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Financial accounting processes automation: Guidelines for implementation

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Abstract

Research Question: How to implement automation solutions in financial accounting?

Motivation: There are claims on the academic literature about no clear guidelines for implementing automation technologies in accounting processes, and that this lack of guidance causes failures to the overall adoption of these new technologies in the field.

Idea: This study aims to identify the essential steps for implementing automation in financial accounting processes.

Data: The authors selected articles on the theme through a systematic literature review, resulting in a sample of 46 papers.

Tools: Content analysis was performed to organize the data into three categories established according to a theory-driven coding approach.

Findings: In addition to consolidating the steps for implementing automation technologies, the results indicate that the step of evaluation of process characteristics is essential, enabling the assessment of compatibility between the automation technology and the accounting processes under analysis. Consequently, for the implementation of such technologies, the technology itself must be capable of automating processes that exhibit specific characteristics identified throughout the research.

Contribution: This study provides guidance on how to implement automation technologies in financial accounting processes. The consolidation of implementation steps and identification of automatable process characteristics organize the knowledge surrounding the

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theme while clearly indicate what kind of process can be automated. In this regard, accounting practitioners can better guide their strategies for adopting process automation technologies, while academics can use the steps to conduct empirical research on the implementation of these technologies.

Keywords: systematic literature review (SLR), research agenda, financial accounting, process automation, robotic process automation (RPA).

JEL codes: M15, M41

1. Introduction

Organizations are showing growing interest in automating their processes as they become more aware of the latest automation solutions (Fernandez & Aman, 2018). Given the rapid pace of technological advancement it is strategically important for companies to invest in these solutions (Gotthardt *et al.*, 2020). Fernandez and Aman (2018) highlight that a substantial portion of the financial industry is planning investments in process automation projects.

The automation phenomenon has reached various types of businesses (Dumitru & Stanculescu, 2020), particularly those whose routines are highly suitable to automation solutions (Klimkeit & Reihlen, 2022). While process automation solutions can be compatible with virtually any organization that relies on manual processes (Morrison, 2018), their primary and growing applicability is observed within financial accounting processes (Januszewski & Kujawski, 2021; Gotthardt *et al.*, 2020; Fernandez & Amana, 2018). This is because many financial accounting processes are inherently 'robotizable' (Januszewski *et al.*, 2021), characterized by their mechanical and standardized nature, such as month-end closing routines (Vincent *et al.*, 2020).

In this context, Robotic Process Automation (RPA) has emerged as a central component of accounting automation in the literature (Klimkeit & Reihlen, 2022; Zhou, 2021; Cooper *et al.*, 2019; Morrison, 2018): "RPA is a big step forward in business-process automation because of its ease of use and broad application", as stated by Tiron-Tudor *et al.* (2024, p. 11). While automation already existed in accounting through the use of macro routines in electronic spreadsheets (Morrison, 2018) and Enterprise Resource Planning (ERP) systems (Tiron-Tudor *et al.*, 2024; Li, 2021), the introduction of RPA has transformed the landscape of accounting automation (Matthias, 2020). This is primarily because RPA projects are designed to automate manual and transactional tasks, including data entry into systems, a prevalent routine within financial accounting (Vincent *et al.*, 2020).

Due to inefficiencies in accounting processes, often reliant on disorganized electronic spreadsheets and excessive manual labor (Gotthardt *et al.*, 2020), there is an expectation for the widespread adoption of process automation (Li, 2021; Qiu & Xiao, 2019). Korhonen *et al.* (2021) emphasize the critical importance of selecting the right processes for a successful automation implementation. However, there is a notable absence of guidelines for the development and implementation of such solutions (Matthias, 2020).

The absence of clear strategies and guidelines for process selection hampers the widespread adoption of automation within the accounting field (Eulerich *et al.*, 2022; Bakarich & O'Brien, 2021; Cooper *et al.*, 2019). Ghobakhloo *et al.* (2023) claim that there is little to no empirical research on the topic of implementation of this kind of solutions. Consequently, companies are missing out on the full range of benefits offered by automation, including increased productivity, process improvement, and cost reduction (Jackson & Allen, 2024; Cooper *et al.*, 2019; Fernandez & Aman, 2018).

Gotthardt *et al.* (2020) emphasize the critical importance of companies adopting technologies in a well-informed manner. The absence of proper guidance can lead to incorrect selection of processes for automation, resulting in the application of automation to non-compatible processes (Dahabiyeh & Mowafi, 2023; Korhonen *et al.*, 2021), which in turn can lead to a waste of valuable resources. Furthermore, while technologies such as RPA are relatively straightforward to implement (Huang & Vasarhelyi, 2019), programming errors can result in systemic issues (Eulerich *et al.*, 2023; Zhang *et al.*, 2022; Gotthardt *et al.*, 2020), thus increasing the need to develop guidance for technologies such as RPA (Eulerich *et al.*, 2024). This underscores the risks associated with the implementation process and the necessity for guidelines when adopting such technologies.

The guidelines offered by automation technology providers often prove overly simplistic, failing to consider critical contextual aspects within the environment where the solution will be implemented (Eulerich *et al.*, 2022). In numerous instances, professionals rely on their past experiences to select processes, a notable issue within professional practice (Eulerich *et al.*, 2022). To enhance the effectiveness of process automation initiatives in financial accounting, it becomes imperative to accurately identify the processes in which humans can or cannot be replaced by these technologies (Korhonen *et al.*, 2021; Kokina & Blanchette, 2019). This highlights the need for guidelines for implementing such tools.

In this regard, studies dedicated to elucidating the process of implementing automation solutions become indispensable (Ghobakhloo *et al.*, 2023; Eulerich *et al.*, 2022; Bakarich & O'Brien, 2021; Cooper *et al.*, 2019), particularly with respect to the selection of processes compatible with automation, a pivotal aspect of implementation (Korhonen *et al.*, 2021). Coupled with this is the significant

applicability of automation within financial accounting routines (Januszewski & Kujawski, 2021; Gotthardt *et al.*, 2020; Fernandez & Amana, 2018). This leads to the formulation of the following research question: *How to implement automation solutions in financial accounting?* The primary objective of this study is to identify the essential steps for implementing automation in financial accounting processes.

The significance of this study is underscored by the scarcity of research on the subject of automating accounting processes, which hampers the adoption of automation within the field (Ghobakhloo *et al.*, 2023; Eulerich *et al.*, 2022; Bakarich & O'Brien, 2021; Cooper *et al.*, 2019). The absence of comprehensive guidelines has given rise to issues concerning the proper implementation of automation solutions (Matthias, 2020), including reliance on experience alone for process selection (Eulerich *et al.*, 2022). These challenges introduce risks to the implementation process (Gotthardt *et al.*, 2020), among which is the inappropriate selection of routines for automation (Korhonen *et al.*, 2021), making it necessary to examine implementation of automation technologies (Dahabiyeh & Mowafi, 2023).

To achieve the set objective, we conducted a systematic literature review (SLR) on the subject, dedicated to consolidating the implementation steps discussed in scientific literature. Among these steps, the evaluation of process characteristics emerged as a crucial element of implementation, serving to assess the compatibility between the automation solution and the processes at hand. We also consolidated the key characteristics of processes suitable to automation. The steps identified clearly organize the knowledge on how to implemente automation in financial accounting processes while the characteristics of the processes define the scope of application of these technologies. As the ultimate outcome of this research, we have developed an agenda for future research, designed to encourage further studies on the subject of accounting process automation, which remains a relatively nascent area of inquiry.

