

Applying robotic process automation (RPA) in auditing: A framework

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ABSTRACT

Robotic process automation (RPA) has been widely adopted in many industries, including the accounting industry, to automate well-defined and repetitive tasks; however, its application to auditing has lagged behind because of the unique nature of this industry. This study applies RPA in the auditing area. An RPA framework is proposed that frees auditors from doing repetitive and low-judgment audit tasks and enables them to focus on tasks that require professional judgment. This paper also demonstrates the feasibility of RPA by implementing a pilot project that applies RPA to the confirmation process.

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1. Introduction

Traditional audit procedures are labor-intensive and time-consuming (Chan and Vasarhelyi, 2011). To free human auditors from doing repetitive and low-judgment audit tasks and help them focus on procedures requiring professional judgment, prior literature has for decades proposed that labor-intensive audit tasks be replaced with automation (e.g., Vasarhelyi, 1984; Vasarhelyi and Halper, 1991). One early application of automation technology in auditing is continuous auditing (CA). In recent years, commercial audit analytics software and electronic spreadsheets such as Microsoft Excel have been widely employed to automate tests and analyses. Although technology has significantly improved audit efficiency, integration across multiple systems or applications is performed mainly by auditors, meaning that the actual external audit is still very labor-intensive and artisanal (Srinivasan, 2016).

For this reason, practitioners have been interested in rethinking their processes in terms of automation and taking advantage of advanced automation technologies such as robotic process automation (RPA). RPA is a methodology for performing routine business processes by automating the way people interact, with multiple applications or analyses through a user interface and also by following simple rules to make decisions (Deloitte, 2017). In the accounting domain, major accounting firms are applying RPA to achieve cost savings and increase operational efficiency in tax and advisory services. For instance, KPMG has recently announced that it will work with a global leader in enterprise RPA to help clients automate manual business processes (KPMG, 2017). As one of the largest RPA consultants, Ernst and Young (EY) has delivered RPA projects to financial services organizations across 20 countries (EY, 2016a). Although repetitive, structured, and labor-intensive audit tasks (such as reconciliations, internal control testing, and detail testing) are ideal candidates for RPA, its application to auditing is lagged behind because of concerns about risk and regulation (Cooper et al., 2019; Moffitt et al., 2018). If such tasks can be automated, auditors will be able to focus on tasks requiring professional judgment. Additionally, automated audit procedures will no longer be limited by the

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constrained processing power of human beings; consequently, the scale of the audit can be increased and more comprehensive evidence can be collected, enhancing audit quality.

This study proposes a 4-stage framework for applying RPA in audit practice and reports the results of a pilot project automating the confirmation process. Our study makes several contributions to the literature. First, although prior literature has widely introduced the applications of RPA, only a few studies in the AIS literature introduced RPA to accounting. For example, Issa et al. (2016) mention auditing robots in their discussion of audit automation. Kokina and Davenport (2017) suggest that RPA would be useful for audit processes, but they are not aware of its adoption in accounting domain. Moffitt et al. (2018) envisage the future of audit by introducing the concept of RPA and discuss its potential usage in auditing. Recently, Cooper et al. (2019) interview global/national RPA leaders at each of the Big 4 and learn the adoption and use of RPA in the accounting industry. Different from prior studies that introduce the concept of RPA or investigate the use of it, this study proposes a systematic framework for applying RPA in audit practice and takes into consideration unique features in auditing. Specifically, factors such as the implementation risk, audit risk, and auditor's independent evaluation are all integrated into the proposed framework, making it more tailored for the audit industry.

Second, guided by the framework, an RPA-based pilot confirmation project was successfully implemented with a CPA firm and the effectiveness and efficiency of this program were independently assessed by comparing the outputs of the RPA program with those of the manual process, demonstrating the feasibility of the framework and the usefulness of RPA in auditing.

