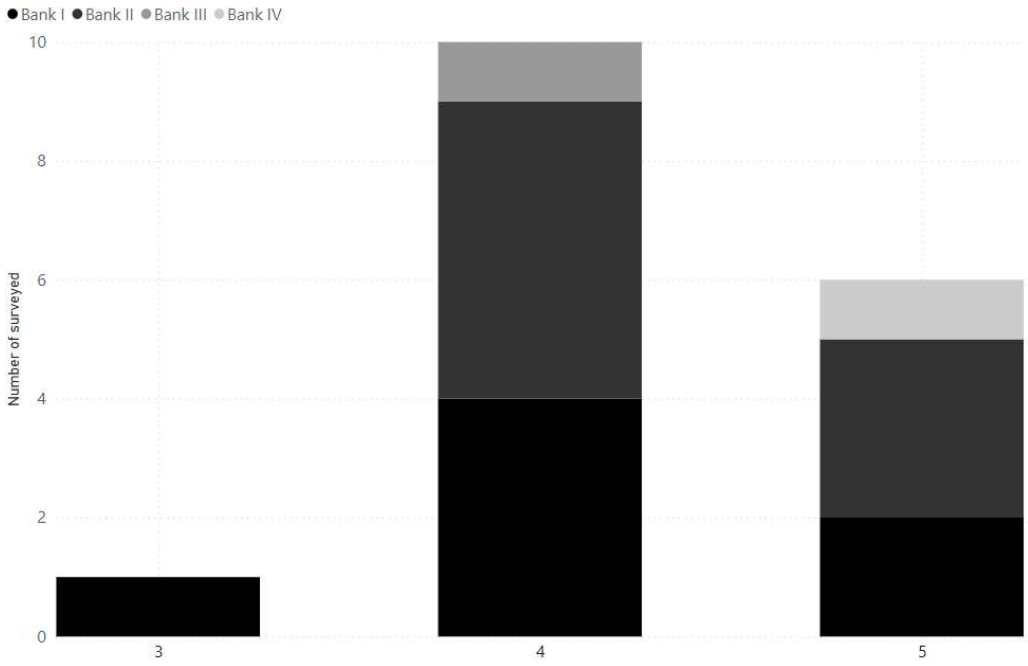

Figure 22 - Evaluation of a Solution

Since the audit areas are used to do the same process repeatedly, there is resistance when a solution is implemented that will bring some change to the structure. Audit is an area that assesses the company's risks, so everything that is implemented within the area must also be devoid of technical errors. However, the fact that all the activities ask for validation from the auditor guarantees the continuity of the process. There is certainly continued work to be done in people and processes to consider automation as an integral part of our work and our life.

CHAPTER 6

Conclusion

The main objective of this work was to automate manual and repetitious activities from the audit process to guarantee a more effective business continuity management, by helping to identify the right solution to automate and by removing potential risks.

To address this objective, several stages were conducted. Firstly, a literature review was performed to provide a full picture of the risks, benefits, and challenges of automating audit processes. Then, a methodology was defined using DSRM, to identify the problem and choose the solution' objective. After that, the design for the proposed solution was presented so as the development phases. Finally, survey was done to an universe of bank auditors in order to understand if the presented solution meet their needs.

In conclusion, the results demonstrated the relevance of the developed IPA in the audit process. The main advantages of this work are the implementation of an alarmistic that will inform auditors when their audit is about to start, and the KPIs representation that will provide an overview of the audit plan accomplishment and identify improvements in audit management area.

When adding the previous activities to the automation in email sending's and meeting requests, it will provide savings in auditors efforts, increased agility for transformation in audit department, and increased speed of auditor's work delivery.

This paper intends to bring to industry a new view of the auditing process. It is an area that has been growing in companies, mainly to audit IT areas, so it is necessary to revolutionize this area and make processes smarter so that auditors' time is allocated to more critical tasks. Additionally, a lot of gray literature was found about this theme. Thus, there is a need for more scientific research on the progress of implementing technologies such as IPA in audit.