2. Method

This research is classified as a qualitative, exploratory-descriptive study. For data collection we employed a systematic literature review (SLR), a method well-suited for synthesizing results from previous research while ensuring transparency and reproducibility (Snyder, 2019). The SLR followed the guidelines outlined in Okoli (2015) and incorporated Snyder's recommendations (2019). The steps undertaken to conduct the review were as follows:

1. Design:
   a. Define the study's theme, problem, and objectives.
   b. Establish the document collection protocol (as depicted in Figure 1).

   c. Apply inclusion criteria: i) employ search terms in databases; ii) select material in English language only; and iii) limit the selection to scientific articles only.
2. SLR Conduction:
   a. Locate relevant documents.
   b. Extract metadata.
   c. Apply exclusion criteria: i) assess relevance to the subject through abstract analysis; and ii) verify document accessibility.
3. SLR Structuring and Writing:
   a. Read, encode, and summarize the gathered documents.
   b. Prepare the SLR.

The search term used was <"accounting" AND "process automation">, and it was applied to titles, abstracts, and keywords of documents indexed in the Scopus and Web of Science (WoS) databases (as illustrated in Figure 1). This selection was influenced by the findings of Meho and Yang (2007), who emphasized the significance of these databases due to their inclusion of high-quality peer-reviewed studies and their extensive coverage of diverse materials. The search was conducted on November 16th, 2024, without imposing any time constraints. Other search terms were attempted; however, the use of certain words resulted in imprecise outcomes or restricted the results:

- "account*": pollutes the results as it considers the verb "to account";
- "financ*": pollutes the results as it encompasses finance broadly, beyond accounting and its processes;
- "robotic process automation": restricts the results to robotic process automation technology;
- "automation": pollutes the results as it considers automation broadly, not limited to process automation;
- "process" AND "automation": pollutes the results as it considers processes and automation separately, not focusing on process automation.

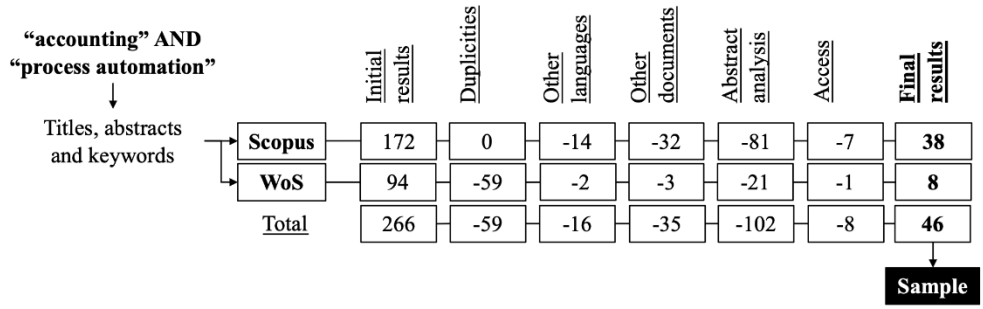

Figure 1. Searching process
Source: the authors' own processing

Initial results yielded 266 documents related to process automation in accounting. Duplicate entries identified in the Web of Science (WoS) database were removed. 16 documents from the Scopus and WoS were excluded because they were written in languages other than English (other languages). The selection process involved retaining documents published as scientific papers while excluding conference abstracts, editorial materials, and book chapters (other documents).

Through abstract analysis it was identified what papers were suited for the research, matching the subject. When the abstract was not enough to evaluate the paper, the full document was analysed. Based on this assessment, 81 papers from Scopus and an additional 21 from WoS were excluded. Finally, any papers that were not accessible were removed from the dataset. This process led to a final selection of 46 scientific papers published in various journals and events, forming the sample for this research.

The content analysis technique, as outlined by Bardin (2016), was applied to the sample making use of NVivo software to organize data and coding the texts (Figure 2). The entire text of each paper was analysed and coded, from introduction to the conclusion section. Although to some extent subjective, the rigor in applying the content analysis technique, describing and coding the findings, provides the necessary objectivity to scientific studies that make use of it (Bardin, 2016). Likewise, applying the technique to pre-existing materials, such as scientific papers, reduces researcher bias issues (Duriau *et al.*, 2007).

Duriau *et al.* (2007) advocates that content analysis is a safe method to apply since the coding process can be corrected as it goes if flaws are identified. The codes, or record units, were extracted from the sample based on their semantic value or underlying themes. This approach is particularly suitable when the research is exploratory in nature (Bardin, 2016). Finfgeld-Connett (2014) states that the way data is encoded is strongly influenced by the research question and the available data itself.

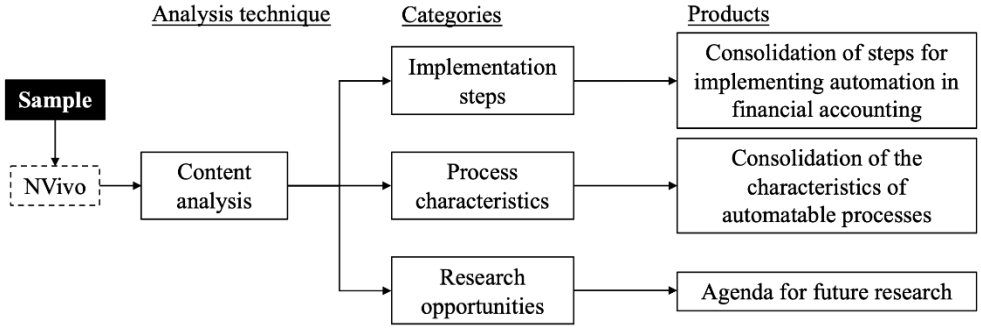

Figure 2. Research produtcs
Source: the authors' own processing

The record units were organized into three categories derived from the sample, following a theory-driven coding approach: i) **Implementation steps**: encompassing sections that delineated the steps required for implementing automation solutions; ii) **Process characteristics**: consolidating the characteristics of processes compatible with automation; and iii) **Research opportunities**: compiling the research gaps identified in the papers. By employing categorical analysis, a rapid and effective method for thematic analysis (Bardin, 2016), the intended outcomes were successfully achieved.

3. Discussion and analysis

3.1 Automation in accounting

Modernizing accounting information systems and embracing digitalization and automation of routines are recognized as means to enhance the quality of financial accounting reports (Chyzhevska *et al.*, 2021; Momo *et al.*, 2021), thereby providing decision-makers with more valuable information (Yoon, 2020). The advent of new Information and Communication Technologies (ICTs), including Artificial Intelligence (AI) and Big Data, is catalyzing a digital transformation within the accounting profession (Kommunuri, 2022; Karmanska, 2021; Yoon, 2020), largely driven by the integration of automation technologies (Cherniyavskyi *et al.*, 2020; Gotthardt *et al.*, 2020).

While automation has the potential to benefit various types of businesses (Dumitru & Stanculescu, 2020), the greatest advantages are often seen in those businesses where numerous processes remain manual (Morrison, 2018). This manual process presence is a key indicator of compatibility with automation solutions (Klimkeit & Reihlen, 2022). Examples of such businesses include Shared Services Centers (SSC) and Global Business Services (GBS) providers offering outsourced financial accounting services (Klimkeit & Reihlen, 2022; Cooper *et al.*, 2019; Fernandez & Aman, 2018). Another less explored example, yet significant, are accounting offices, which also provide accounting outsourcing services (Januszewski *et al.*, 2021).

Januszewski *et al.* (2021) and Matthies (2020) recognize that automation and robotization will play pivotal roles in the future of accounting, reshaping the processes (Korhonen *et al.*, 2021) and the nature of work performed by accountants (Kokina *et al.*, 2021), ultimately enhancing overall performance and efficiency in these processes (Cooper *et al.*, 2022). The increasing applicability of automation in financial accounting (Januszewski & Kujawski, 2021; Gotthardt *et al.*, 2020; Fernandez & Amana, 2018) stems from the fact that these services are viewed as commodity services (Klimkeit & Reihlen, 2022), they are standardized with highly robotized processes (Januszewski *et al.*, 2021).