Third, since Cooper et al. (2019) identify the regulation issue as the main factor in the delay of RPA in auditing, the evidence from this study, the feasibility and usefulness of RPA in this industry, provides valuable insights to regulators such as the Securities and Exchange Commission (SEC) and the Public Company Accounting Oversight Board (PCAOB). This study will help regulators understand RPA and facilitate its adoption and use in this industry.

The remainder of this paper is organized as follows. Section 2 provides the research background and literature review, followed by the details of the proposed framework in Section 3. Next, the implementation and evaluation of the pilot project are presented. Section 5 includes the discussion of RPA in auditing. The final section contains the concluding remarks.

2. Background and literature review

2.1. Audit procedure automation

Because of its labor intensiveness and the range of decision structures, auditing has employed automation technology for more than three decades (Issa et al., 2016). Vasarhelyi and Halper (1991) proposed the concept of continuous auditing (CA), which is defined by the CICA/AICPA as "a methodology for issuing audit reports simultaneously with, or a short period of time after, the occurrence of the relevant events" (CICA/AICPA, 1999). Later, CA and continuous monitoring (CM) (hereafter CA/CM) became one of the applications of automation technology (Vasarhelyi et al., 2004). As part of their pilot project, Alles et al. (2008) apply CA/CM to an internal IT audit process. They develop guidelines for the formalization of the audit procedures into a computer-executable format and determine which procedures are automatable and which require reengineering. Many internal/IT audit procedures have been demonstrated to be automatable, thus saving costs, which allows for more frequent audits and frees up the audit staff for tasks that require human judgment (AICPA, 2015).

Audit software vendors such as ACL, CaseWare, and CA technology, provide commercial and standardized IT packages and analytical software, supporting automation of basic audit tests such as three-way matching, sampling, and handling fairly large data sets (Appelbaum et al., 2017). Furthermore, commercial spreadsheets such as Microsoft Excel allow auditors to perform tests effectively and efficiently. Instead of manually filtering or copying and pasting spreadsheet data, the macro programming language Visual Basic Application (VBA) is widely employed to automate various tasks or analyses (e.g., AICPA, 2012; Debreceeny et al., 2005).

To further improve audit effectiveness and efficiency, accounting firms have adopted audit management systems such as electronic workpapers. An electronic workpaper system can enhance the audit quality by tailoring the file to address specific client risks, including setting the strategy to be used during the engagement and altering the nature, timing, and/or extent of planned audit procedures. In addition, electronic systems allow auditors to directly link information between documents and enable managers/reviewers to electronically access files and communicate remotely with their audit teams (Agoglia et al., 2010; Bedard et al., 2006).

Recent literature stresses the need for auditors to take advantages of emerging technologies to automate procedures. Zhaokai and Moffitt (2019) propose the Automated Contract Analysis System (ACAS) framework, which is based on auditing standards with contract-specific requirements. They demonstrate the feasibility, through the proposed ACAS framework, of incorporating text mining into contract audit procedures to automate contract analysis in the audit stages of risk assessment, substantive tests, and review, and to provide auditors with contract data that can be used to identify audit risk and generate audit evidence. Furthermore, Appelbaum and Nehmer (2017) propose the use of drones in audit automation and continuous auditing environments and illustrate how drones fit into audits for inventory count by gathering evidence to support specific assertions made by management.

2.2. Robotic process automation

By automating audit tests and analyses, technologies such as CA/CM, analytical tools, and electronic workpaper systems have significantly improved audit effectiveness and efficiency. However, these technologies focus mainly on automating a specific task

or test, leaving the coordination and integration across different systems or applications to be performed largely by auditors, causing the actual audit to remain labor intensive. The application of robotic process automation (RPA), an automation overlay for existing IT systems that enables the execution of a combination of audit tasks or analyses over multiple unrelated software systems, may help solve the problem.