Therefore, it is possible to conclude that the developed work meets the proposed objective, being a relevant contribution to implementing Artificial Intelligence and Robotic Process Automation in the audit process.

6.1 Limitations

During the analysis of the surveys' results, one limitation associated with the subject under study was found. The analysis was performed by 4 different companies, specifically small, medium, and large banks. For this reason, the answers correspond to different realities. Large

companies need to apply more automation, as they have more processes to perform, and many of them are quite repetitive. On the opposite side, we see small companies, which, due to cost containment, tend to not invest in automation.

This solution is more targeted at large companies that have an exhaustive audit plan. Even though it is a low-cost solution, it requires resources to continuously evaluate IPA progression.

6.2 Future work

Regardless of the validations considered, we hope that the developed work can inspire future iterations to implement more automated audit processes. Since audit is an increasingly important area in organizations to identify risks and problems in processes, it is important to eliminate all the repetitive tasks that the process requires. This work has demonstrated that the audit area can become agile with the implementation of automation throughout the process. Naturally, there are certain activities already automated during fieldwork, however, it is always unclear whether it is the best activity to automate or a waste of money and resources.

This solution is used 24/7 and can be implemented by the audit areas at a low cost. Furthermore, it can be enhanced according to the needs of each company. After the areas have identified the main gaps through KPIs, such as an audit performed annually that needs a lot of time to be executed, management can decide that the most useful thing in the long term will be to automate the whole process. This could be done by adding a new IPA process in the developed solution, which will be executed whenever the respective audit is included in the plan. Therefore, in future work it is important to add new IPA processes to the developed solution, aligned with company needs.

Based on the respondents' answers, some feedback was obtained about what could be added. It was mentioned the creation of automatic alert procedures at the different milestones of the audit process, i.e. (i) total time spent vs. planned and (ii) alerts about the days left to finish the project. It was also mentioned the need to apply more automation in data extraction activities, working maps, characterization of findings and regular status reports sending.

Bibliography

[1] KGiSL, "COVID-19 Outbreak: How Robotic Process Automation (RPA) could ensure Business Continuity," *https://www.kgisl.com/blog/covid-19-how-robotic-process-automation-rpa-helps-ensure-business-continuity/*, Mar. 27, 2020.

[2] C. Maria L. Murphy, "Assessing audit risks during the pandemic," *Journal of Accountancy*, Dec. 2020.

[3] V-Softconsulting, "What is RPA and How is it Used for Business Automation?," *https://blog.vsoftconsulting.com/blog/what-is-rpa-and-how-it-can-be-a-key-enabler-of-automation-efforts*.

[4] S. Anagnoste, "Robotic Automation Process - The next major revolution in terms of back office operations improvement," *Proceedings of the International Conference on Business Excellence*, vol. 11, no. 1, pp. 676–686, Jul. 2017, doi: 10.1515/picbe-2017-0072.

[5] Y. Devarajan, "A Study of Robotic Process Automation Use Cases Today for Tomorrow's Business," *International Journal of Computer Techniques*, vol. 5, [Online]. Available: http://www.ijctjournal.org

[6] Javatpoint, "History of RPA (Robotic Process Automation)." https://www.javatpoint.com/history-of-rpa (accessed Jan. 23, 2022).

[7] S. Sikora, B. Hurley, and A. G. Tharakan, "Automation with intelligence Pursuing organisation-wide reimagination," 2019.

[8] B. L. Handoko, A. S. L. Lindawati, and M. Mustapha, "Robotic Process Automation in Audit 4.0," Jul. 2021, pp. 128–132. doi: 10.1145/3481127.3481140.

[9] H. Bharadhwaj, "Auditing Robot Learning for Safety and Compliance during Deployment," 2021.