Discussing application of RPA for automating accounting and auditing processes, Tiron-Tudor *et al.* (2024) identified several routines well fitted for applying such technology: accounts receivable and payable; travel and expense; payroll; fixed assets and inventory management; closure, consolidation, and internal and external reporting; tax; planning and budgeting; data collection and validation; reconciliation; audit risk assessment; audit documentation; internal audit and control. The range of processes demonstrates the feasibility of automation in the accounting field.

Zhang *et al.* (2022) studied attended process automation (APA) implementation over auditing services, which is the application of RPA as a digital assistant for humans. Under this configuration, the user can call upon the bot (RPA robot software) to help complete specific tasks, being suited for tasks that still need human judgement. Such automation emphasizes the collaboration between human and machine, and can prevent side effects over employees by achieving human-machine synergy (Zhang *et al.*, 2022).

Automation solutions offer the potential to boost productivity, enhance processes, and cut costs (Tiron-Tudor *et al.*, 2024; Cooper *et al.*, 2019; Fernandez & Aman, 2018). They bring quality improvements through increased accuracy and data consistency (Tiron-Tudor *et al.*, 2024; Kokina & Blanchette, 2019; Fernandez & Aman, 2018). As noted by Gotthardt *et al.* (2020), the advantages of automation in accounting are particularly evident in the face of inefficient processes that still rely on disorganized electronic spreadsheets, resulting in elevated error rates. Kommunuri (2022) highlights the utilization of Machine Learning (ML) for error and fraud detection in audit services.

> "*the field is still plagued by numerous simple, manual, and recurring tasks that are rule-based, time-consuming, and prone to human error. Copying data from different sources, engaging in manual annotation processes, preparing data for reports or audits, organizing data into homogeneous files, incorporating data from files that are more heterogeneous, and applying simple controls and tests are examples of such tasks.*" (Tiron-Tudor *et al.*, 2024, p. 10)

Nevertheless, the majority of companies are still in the early stages of digitizing their processes (Korhonen *et al.*, 2021), far from harnessing the full benefits promised by process automation (Gotthardt *et al.*, 2020). This is true for the area of financial accounting, where the implementation of solutions is still primarily in its infancy (Bakarich & O'Brien, 2021; Matthias, 2020; Kokina & Blanchette, 2019). Similar situations exists in audit firms, including the industry's leaders, the Big 4, which is the focus of much research (Hsiung & Wang, 2022; Cooper *et al.*, 2019). Bakarich and O'Brien (2021) conducted a study to assess the use of automation technologies in accounting. Their findings revealed that accounting service companies are not

fully leveraging automation solutions and that there is a need for more comprehensive employee training to effectively utilize these technologies.

This slow development is primarily attributed to the absence of appropriate strategies and guidelines for the implementation of automation (Eulerich *et al.*, 2022; Hsiung & Wang, 2022; Bakarich & O'Brien, 2021; Cooper *et al.*, 2019). As Korhonen *et al.* (2021, p. 258) state "The clear implication is that we must be sure that we understand the type of accounting work that is appropriate for automation before drawing conclusions about how advanced technologies can be used in the accounting profession". Korhonen *et al.* (2021) also emphasize the necessity of identifying processes compatible with automation to mitigate the risk of failure in the implementation process. Dahabiyeh and Mowafi (2023) remember that automating too many processes at once may be risky. Januszewski and Kujawski (2021) draw attention to the lack of clarity on how to prepare routines for automation, as adjustments to the process flow are often required.

Another factor that hampers organizations' adoption of automation, often leading to the failure of implementation initiatives, is the excessive focus on technical aspects of automation technology at the expense of social and contextual considerations (Eulerich *et al.*, 2022). The same focus on technical circumstances instead of customers', societal actors' and other environmental players was identified by Ghobakhloo *et al.* (2023). Cooper *et al.* (2019) point out that scientific papers frequently adopt a technological perspective, neglecting to explore automation as a phenomenon within the accounting field. Treating technologies merely as tools, without acknowledging their interconnectedness with other organizational elements, is deemed inadequate (Klimkeit & Reihlen, 2022). Excessive emphasis on practical aspects is mentioned as one of the main limitations of scientific papers (Gotthardt *et al.*, 2020).

Among contemporary technologies, RPA is identified as the linchpin of the accounting automation process (Tiron-Tudor *et al.*, 2024; Klimkeit & Reihlen, 2022; Zhou, 2021; Cooper *et al.*, 2019; Morrison, 2018). Prior to RPA, automation in accounting was primarily associated with computer-assisted routines, often utilizing macros in electronic spreadsheets (Morrison, 2018) or relying on ERP or similar systems (Tiron-Tudor *et al.*, 2024; Li, 2021). RPA has ushered a new perspective on automation (Matthias, 2020). This is because most RPA projects are geared towards eliminating repetitive data entry tasks into systems, which are prevalent in accounting (Vincent *et al.*, 2020). Researchers anticipate a new wave of automation through RPA in the accounting field, poised to bring about significant changes in the profession (Bakarich & O'Brien, 2021; Gotthardt *et al.*, 2020; Cooper *et al.*, 2019).

In their quest to offer guidance for selecting routines to automate via RPA within audit services, Eulerich *et al.* (2022) employed the design science research (DSR) approach. Through this approach, they created an artifact that served a dual purpose:

identifying which processes to automate and prioritizing which ones to automate first. The significance of their method is underscored by the observation that the guidelines offered by RPA solution providers were overly simplistic and did not encompass the contextual intricacies of audit services.

Dumitru and Stanculescu (2020) conducted a literature review on RPA in accounting and pinpointed shortcomings in the guidelines and training practices during technology implementation, which, as Eulerich *et al.* (2022) suggest, contribute to high failure rates. Similarly, Chyzhevska *et al.* (2021) identified lack of guidance and inadequate employee training as primary obstacles faced by Ukrainian companies when adopting new technologies. Fernandez and Aman (2018) delved into the SSC and GBS sectors, recognizing that a critical aspect of RPA implementation was associated with employee training. Vincent *et al.* (2020) underscored that among accounting professionals, only a few possess the knowledge necessary to work with automation solutions like RPA. To address this knowledge gap, Vincent *et al.* (2020) proposed the introduction of a dedicated discipline on RPA automation technology within undergraduate accounting courses.

Dumitru and Stanculescu (2020) also highlighted issues related to the inappropriate selection of technology – a compatibility problem. The evaluation of automation technology compatibility should consider not only the systems used within the company (Yoon, 2020) but, more importantly, the characteristics of the processes selected for automation (Fernandez & Aman, 2018). Therefore, the compatibility of automation technologies such as RPA hinges on their alignment with processes possessing specific characteristics. However, an effort to consolidate these characteristics was only identified in the study conducted by Eulerich *et al.* (2022), which was primarily centered on the context of audit services.

Despite the extensive applicability of automation in financial accounting (Kokina & Blanchette, 2019), it's imperative to exercise caution when embracing new technologies, particularly those considered 'trendy technologies', as there are limits to what can be automated (Bakarich & O'Brien, 2021). Even though the use of automation technologies in the accounting field is not a recent theme, the precise manner of its implementation remains uncertain, posing a contemporary challenge in the field (Cooper *et al.*, 2019).