The idea behind RPA is not new; it is traditional automation in terms of assembly line technology (Moffitt et al., 2018). RPA is defined 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” (IEEE Corporate Advisory Group, 2017). An example of the RPA process is the automated retrieval of information from one system and entering of the same information into another system or activating another system function. Unlike some traditional IT implementation and business reengineering that changes the existing systems, RPA tries not to disturb underlying IT systems and only replaces the existing manual process with the automated one through a presentation layer (IRPA, 2016). Therefore, compared with major IT platform updates, the burdens of RPA implementation (cost, timelines, and risk) are relatively insignificant (EY, 2016b).

RPA tools help businesses improve the efficiency of processes and the effectiveness of services. First, replacing the human workforce reduces the cost and processing time for high-frequency tasks. The running cost of an RPA software is around one-ninth that of employing a human being, and RPA “robots” can work 24 h a day and 7 days a week (Burgess, 2016). Secondly, the accuracy of the business process is improved. As long as an RPA tool is properly programmed, there is no need to worry that software robots will make the mistakes that human beings might (IRPA, 2015). Finally, RPA offers flexibility and scalability. Once a process has been executed by a software robot, it can be scheduled for a particular time. In addition, the RPA robot is capable of performing many types of processes and can be quickly reassigned to other processes (Deloitte, 2017).

Because of its low implementation cost and high potential benefits, RPA has been widely adopted in many industries. As of April 2015, Telefónica O2, the second-largest mobile telecommunications provider in the United Kingdom, had adopted more than 100 RPA “robots” to handle 500,000 transactions each month (Lacity et al., 2015). In addition, a business process outsourcing provider automated 14 core processes with RPA, achieving a typical 30% cost saving per process and improving service quality and accuracy. Also, in the process of updating London Premium Advice Notes (LPANs) to a central insurance market repository, an RPA robot was used to automate the most onerous steps: validating data, accessing the database, creating documents, and uploading the repository. After adoption, the processing time was only 30 min instead of several days (Deloitte, 2017). Furthermore, Australia and New Zealand Banking Group (ANZ), Australia's fourth largest bank, integrated RPA into their finance, HR, and payments operations and dramatically reduced the needs for human employees (KPMG, 2016).

Many audit tasks are well-defined, highly repetitive, predictable, multi-step tasks across multiple systems, and thus are the ideal candidates for RPA (IRPA, 2015). For instance, RPA can automate revenue reconciliations by

- (1) logging in to the server,
- (2) entering a query to search for the revenue listing and trial balance,
- (3) extracting the revenue transaction listing and trial balance,
- (4) importing the revenue transaction listing and the trial balance to Excel or IDEA,
- (5) calculating the total per revenue transaction listing, and
- (6) comparing the total per the listing to the total reported in the trial balance revenue account (Moffitt et al., 2018).

The improved processing power of RPA can enable an increase in the scale of audit procedures and free auditors to focus on tasks that require professional judgment and higher order thinking skills, thereby enhancing audit quality. For example, auditors can then spend more time brainstorming fraud risk, analyzing exceptions from analytical procedures, and applying follow-up actions. However, even though the accounting industry has observed the benefits of RPA, its applications in auditing practice are still lagged behind. Cooper et al. (2019) interviewed global/national RPA leaders at each of the Big 4 and suggested that the implementation of RPA is more developed in the areas of taxation and advisory services. Because of the additional precautions given the degree of risk and the regulations surrounding audits, RPA has not been applied to actual audit engagements and the current use in assurance service is still at the pilot stage in most major accounting firms.¹ In this study, we propose a framework to apply RPA in auditing and demonstrate its feasibility by implementing a pilot project for the confirmation process.

3. The framework

Fig. 1 illustrates the four stages in the framework: 1) procedure selection, 2) procedure modification, 3) implementation, and 4) evaluation and operation. Following is a more detailed description of each stage.

3.1. Stage 1: procedure selection

When planning the adoption and application of RPA, the accounting firm should first review the structure of its audit procedures and identify appropriate candidates based on several factors. Below, we provide a detailed description of each factor.

¹ One exception is that RPA is now being used in the field for AR confirmations in EY (2017).