[10] M. Gotthardt, D. Koivulaakso, O. Paksoy, C. Saramo, M. Martikainen, and O. Lehner, "Current state and challenges in the implementation of smart robotic process automation in accounting and auditing," *ACRN Journal of Finance and Risk Perspectives*, vol. 9, no. 1, pp. 90–102, May 2020, doi: 10.35944/JOFRP.2020.9.1.007.

[11] S. Mandal, C. Amrein, J. Switchenko, R. Ryan Martin, and S. Rosensweig, "Robotic process automation: A primer for internal audit professionals," 2017.

[12] K. C. Moffitt, A. M. Rozario, and M. A. Vasarhelyi, "Robotic process automation for auditing," *Journal of Emerging Technologies in Accounting*, vol. 15, no. 1. American Accounting Association, pp. 1–10, Mar. 01, 2018. doi: 10.2308/jeta-10589.

[13] F. K. Kamei, S. Soares, and G. Pinto, "The Use of Grey Literature Review as Evidence for Software Engineering," 2018.

[14] V. Garousi, M. Felderer, and M. v. Mäntylä, "Guidelines for including grey literature and conducting multivocal literature reviews in software engineering," *Inf Softw Technol*, vol. 106, pp. 101–121, Feb. 2019, doi: 10.1016/j.infsof.2018.09.006.

[15] R. Hayes, R. Dassen, A. Schilder, and P. Wallage, "PRINCIPLES OF AUDITING An Introduction to International Standards on Auditing." [Online]. Available: www.booksites.net/hayes

[16] A. Rocha, Associação Ibérica de Sistemas e Tecnologias de Informação, Institute of Electrical and Electronics Engineers. Spain Section, and Institute of Electrical and Electronics Engineers, *2020 15th Iberian Conference on Information Systems and Technologies (CISTI) : proceedings of CISTI'2020 - 15th Iberian Conference on Information Systems and Technologies : 24 to 27 of June 2020, Seville, Spain*.

[17] R. Widuri, B. L. Handoko, and I. C. Prabowo, "Adoption of Information Technology in Public Accounting Firm," in *Proceedings of the 2019 4th International Conference on Big Data and Computing - ICBDC 2019*, 2019, pp. 198–202. doi: 10.1145/3335484.3335500.

[18] Chicago State University, "Audit Process," *https://www.csu.edu/internalaudit/auditprocess.htm*.

[19] D. Appelbaum and R. Nehmer, "The Coming Disruption of Drones, Robots, and Bots," 2017. [Online]. Available: http://fam.ag/2rUAEG9

[20] L. Griffiths and H. W. Pretorius, "Implementing Robotic Process Automation for Auditing and Fraud Control," in *Communications in Computer and Information Science*, 2021, vol. 1477 CCIS, pp. 26–36. doi: 10.1007/978-3-030-86761-4_3.

[21] IEEE, "IEEE Guide for Terms and Concepts in Intelligent Process Automation," *IEEE Std 2755-2017*, pp. 1–16, 2017.

[22] R. Herrera, L. Burke, E. Diquez, and D. Graff, "RPA and the Path to Digitalization : What ' s in it for Internal Audit ?," 2020. Accessed: Jan. 22, 2022. [Online]. Available: https://f.hubspotusercontent00.net/hubfs/2762002/RPA and the Path to Digitalization - Whats in it for Internal Audit.pdf

[23] F. Huang and M. A. Vasarhelyi, "Applying robotic process automation (RPA) in auditing: A framework," *International Journal of Accounting Information Systems*, vol. 35, Dec. 2019, doi: 10.1016/j.accinf.2019.100433.

[24] KPMG, "Balancing risk and change in Robotics Process Automation (RPA) transformation," 2018.

[25] R. Syed *et al.*, "Robotic Process Automation: Contemporary themes and challenges," *Comput Ind*, vol. 115, Feb. 2020, doi: 10.1016/j.compind.2019.103162.

[26] S. Wojciechowska-Filipek, "Automation of the process of handling enquiries concerning information constituting a bank secret," *Banks and Bank Systems*, vol. 14, no. 3. LLC CPC Business Perspectives, pp. 175–186, 2019. doi: 10.21511/bbs.14(3).2019.15.