From the reviewed, it becomes evident that the adoption of automation solutions remains in its initial stages due to a lack of implementation guidance and insufficient employee training. Additionally, the importance of considering contextual factors during implementation to mitigate errors and failures is emphasized. The ongoing transformation in the accounting field is closely linked to the integration of new technologies, with RPA standing out for its compatibility with the characteristics of

processes within financial accounting, marked by their transactional, standardized, repetitive, and robotic nature.

3.2 Implementation steps

At the beginning, an assessment over the regulatory environment must be taken, since, if not permited to automate a processes, it would be useless to implement any automation technology in the first place. That is the case of assurance services, where Eulerich *et al.* (2022) identified that the assessment over the regulatory environment was one crucial contextual aspect that technology providers did not took into account. If permited, regulatory accounting bodies play an important role over the adoption of new technologies by setting standards and best practices (Eulerich *et al*., 2024), stimulating and providing support for adoption of new technologies (Jackson & Allen, 2024).

One of the primary challenges in implementing automation is the identification of processes compatible with automation, requiring an evaluation of their suitability (Cooper *et al.*, 2019). Gotthardt *et al.* (2020) and Cooper *et al.* (2019) emphasize the need to consider process characteristics, specifically the possibility of translating them into rules and a logical flow, to successfully implement automation. The significance of these process characteristics in automation initiatives is underscored by Eulerich *et al.* (2022), who extensively explored this aspect, providing guidance for implementing automation in audit routines.

Eulerich *et al.* (2022) delved into two distinct categories of process characteristics. The first category encompassed those characteristics that rendered the process compatible with the automation technology itself, rooted in the technology's capabilities to automate specific types of processes – essentially the technical aspects. The second category involved characteristics associated with the context in which the process unfolds, including the assessment of potential legal constraints that might impede automation. The researchers underscored the necessity of evaluating both technological and contextual aspects, ensuring that the chosen technology aligns with both categories.

Once a process is identified and evaluated, it becomes imperative for the company to invest in designing and documenting this process (Tiron-Tudor *et al.*, 2024; Kokina & Blanchette, 2019). This initial preparation provides companies with an opportunity to streamline their processes, making them more straightforward and comprehensible (Morrison, 2018). It also aids employees in staying updated with the new process configuration (Ludacka *et al.*, 2019; Fernandez & Aman, 2018). Flowchart design serves a crucial role in evaluating process compatibility with automation technology, enabling the identification of how dependent the processes are on human subjectivity (Tiron-Tudor *et al.*, 2024; Kokina & Blanchette, 2019).

In their research, Korhonen *et al.* (2021) found that there was an initial presumption that a company's sales process relied little on human cognitive factors, such as decision-making. However, during the automation implementation, the process proved to be more intricate than anticipated, resulting in the failure of the initiative (Korhonen *et al.*, 2021).

Huang and Vasarhelye (2019) stress the necessity of revising process structures to align them with automation. Consequently, creating a comprehensive flowchart depicting the current state of the process is essential to identify and document all decision-making nodes (Matthies, 2020; Kokina & Blanchette, 2019). With the flowchart available, the process becomes transparent, enabling adjustments and enhancements to align with the chosen automation technology (Kokina & Blanchette, 2019).

In line with the literature reviewed, a limited number of studies dedicated to elucidating the steps to automation implementation in accounting processes were observed (Eulerich *et al.*, 2022; Bakarich & O'Brien, 2021; Cooper *et al.*, 2019). Within the research sample, only seven studies were identified, with three of them focusing on the audit context. Despite being applied in the context of audit, the steps remain consistent with the routines of financial accounting.

Huang and Vasarhelyi (2019) outlined four steps for implementing automation via RPA in audit routines: process selection, process adjustment (review), implementation, and outcome assessment. In a similar vein, Kokina and Blanchette (2019) identified analogous steps, also applied in the context of audit when using a RPA solution: process selection, process automation (implementation), process execution, process monitoring, and exception management (managing tasks beyond RPA's capabilities).

The framework crafted by Eulerich *et al.* (2022) underscored the significance of process characteristics as a primary factor for evaluating process compatibility with RPA automation technology before implementation. On the other hand, Ludacka *et al.* (2019) examined the adoption of automation in the accounting processes of a large company, outlining the following implementation steps: process identification, process analysis, process design, process implementation, and process monitoring.

The steps undertaken by Zhang *et al.* (2022) consisted first of setting an objective for the automation initiative, not considered in the present study as an implementation step itself. The next proposed steps are process understanding and activity identification, related to detail and evaluate if the process is suited for automation. In sequence, the researchers point out the necessity of a redesign just befor implement the automation (activity automation). Zhang *et al.* (2022) argue the

need for a coordination step that is close related to define a process flowchart. Finally, the last step relates to evaluate the output delivered by the bot.

The study conducted by Brandstätter *et al.* (2023) identified four steps for implementing RPA including selection of the process suitable for automation; followed by the selection and testing of an RPA off the shelf software, which consists in evaluate the compatibility of the solution with the organizational IT infrastructure. This second step is not considered in the present study as a proper implementation step once automation can be self delivered. The third step, development of the RPA-solution, means to program the software. The final step of the study is go-live, when the RPA software is tested and adjusted, that is, to launch the tool and monitor it.

Zhang *et al.* (2023) studied the RPA implementation of one of Denmark's largest telecommunications provider and identified ten steps. It starts with an overview to identify process to automate (identification), followed by an assessment of the process maturity, which involves evaluate the process characteristics. The next step is to design the process so it is refined, developed and tested (adjustment and implementation). The hyper-care step consists in monitoring the bot release step when it is put on execution. The last two steps included on Zhang *et al.* (2023) framework are a formal handover of the bot to the process owner manager, called change management, followed by a benefit realization step, which means the output evaluation.

By integrating the steps outlined in these four implementation studies with the findings from the review, a consolidated framework was developed and is presented in Table 1. It's worth noting that the final stage mentioned by Kokina and Blanchette (2019) – exception management – is not directly associated with the implementation phase and has been removed. In Appendix A, the references for each step are provided.

Based on the literature reviewed, eleven essential steps for implementing automation in accounting processes were identified. The process for implementing an automation solution in accounting should first start by analysing the regulatory environment, followed by identifying the target process, evaluating its key characteristics, and creating a detailed flowchart. After that, the process flow is carefully analyzed, adjustments are made, control mechanisms are reviewed, and the actual automation solution is implemented through software programming. Once the solution is in place, the automated process executed by the bot is set into motion and the bot handover to the process owner manager. At the end, it is essential to monitor the bot to ensure it meets the expected performance standards.

Table 1. Steps to implement automation

#	Step	Description
1	Environment assessment	Identify if automation solutions are permitted by regulatory bodies over the process intended to be automated
2	Identification	Compile a list of processes suitable for automation.
3	Characteristics evaluation	Assess the compatibility of identified processes with automation technology, considering both technological and contextual factors.
4	Design	Create detailed flowcharts for the selected processes, encompassing all decision-making nodes.
5	Adjustment	Examine the process flow and make necessary adjustments to enhance compatibility and performance.
6	Review of controls	Redesign control mechanisms within the process flow.
7	Implementation	Program the software to automate the process, incorporating adjusted flow and redesigned control mechanisms.
8	Execution	Launch and operate the automated process using a bot.
9	Bot handover	Hand the process back to the manager owner together with the bot.
10	Monitoring	Continuously oversee the bot's performance and process execution.
11	Output evaluation	Evaluate the results and output generated by the bot.

Considering the prominence of RPA as the primary technology in current accounting automation efforts (Klimkeit & Reihlen, 2022; Zhou, 2021; Cooper *et al.*, 2019; Morrison, 2018), it was sought to extract practical guidelines from professional practice. To achive this goal, we examined the websites of the three largest RPA solution providers: UiPath, Blue Prism, and Automation Anywhere (Kokina & Blanchette, 2019). However, much like the findings of Eulerich *et al.* (2022), the guidelines provided by these companies were overly generic, offering limited practical insights for real-world implementation.