[27] Deloitte, "Creating an environment for apt and adept automation Seven-step progression of RPA risks and controls." [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2019-03-07-gartner-predicts-up-to-two-thirds-of-ipaas-vendors-wi.

[28] T. Avasthy, "The New Frontier Of Automation: Enterprise RPA," Dec. 2017.

[29] J. Steinhoff, A. Lewis, and K. Everson, "The march of the robots," *J. Gov. Financ. Manage.* , pp. 26–33, 2019.

[30] A. Hale, E. VanVleet, J. Butt, and T. Hollis, "The 'Power of With': Combining humans and machines to transform tax," 2020. https://www.internationaltaxreview.com/article/b1kblrgr0f73s7/the-power-of-with-combining-humans-and-machines-to-transform-tax (accessed Feb. 04, 2022).

[31] T. Nunes, J. Leite, and I. Pedrosa, “Intelligent Process Automation: An Overview over the Future of Auditing,” in *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, Jun. 2020, pp. 1–5. doi: 10.23919/CISTI49556.2020.9140969.

[32] F. A. Lievano-Martínez, J. D. Fernández-Ledesma, D. Burgos, J. W. Branch-Bedoya, and J. A. Jimenez-Builes, “Intelligent Process Automation: An Application in Manufacturing Industry,” *Sustainability (Switzerland)*, vol. 14, no. 14, Jul. 2022, doi: 10.3390/su14148804.

[33] IBM, “What is computer vision?,” *https://www.ibm.com/topics/computer-vision*.

[34] Avi Bhagtani, “Computer Vision: Intelligent Automation that Sees,” *https://www.automationanywhere.com/company/blog/rpa-thought-leadership/computer-vision-intelligent-automation-that-sees*, Mar. 09, 2021.

[35] D. Seshadri and A. Sharma, “Auditing the RPA environment Our approach towards addressing risks in a BOT environment Risk Advisory,” 2018. [Online]. Available: www.deloitte.com/about

[36] H. Issa, T. Sun, and M. A. Vasarhelyi, “Research ideas for artificial intelligence in auditing: The formalization of audit and workforce supplementation,” *Journal of Emerging Technologies in Accounting*, vol. 13, no. 2. American Accounting Association, pp. 1–20, 2016. doi: 10.2308/jeta-10511.

[37] AICPA, *Audit Analytics and Continuous Audit: Looking Toward the Future*. New York: American Institute of Certified Public Accountants, Inc., 2015.

[38] M. A. Vasarhelyi, M. G. Alles, and A. Kogan, “Principles of Analytic Monitoring for Continuous Assurance,” *Journal of Emerging Technologies in Accounting*, vol. 1, no. 1, pp. 1–21, Jan. 2004, doi: 10.2308/jeta.2004.1.1.1.

[39] C. P. Agoglia, J. F. Brazel, R. C. Hatfield, and S. B. Jackson, “How doaudit workpaper reviewers cope with the conflicting pressures of detecting misstatements and balancing client workloads?,” *Auditing*, vol. 29, no. 2, pp. 27–43, Nov. 2010, doi: 10.2308/aud.2010.29.2.27.

[40] J. C. Bedard, M. L. Ettredge, and K. M. Johnstone, “Using Electronic Audit Workpaper Systems in Audit Practice: Task Analysis, Learning, and Resistance,” *SSRN Electronic Journal*, 2006, doi: 10.2139/ssrn.934201.

[41] H. Dabthong, M. Warasart, P. Duma, P. Rakdej, N. Majaroen, and W. Lilakiatsakun, “Low Cost Automated OS Security Audit Platform Using Robot Framework,” in *Proceedings - 2021 Research, Invention, and Innovation Congress: Innovation Electricals and Electronics, RI2C 2021*, Sep. 2021, pp. 31–34. doi: 10.1109/RI2C51727.2021.9559826.

[42] M. G. Alles, A. Kogan, and M. A. Vasarhelyi, “Audit Automation for Implementing Continuous Auditing: Principles and Problems.”

[43] Hevner, March, Park, and Ram, “Design Science in Information Systems Research,” *MIS Quarterly*, vol. 28, no. 1, p. 75, 2004, doi: 10.2307/25148625.

[44] K. Peffers, T. Tuunanen, and M. Rossi, “The design science research process: A model for producing and presenting information systems research Cross-border Shopping View project Wide Audience End-Users for Digital Services View project,” 2006. [Online]. Available: https://www.researchgate.net/publication/228650671

[45] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, “A design science research methodology for information systems research,” *Journal of Management Information Systems*, vol. 24, no. 3, pp. 45–77, Dec. 2007, doi: 10.2753/MIS0742-1222240302.

[46] C. Martins, M. Mamede, J. Monteiro, and M. Silva, “Robotic Process Automation A Lean Approach to RPA Information Systems and Computer Engineering Examination Committee,” 2018.

[47] SoftwareTestingHelp, “10 Most Popular Robotic Process Automation RPA Tools In 2022,” *https://www.softwaretestinghelp.com/robotic-process-automation-tools/*, Nov. 12, 2022.

[48] MetricStream, “Audit Performance Measurement,” *https://www.metricstream.com/insights/audit_performance_measurement.htm*.

[49] AuditBoard, “KPI Audit Checklist: Top Metrics to Track,” *https://www.auditboard.com/blog/top-metrics-to-track-in-your-audits-checklist/*, Jul. 24, 2019.

[50] AuditNet, “AuditNet Audit-library: Annual-audit-planning,” *https://www.auditnet.org/audit-library/annual-audit-planning*.

[51] Chartered Institute of Internal Auditors, “Annual internal audit coverage plans Chartered Institute of Internal Auditors,” Sep. 2020.

[52] Ministério da Defesa Nacional, “Plano Anual de Auditoria v2– Instituto de Ação Social das Forças Armadas, I.P.,” May 2020.

[53] Stephen S., “Audit Report Issue Email Template,” *https://www.studocu.com/en-us/document/the-university-of-texas-at-dallas/auditing/audit-report-issue-email-template/6320637*. Stephen S., Texas, 2020.

[54] The Internal Auditor, “Internal Audit Reporting Template,” *https://www.theinternalauditor.org/Documents/*.

[55] Zebra BI, “Total Table Flexibility, From Calculations to Design,” *https://zebrabi.com/power-bi-custom-visuals/tables/*.

Appendix A

Survey: Automação Inteligente do Processo de Auditoria

Este inquérito tem como principal objetivo recolher dados estatísticos sobre a satisfação da implementação de um IPA (Intelligent Process Automation) no processo de auditoria em contexto empresarial, estando enquadrado no âmbito da Dissertação de Mestrado em Engenharia Informática no ISCTE- Instituto Universitário de Lisboa.

A participação é voluntária e os dados fornecidos são confidenciais, apenas para uso exclusivo desta pesquisa. A veracidade das respostas é importante e devem corresponder à opinião pessoal do inquirido.

Obrigada pela colaboração.

---

*Obrigatório

1. Idade *

   Marcar apenas uma oval.

   - ◯ 18 - 29 anos
   - ◯ 30 - 39 anos
   - ◯ 40 - 49 anos
   - ◯ 50 - 59 anos
   - ◯ > 59 anos

2. Género *

   Marcar apenas uma oval.

   - ◯ Feminino
   - ◯ Masculino
   - ◯ Outra:

3. Formação Académica *

   Marcar apenas uma oval.

- Licenciatura
- Pós Graduação
- Mestrado
- Doutoramento
- Outra:

4. Área de Formação Académica *

5. Profissão *

Marcar apenas uma oval.