It's evident that these company websites primarily serve as marketing tools, offering superficial information on the complexities of implementing automation within an organization. This aligns with the observations made by Cooper *et al.* (2019), who noted that audit firms often use RPA as a sales technique rather than a comprehensive solution.

3.2.1 Characteristics of Automatable Processes

During the review, it was observed that the characteristics evaluation step is the primary factor used to determine if a process is suitable for automation and to assess its compatibility with the automation technology being implemented. Recognizing the significance of this step, Table 2 was created to catalog the characteristics of processes that can be automated, as identified in the literature. These characteristics are presented according to six dimensions proposed in this study. The references for Table 2 can be found in Appendix B.

Table 2. Automatable process characteristics

Dimension	Characteristic
Flow	Rule-based (follows established standards)
	Well-defined (structured and clearly organized)
	Mature (undergoes infrequent changes)
	Predictable (involves few exceptions)
	Provides deterministic results
Frequency	Repetitive
	Voluminous
	Performed daily
Execution	Transactional (involves data exchange between systems)
	Manual interaction with systems
	Susceptible to many errors
	Involves consolidating data
Data usage	Digital
	Structured in a standardized manner (organized uniformly)
	Accessible
	Centralized
	High quality
Complexity	Simple (not complex)
	Requires little judgment (minimal cognitive effort)
	Easy to decompose
Cost	Time-consuming (requires many hours of work)
	Defined cost

A total of 22 characteristics have been identified that processes should exhibit when implementing an automation solution in accounting. These characteristics have been organized into six dimensions: flow, frequency, execution, data usage, complexity, and cost.

In the flow dimension, the most frequently mentioned characteristic required for a process to be suitable for automation is that it should be rule-based. Regarding frequency, it should be repetitive. For its execution, it must involve data exchange between systems, making it transactional. In terms of data usage in the process, it should be in digital format. Concerning complexity, the process should be simple. Lastly, regarding cost, processes that are time-consuming should be considered when implementing automation technology in accounting processes.

The list of characteristics serves to provide better guidance during the characteristics evaluation step, which is considered the central step in the implementation of automation solutions. Consequently, assessing the compatibility of an automation solution should encompass the consideration of all six identified dimensions. To achieve this, all 22 characteristics should be taken into account, with a primary focus on assessing the technology compatibility with processes that are rule-based, repetitive, transactional, involve digital data, are simple and require minimal cognitive effort, and are time-consuming.

3.2.2 Recommendations for automation implementation

Prior to the implementation of automation, recommendations were identified from the review. A valuable insight is the necessity of a savvy manager to guide the implementation process in the first place (Ghobakhloo *et al.*, 2023). Following that, establishing a digital infrastructure ready for automation was highlighted (Karmanska, 2021; Korhonen *et al.*, 2021). This preparation includes assessing the compatibility of the company's systems with the automation technology being implemented (Korhonen, 2021; Yoon, 2020). Before starting the implementation, it is essential to create a suitable environment by transitioning physical processes into a digital format (Perdana *et al.*, 2023; Chyhevska *et al.*, 2021), as the processes to be automated must be in digital format (Eulerich *et al.*, 2022; Gotthardt *et al.*, 2020). This transition helps ensure the compatibility of the company's existing systems with automation technology. Karmanska (2021) specifically discussed accounting automation based on the Internet of Things (IoT) and emphasized the importance of preparing the company before implementing automation.

Dahabiyeh and Mowafi (2023) research focused on challenges during RPA implementation in audit services. They identified technical and social issues related to clients. This initial challenge brings light to issues surrounding the process of digitalization that may be related to the fact that it requires clients to change their practices and also digitize their processes. In this sense, implementation must take into account clients needs and expectations (Jackson & Allen, 2024; Perdana *et al.*, 2023). Educating them to adopt a digital mindset is often necessary (Januszewski *et al.*, 2021). Additionally, facilitating data exchange in a digital format and using standardized tools between the company and its clients can be a solution to make more processes compatible with automation (Januszewski *et al.*, 2021).

The acceptance of new technology by employees can pose a significant challenge that needs to be properly addressed (Ludacka *et al.*, 2019; Fernandez & Aman, 2018). Ghobakhloo *et al.* (2023, p. 14) highlighted that "automation may adversely affect some aspects of social sustainability, such as job security, workplace dignity, employee privacy, and autonomy at work". Since employee engagement is essential for a well designed system and a successful implementation (Tiron-Tudor *et al.*, 2024), one strategy to promote greater acceptance is to begin by automating processes that employees find less satisfying to perform, as suggested by Dumitru and Stanculescu (2020). Starting with simpler processes is also recommended (Korhonen *et al.*, 2021) because it can increase employees' confidence with the technology and serve as a valuable training opportunity (Kokina & Blanchette, 2019).

Even for these simple processes, a basic level of programming knowledge is necessary (Morrison, 2018). Therefore, employee training should be conducted prior to the implementation of automation (Korhonen *et al.*, 2021; Gotthardt *et al.*, 2020;

Ludacka *et al.*, 2019) to ensure that employees have a good understanding of the technology's capabilities and can effectively identify opportunities for automation (Tiron-Tudor *et al.*, 2024; Cooper *et al.*, 2019). Recognizing the ongoing advancement of accounting automation, Bakarich and O'Brien (2021) stress the importance of training employees to use these solutions, enabling them to develop the necessary skills within an increasingly digitized accounting context (Kommunuri, 2022; Chyzhevska *et al.*, 2021) and perform more value-added work (Zhang *et al.*, 2023). Results from Jackson and Allen (2024) indicated that, in face of new technologies, developing staff capability is critical.

Considerable attention must be given to process adjustments since poorly designed processes pose a risk of systemic errors (Gotthardt *et al.*, 2020; Kokina & Blanchette, 2019). The use of bots for financial routines aims to enhance the information system but demands the implementation of security and control measures (Hong *et al.*, 2023; Perdana *et al.*, 2023; Li, 2021; Polenova *et al.*, 2019) and a proper Information Technology (IT) governance infrastructure (Zhang *et al.*, 2023). Eulerich *et al.* (2023, p. 145) identified several concerns over RPA bots, such as "uncontrolled bots, unknown bots, a failure to assess bot risk, fraudulent bot activities, and changing processes leading to bots providing bad data". Another issue detected by Eulerich *et al.* (2023) concerns organizational knowledge loss, since there will be a bot in the place of a human executing the process.

Hong *et al.* (2023) argue that risk management over RPA are more problematic than other systems like ERP, while Eulerich *et al.* (2023) claim for more careful regarding risks and challenges over RPA usage. In this sense, Eulerich *et al.* (2024) developed a governance framework for RPA projects as a way to improve control over the bots while improving management forecast accuracy, operational efficiency and reporting quality and reducing cost of capital and tax avoidance. Consequently, when implementing automation, it becomes imperative to review and ensure that control mechanisms are embedded over the bots (Eulerich *et al.*, 2023; Kokina *et al.*, 2021; Kokina & Blanchette, 2019; Morrison, 2018).

From the review, it is evident that to successfully implement automation technologies, it is essential to prepare the company in advance by establishing a digital infrastructure, addressing potential acceptance issues, and providing comprehensive training to employees together with an updated IT governance infrastructure so they can make the most of the technology's capabilities.