- Diretor - Auditoria
- Coordenador - Auditoria
- Técnico - Auditoria
- Outra:

6. Empresa *

A automação inteligente de processos é uma combinação de tecnologias de Automação Robótica de Processos (RPA) e Inteligência Artificial (AI) que automatiza tarefas repetitivas, replicáveis, comuns e não especializadas. Junto com o efeito colateral desejável de eliminar o erro humano, simplifica as interações e economiza tempo, tornando esses processos de rotina mais rápidos.

Exemplos : Processamento de pedidos, envio de notificações, gestão de relatórios de conformidade e registo, validação e análise de dados da empresa.

7. Tem conhecimento de alguma atividade/processo de auditoria automatizado na * sua empresa?
Marcar apenas uma oval.

- Sim
- Não

8. Caso conheça, considera que a automatização do processo/atividade teve impacto positivo na Direção?

   Marcar apenas uma oval.

   - Sim
   - Não
   - Talvez

9. Considera que existe resistência por parte dos colaboradores na aplicação de automação em áreas como auditoria? *

   Marcar apenas uma oval.

   - Sim
   - Não
   - Talvez

Nesta secção é solicitada uma avaliação das atividades automatizadas do processo E2E de auditoria. Esta automação foi desenvolvida através da ferramenta UIPath e de técnicas de Inteligência Artificial, nomeadamente *Computer Vision,* e tem como principal objetivo acompanhar todo o processo das auditorias identificadas no Plano Anual de Auditoria.

Nota: No desenvolvimento é dada a possibilidade ao auditor de recusar a execução das atividades por parte do robot, quando necessário, de modo a garantir a continuidade do processo.
O controlo será realizado através de botões de aprovar/recusar, incluídos nos emails enviados pelo robot, antes da execução de qualquer tarefa.

Para a automação do processo, o Plano Anual de Auditoria deverá conter, pelo menos, as seguintes informações: Nome da auditoria, email dos auditores, data de início da ação e email do responsável da área auditada.

10. Envio de um alerta (email) aos auditores quando o robot identificar, no Plano Anual de Auditoria, uma ação de auditoria a iniciar nos próximos 7 dias. *

    Marcar apenas uma oval.

- Concordo totalmente
- Concordo
- Não concordo, nem discordo
- Discordo
- Discordo totalmente

11. Agendamento automático da reunião de comunicação de auditoria com a área auditada. *

Marcar apenas uma oval.

- Concordo totalmente
- Concordo
- Não concordo, nem discordo
- Discordo
- Discordo totalmente

12. Envio automático de um email com os pedidos de informação à área auditada. *

Marcar apenas uma oval.

- Concordo totalmente
- Concordo
- Não concordo, nem discordo
- Discordo
- Discordo totalmente

13. Envio automático do relatório final e agendamento da reunião de fecho de auditoria. *

Marcar apenas uma oval.

- Concordo totalmente
- Concordo
- Não concordo, nem discordo
- Discordo
- Discordo totalmente

14. Alimentação de um relatório Power BI, com base na informação recolhida do relatório final (findings identificados) e das horas dispendidas desde o início da auditoria, que suportará os seguintes KPIs: *

1. Percentagem do Plano Anual de Auditoria completo;
2. Número de auditorias concluídas;
3. Número de findings por gravidade; e
4. Horas dispendidas por auditoria.

(Possibilidade de filtrar por auditor que realizou a ação, ano, auditoria e área auditada. É importante sublinhar que a informação estará sempre atualizada e servirá de suporte em tomadas de decisão.)

Marcar apenas uma oval.

- ◯ Concordo totalmente
- ◯ Concordo
- ◯ Não concordo, nem discordo
- ◯ Discordo
- ◯ Discordo totalmente

15. De 0 a 5, avalie o valor acrescentado da implementação da automação das atividades acima descritas na Direção de Auditoria. Considere 1 como pouco útil e 5 como muito útil. *

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

16. Considera que existem outras atividades do processo de auditoria que carecem de automação? Se sim, indique quais.

_____

17. Considera que existem pontos de melhoria no desenvolvimento? Se sim, indique quais.

_____