4. Research opportunities

Researchers have noted a shortage of studies concerning the automation of financial accounting processes (Bakarich & O'Brien, 2021; Huang & Vasarhelyi, 2019). This area remains relatively underexplored within the scientific community (Januszewski & Kujawski, 2021; Cooper *et al.*, 2019). As a result, one of the outcomes of this

systematic literature review (SLR) is the creation of a research agenda that summarizes opportunities within the area of accounting automation.

Chyzhevska *et al.* (2021) and Yoon (2020) emphasize the scarcity of studies on the implementation of automation technologies in accounting, underscoring the need for more research in this area. Specifically, within the realm of implementation, the process of selecting routines for automation, as highlighted by Korhonen *et al.* (2021), remains inadequately explored, lacking clarity on the best approaches. Cooper *et al.* (2019) recommend conducting further studies to evaluate more efficient ways of implementing these solutions, including the use of experts or providing training for company employees. Therefore, there is a clear need for empirical studies to delve deeper into the process of implementing automation solutions in accounting (Dahabiyeh & Mowafi, 2023).

Another noteworthy aspect is the prevalent focus of research on audit services, especially within the Big 4 firms. It has become evident that contextual factors play a crucial role in the successful implementation of automation (Eulerich *et al.*, 2022; Korhonen *et al.*, 2021; Kokina & Blanchette, 2019). Thus, it is imperative for future research to explore contexts beyond audit services (Dumitru & Stanculescu, 2020). One such area of interest is outsourced accounting services, which encompass accounting SSC and GBS (Januszewski & Kujawski, 2022), in addition to accounting offices. These studies should aim to evaluate the impacts of automation on various facets, including processes quality and efficiency, employees satisfaction, employees new skills and abilities needed, and acceptance of new technologies such as RPA (Tiron-Tudor *et al.*, 2024). It is recommended that research extends to different accounting practice contexts, such as the realities of outsourced services and public accounting.

In addition to larger accounting firms, small offices can also reap substantial benefits from process automation (Januszewski *et al.*, 2021; Gotthardt *et al.*, 2020), and sometimes even more than their larger counterparts (Gotthardt *et al.*, 2020). However, there is a lack of research dedicated to the small business context (Tiron-Tudor *et al.*, 2024; Hsiung & Wang, 2022; Januszewski *et al.*, 2021), highlighting the need for studies that delve into the implementation of automation, its effects, and the identification of automatable processes, particularly in the context of small accounting businesses.

Future research should delve into unexplored areas and identify accounting processes where automation technologies can be effectively applied (Bakarich & O'Brien, 2021; Kokina & Blanchette, 2019). Processes within management accounting, which are suitable for automation, offer promising opportunities for research (Yoon, 2020). The lack of clarity in this domain regarding which processes can be automated and which should remain under human control highlights the need

for studies aiming at establishing criteria and recommendations for more effectively defining which processes should be automated.

Performance measurement for implementation initiatives is also an underdeveloped area, and there is a lack of clarity on how to evaluate the results of automation (Zhang *et al.*, 2023; Eulerich *et al.*, 2022; Kokina *et al.*, 2021). There is a need for a better understanding of how to assess the quality of outputs delivered by automation technologies (Cooper *et al.*, 2019). Therefore, future studies focused on establishing performance criteria, both quantitative and qualitative, for automation implementation projects in the accounting field are imperative to accurately assess the outcomes of investments in automation solutions. In this sense, additional investigations over cost and benefits of automating processes are necessary (Tiron-Tudor *et al.*, 2024).

Studying the audit services market, Bakarich and O'Brien (2021) observed that the varying levels of automation between Big 4 and non-Big 4 firms could create disparities in competition, potentially leading to market inefficiencies and income inequality. Surprisingly, there have been no studies dedicated to analyzing the relationship between the level of automation in accounting firms and their profitability. Therefore, there is an opportunity for research to investigate this relationship and determine whether unequal utilization of automation technologies can result in economic challenges.

Studies focusing on analyzing the risks associated with process automation (Hong *et al.*, 2023; Polenova *et al.*, 2019) and its compatibility with legal issues (Dumitru & Stanculescu, 2020) are relatively scarce. Cooper *et al.* (2022) and Kokina and Blanchette (2019) have expressed concerns about the limited research on potential risks during the implementation of automation solutions. They both emphasize the necessity for studies dedicated to governance and internal audit mechanisms and controls specifically designed for bots.

Hong *et al.* (2023) compared the risks surrounding ERP system implementation and RPA implementation, as they found it is mandatory to begin considering RPA risk management once risks surrounding RPA can be more problematic. In the same way, Zhang *et al.* (2023) discussed risks surrounding automation implementation, highlighting the need for a proper IT governance infrastructure, with necessary auditability mechanisms and internal controls, together with a data privacy and security awareness. Additionally, Cooper *et al.* (2022) have highlighted the absence of guidance from regulatory agencies to support the use of automation technologies in accounting. Therefore, research focused on the regulatory context, exploring the legal aspects associated with the implementation of automation solutions, including any barriers to their use, is of utmost importance (Ghobakhloo *et al.*, 2023).

The impact of automation on the accounting profession remains uncertain due to the novelty of the topic (Cooper *et al.*, 2019; Kokina & Blanchette, 2019). Many researchers have pointed to changes in skills and abilities as one of the key impacts of automation on the practice (Tiron-Tudor *et al.*, 2024; Kommunuri, 2022; Bakarich & O'Brien, 2021; Kokina *et al.*, 2021; Dumitru & Stanculescu, 2020; Vincent *et al.*, 2020; Cooper *et al.*, 2019; Kokina & Blanchette, 2019; Fernandez & Aman, 2018). Therefore, it is essential to identify the new set of skills and abilities that accountants will need as a result of the advancement of automation in the field.

There is a noticeable shortage of studies regarding the necessary training for accountants in the context of automation (Cooper *et al.*, 2022; Bakarich & O'Brien, 2021; Momo *et al.*, 2021). The timing is right to reevaluate the training process for accountants (Vincent *et al.*, 2020). Along these lines, conducting research on the impact of automation on accounting education (Tiron-Tudor *et al.*, 2024; Dumitru & Stanculescu, 2020) and the necessity for curriculum updates (Kokina *et al.*, 2021) present valuable opportunities for exploration.

There is a need for studies examining the potential long-term qualitative impacts of automation on accounting information (Polenova *et al.*, 2019) and on accounting practices in a broader sense (Eulerich *et al.*, 2022; Kokina & Blanchette, 2019). In addition to organizational impact, Cooper *et al.* (2019) recommend longitudinal studies to evaluate the effects of automation on clients, including the digitalization of their processes (Januszewski *et al.*, 2021). Future research focused on monitoring the evolution of the use of automation solutions in accounting procedures represents a promising research direction (Bakarich & O'Brien, 2021). Kokina and Blanchette (2019) also suggest the need for longitudinal studies to evaluate the impacts of accounting automation on organizations and their employees. When it comes to organizations, there's a requirement for studies that examine the effects of automation on organizational processes (Korhonen *et al.*, 2021). Concerning employees, it is crucial to identify the changes in their roles and responsibilities resulting from automation (Tiron-Tudor *et al.*, 2024; Kokina *et al.*, 2021). Zhang *et al.* (2022) state that process automation should be focused on technologies assisting accountants, not replacing them, defending an attended process automation perspective.

Finally, Cooper *et al.* (2019) recommend that studies provide more attention to the perspective of employees when introducing automation technologies. The advancement of automation has also brought ethical and societal concerns (Ghobakhloo *et al.*, 2023), the disruptive effect on the outsourced services labor market is an example, where automation is replacing human employees, reducing the workforce (Zhang *et al.*, 2023; Dumitru & Stanculescu, 2020; Cooper *et al.*, 2019). In this regard, future studies dedicated to assessing the effects of automation on the accounting job market are necessary (Cooper *et al.*, 2019).

Closing this section, Table 3 summarizes the identified research gaps, organized according to thematic areas.

Table 3. Research opportunities in the accounting field

Topic	Opportunity
Implementation	• Determine the necessary steps for selecting processes suitable for automation. • identify the most efficient and appropriate methodologies for implementing automation solutions. • Establish criteria for evaluating which processes are suitable for automation and which should remain under human control. • Devise performance measures for assessing the success of the implementation and the quality of the outputs delivered by the bots. • Clarify costs and benefits associated to implement automation solutions.
Contextual aspects	• Explore the application of automation in contexts beyond audit services, including accounting outsourcing services and management accounting services. • Investigate the impact of automation on small accounting businesses, a relatively underexplored area. • Examine the regulatory landscape concerning the use of automation technologies in the accounting field.
Economic effects	• Assess the impact of automation on competitiveness in accounting services markets. • Evaluate the influence of automation on business profitability. • Investigate the relationship between automation and income inequality.
Risk and control	• Examine the impacts of automation on processes, employees, and business continuity. • Identify the risks associated with automation implementation. • Create dedicated IT governance and internal audit mechanisms and controls for bots.
Professional skills and abilities	• Identify the skills and abilities required by accountants in the context of process automation. • Analyze the effects of automation on the accountant's training process. • Assess the curricular updates needed in accounting education.
Qualitative aspects of accounting information	• Analyze the medium and long-term consequences of using automation technologies on the quality of accounting information.
Employees	• Analyze the effects of automation on the accounting profession. • Assess the impacts of automation on the accounting job market.

In this section, several research opportunities have been presented for the further development of the accounting automation process, a topic that requires more

attention from the academic community (Bakarich & O'Brien, 2021; Januszewski & Kujawski, 2021; Cooper *et al.*, 2019; Huang & Vasarhelyi, 2019). The agenda summarized in Table 3 can aid in advancing this field by providing a theoretical foundation for future studies.

5. Conclusions

This study aimed to identify the essential steps for implementing automation in financial accounting processes. To accomplish this, a SLR was conducted, resulting in a sample of 33 scientific papers discussing the topic of accounting process automation. Content analysis was performed, guided by three categories: i) Implementation steps; ii) Process characteristics; and iii) Research opportunities.

Based on the first category, eleven steps have been identified to be followed for implementing automation in financial accounting processes. The identification of these steps makes it possible for companies to adopt automation technologies in a well-informed manner, as advocated by Gotthardt *et al*. (2020). Among these steps, it was found that the second one, which relates to evaluating the process characteristics, is the most critical one.

It was identified that to implement process automation in accounting it is necessary to evaluate the compatibility of the tool with the characteristics of the processes to be automated. The second category consolidated 22 characteristics that the processes should exhibit, wich were organized into six dimensions. In this sense, a solution designed to automate financial accounting processes should be capable of handling routines that align with the identified characteristics. Among current solutions, RPA stands out as a central piece, as it is applicable to financial accounting routines due to its compatibility with the characteristics of the processes in this area.

This study has also provided an overview of the research on the topic of accounting process automation. Issues like inadequate guidelines for implementing solutions and insufficient employee training have been identified as current challenges. As noticed, it is essential for companies to establish a digital infrastructure along with a IT governance infrastructure so processes can be automated, being aware of acceptance issues. Also, it is necessary to train employees so that they can use the technology in the best way. Those are contextual aspects surrounding the implementation of automation in financial accounting processes yet to be explored. In this sense, the third category summarized research oportunites identified over the review. Several opportunities were identified and listed, what represents guidelines for future studies.

Prior studies focused on particular issues, such as contextual aspects (Eulerich *et al*., 2022), or offered over simplistic steps (Brandstätter *et al.*, 2023; Huang & Vasarhelyi, 2019). When a longer list of steps was offered (Zhang *et al.*, 2023), yet

it missed some important steps discussed in other papers. By consolidating the steps discussed in different studies, we offer a more complete list of steps required to implement automation solutions in financial accounting.

Another contribution of the present study surrounds the characteristics of automatable processes. Prior research have not deeply discussed it. Despite identifying that the evaluation of process characteristics is the primary factor used to determine if a process is suitable for automation and if it is compatible with the automation technology being implemented, no research have focused on list these characteristics. By listing them, we highlight the essential characteristics that processes should exhibit to be suitable for automation.

The steps and characteristics identified represent an advance in the scientific literature, given the absence of such guidelines (Matthies, 2020), what causes delays in the adoption of solutions (Eulerich *et al*., 2022; Bakarich & O'Brien, 2021; Cooper *et al*., 2019). Through these steps, knowledge on the subject is organized, providing clarity on how to implement automation in financial accounting processes. The characteristics, in turn, detail which processes are suitable for automation, preventing selection errors, as noted by Korhonen *et al*. (2021), thus defining the scope of application for these technologies. The proposed research agenda summarizes research opportunities that can serve as a theoretical foundation for future studies aiming to further develop this field, such as empirical studies focused on implementing automation effectively.

The steps and characteristics identified in this study also offer valuable practical insights for the implementation of automation technologies in financial accounting. They serve as guidance for practitioners, helping them navigate the process effectively. The steps enable more assertive automation initiatives, thus stimulating adoption of automation solutions in the financial accounting field, resulting in benefits for accounting such as increased productivity, process improvement, and cost reduction (Cooper *et al.*, 2019; Fernandez & Aman, 2018).

The identified characteristics help to avoid errors in process selection (Korhonen *et al*., 2021) during implamentation, thus saving valuable resources. Likewise, issues related to process selection based on professional experience are circumvented (Eulerich *et al*., 2022), providing greater objectivity to the selection. This objective criteria can enhance the decision-making process when considering automation solutions.

While the databases used in this study were of high quality, they may not encompass the entire knowledge on the topic of accounting process automation. This limitation should be noted. It is advisable for future studies to explore different databases to supplement the findings of this research. Furthermore, it is important to emphasize that this study is primarily theoretical in nature. As a result, there is an opportunity for practical studies dedicated to implementing the identified steps for automation in financial accounting routines.

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Appendix A: References of the implementation steps

Steps to implement automation

#	Step	Description	Reference
1	Environment assessment	Identify if automation solutions are permited by regulatory bodies over the process intended to be automated	Eulerich *et al.* (2024); Jackson & Allen (2024); Eulerich *et al*. (2022)
2	Identification	Compile a list of processes suitable for automation.	Brandstätter *et al.* (2023); Zhang *et al.* (2023); Zhang *et al.* (2022); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Ludacka *et al.* (2019)
3	Characteristics evaluation	Assess the compatibility of identified processes with automation technology, considering both technological and contextual factors.	Zhang *et al.* (2023); Eulerich *et al.* (2022); Zhang *et al.* (2022); Gotthardt *et al.* (2020); Cooper *et al.* (2019); Ludacka *et al.* (2019)
4	Design	Create detailed flowcharts for the selected processes, encompassing all decision-making nodes.	Zhang *et al.* (2023); Zhang *et al.* (2022); Matthies (2020); Kokina & Blanchette (2019); Ludacka *et al.* (2019); Fernandez & Aman (2018); Morrison (2018)
5	Adjustment	Examine the process flow and make necessary adjustments to enhance compatibility and performance.	Zhang *et al.* (2023); Zhang *et al.* (2022); Gotthardt *et al.* (2020); Huang & Vasarhelye (2019); Kokina & Blanchette (2019)
6	Review of controls	Redesign control mechanisms within the process flow.	Eulerich *et al.* (2024); Kokina *et al.* (2021); Kokin & Blanchette (2019); Morrison (2018)
7	Implementation	Program the software to automate the process, incorporating adjusted flow and redesigned control mechanisms.	Brandstätter *et al.* (2023); Zhang *et al.* (2023); Zhang *et al.* (2022); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Ludacka *et al.* (2019)
8	Execution	Launch and operate the automated process using a bot.	Brandstätter *et al.* (2023); Zhang *et al.* (2023); Kokina & Blanchette (2019)
9	Bot handover	Hand the process back to the manager owner together with the bot.	Zhang *et al.* (2023)

#	Step	Description	Reference
10	Monitoring	Continuously oversee the bot's performance and process execution.	Brandstätter *et al.* (2023); Zhang *et al.* (2023); Kokina & Blanchette (2019); Ludacka *et al.* (2019)
11	Output evaluation	Evaluate the results and output generated by the bot.	Zhang *et al.* (2023); Zhang *et al.* (2022); Huang & Vasarhelyi (2019)

Appendix B: References of the processes characteristics

Automatable process characteristics

Dimension	Characteristic	Reference
Flow	Rule-based (follows established standards)	Eulerich *et al.* (2024); Brandstätter *et al.* (2023); Eulerich *et al.* (2023); Meiryani *et al.* (2023); Eulerich *et al.* (2022); Klimkeita & Reihlen (2022); Zhang *et al.* (2022); Bakarich & O'Brien (2021); Belskis *et al.* (2021); Januszewski & Kujawski (2021); Januszewski *et al.* (2021); Kokina *et al.* (2021); Korhonen *et al.* (2021); Li (2021); Zhou (2021); Dumitru & Stanculescu (2020); Gotthardt *et al.* (2020); Matthies (2020); Vincent *et al.* (2020); Yoon (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina e Blanchette (2019); Qiu & Xiao (2019); Fernandez & Aman (2018); Morrison (2018)
	Well-defined (structured and clearly organized)	Brandstätter *et al.* (2023); Dahabiyeh & Mowafi (2023); Eulerich *et al.* (2023); Kommunuri (2022); Perdana & Arisandi (2022); Sivaretinamohan & Sujatha (2022); Zhang *et al.* (2022); Januszewski & Kujawski (2021); Januszewski *et al.* (2021); Kokina *et al.* (2021); Dumitru & Stanculescu (2020); Matthies (2020); Vincent *et al.* (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019)
	Mature (undergoes infrequent changes)	Brandstätter *et al.* (2023); Meiryani *et al.* (2023); Eulerich *et al.* (2022); Dumitru & Stanculescu (2020); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Morrison (2018)
	Predictable (involves few exceptions)	Meiryani *et al.* (2023); Kokina *et al.* (2021); Dumitru & Stanculescu (2020); Huang & Vasarhelyi (2019)
	Provides deterministic results	Zhang *et al.* (2022); Dumitru & Stanculescu (2020); Morrison (2018)

Dimension	Characteristic	Reference
Frequency	Repetitive	Tiron-Tudor *et al.* (2024); Brandstätter *et al.* (2023); Dahabiyeh & Mowafi (2023); Eulerich *et al.* (2023); Hong *et al.* (2023); Meiryani *et al.* (2023); Perdana *et al.* (2023); Zhang *et al.* (2023); Eulerich *et al.* (2022); Hsiung & Wang (2022); Klimkeit & Reihlen (2022); Kommunuri (2022); Perdana & Arisandi (2022); Sivaretinamohan & Sujatha (2022); Bakarich & O'Brien (2021); Januszewski & Kujawski (2021); Li (2021); Zhou (2021); Dumitru & Stanculescu (2020); Matthies (2020); Vincent *et al.* (2020); Yoon (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Ludacka *et al.* (2019); Qiu & Xiao (2019); Fernandez & Aman (2018)
	Voluminous	Brandstätter *et al.* (2023); Meiryani *et al.* (2023); Perdana *et al.* (2023); Eulerich *et al.* (2022); Kommunuri (2022); Dumitru & Stanculescu (2020); Gotthardt *et al.* (2020); Vincent *et al.* (2020); Yoon (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Fernandez & Aman (2018); Morrison (2018)
	Performed daily	Eulerich *et al.* (2024); Brandstätter *et al.* (2023); Dahabiyeh & Mowafi (2023); Eulerich *et al.* (2022); Klimkeit & Reihlen (2022); Perdana & Arisandi (2022); Sivaretinamohan & Sujatha (2022); Bakarich & O'Brien (2021); Januszewski & Kujawski (2021); Kokina *et al.* (2021); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Fernandez & Aman (2018); Morrison (2018)
Execution	Transactional (involves data exchange between systems)	Tiron-Tudor *et al.* (2024); Eulerich *et al.* (2022); Klimkeit & Reihlen (2022); Perdana & Arisandi (2022); Bakarich & O'Brien (2021); Belskis *et al.* (2021); Januszewski & Kujawski (2021); Kokina *et al.* (2021); Zhou (2021); Dumitru & Stanculescu (2020); Matthies (2020); Vincent *et al.* (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Qiu & Xiao (2019); Morrison (2018)
	Manual interaction with systems	Tiron-Tudor *et al.* (2024); Brandstätter *et al.* (2023); Hong *et al.* (2023); Meiryani *et al.* (2023); Bakarich & O'Brien (2021); Belskis *et al.* (2021); Li (2021); Zhou (2021); Eulerich *et al.* (2022); Dumitru & Stanculescu (2020); Yoon (2020); Ludacka *et al.* (2019)
	Susceptible to many errors	Eulerich *et al.* (2022); Belskis *et al.* (2021); Ludacka *et al.* (2019); Qiu & Xiao (2019)

Dimension	Characteristic	Reference
	Involves consolidating data	Sivaretinamohan & Sujatha (2022); Cooper *et al.* (2019)
Data usage	Digital	Tiron-Tudor *et al.* (2024); Klimkeit & Reihlen (2022); Bakarich & O'Brien (2021); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Qiu & Xiao (2019)
	Structured in a standardized manner (organized uniformly)	Dahabiyeh & Mowafi (2023); Meiryani *et al.* (2023); Perdana *et al.* (2023); Eulerich *et al.* (2022); Klimkeita & Reihlen (2022); Zhang *et al.* (2022); Dumitru & Stanculescu (2020); Matthies (2020); Vincent *et al.* (2020); Kokina & Blanchette (2019)
	Accessible	Eulerich *et al.* (2022)
	Centralized	Eulerich *et al.* (2022); Januszewski & Kujawski (2021) Januszewski *et al.* (2021); Gotthardt *et al.* (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019)
	High quality	Eulerich *et al.* (2022); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Morrison (2018)
Complexity	Simple (not complex)	Tiron-Tudor *et al.* (2024); Brandstätter *et al.* (2023); Dahabiyeh & Mowafi (2023); Meiryani *et al.* (2023); Eulerich *et al.* (2022)
	Requires little judgment (minimal cognitive effort)	Eulerich *et al.* (2022)
	Easy to decompose	Gotthardt *et al.* (2020)
Cost	Time-consuming (requires many hours of work)	Meiryani *et al.* (2023); Perdana *et al.* (2023); Eulerich *et al.* (2022); Perdana & Arisandi (2022); Sivaretinamohan & Sujatha (2022); Kokina *et al.* (2021); Li (2021); Zhou (2021); Yoon (2020); Cooper *et al.* (2019); Huang & Vasarhelyi (2019); Kokina & Blanchette (2019); Ludacka *et al.* (2019); Qiu & Xiao (2019)
	Defined cost	Eulerich *et al.* (2022)