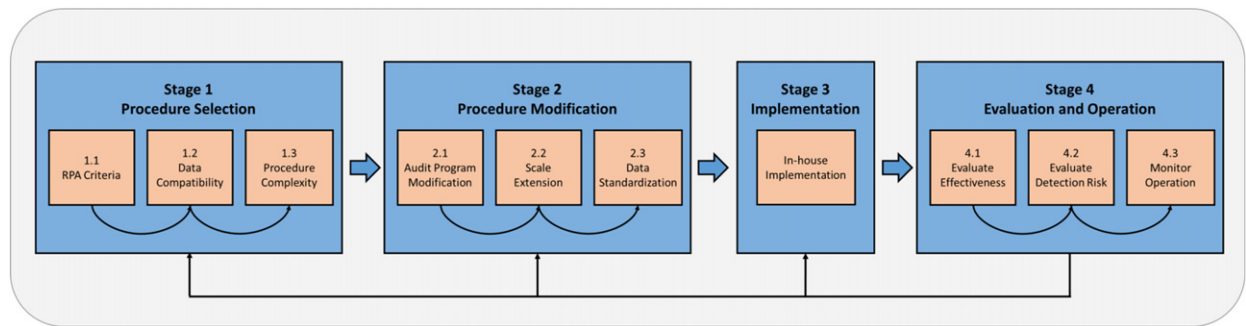


Fig. 1. The framework. Note: Fig. 1 displays the structure of the proposed framework. The first stage guides auditors to select appropriate audit procedures based on three factors: the RPA criteria, data compatibility, and the procedure complexity. The second stage contains three steps to help auditors to modify the current audit program, extend the scale of the procedure, and confirm the data standardization. In the third stage, the framework recommends auditors to implement in-house. The last stage is to evaluate and operate the RPA-based audit procedure by evaluating the performance, assessing the detection/audit risk, and monitoring the operation.

3.1.1. Factor 1: RPA criteria

The audit procedures must meet three conditions to be selected for automation: they must be well-defined, highly repetitive, and mature (Lacity et al., 2015). First, well-defined audit procedures are structured and non-subjective, so that the RPA software is able to complete tasks based on explicit, rule-based instructions. Second, the procedures should be high in volume, which maximizes the potential benefits of automation. Third, mature audit tasks should be automated first because the outcomes and cost are more predictable, and mature procedures are less likely to encounter exceptions and require less human intervention.

Abdolmohammadi (1999) considers audit tasks as structured if they require very little judgment, while tasks with many alternative solutions that require considerable judgment are regarded as unstructured. Semi-structured tasks, which have limited alternative solutions and require a medium level of judgment, fall somewhere on the “structured-unstructured” spectrum. In the early stage of RPA adoption, structured audit tasks are better candidates.² Therefore, reconciliations, internal control testing, and revenue audits are potential targets for RPA (Moffitt et al., 2018; Rozario and Vasarhelyi, 2018).

3.1.2. Factor 2: data compatibility

After reviewing the automation conditions, the audit team should examine a second important component of RPA-based audits: whether the data used in those procedures is compatible with RPA software. Data should be in a digital format or be able to be efficiently transformed into digital content (Moffitt et al., 2018). Even though RPA commercial software is able to extract and interpret textual information from unstructured sources (such as images), structured data is preferred for accuracy and to minimize processing cost (Vinutha, 2017). Therefore, to avoid high error rates and processing costs, auditors need to understand data compatibility and be sure the data are in a structured and digital format.

3.1.3. Factor 3: procedure complexity

Another factor in deciding whether to use RPA in a given audit procedure is complexity. Audit firms should be aware that even though RPA is relatively easy to implement, the implementation process takes time and involves risks, and many implementations actually fail (PwC, 2017a, 2017b). An individual RPA program can be implemented in a matter of days or weeks depending on the complexity of the programming involved (PwC, 2017a). To reduce implementation risk, the accounting firm should evaluate the complexity of potential audit procedures and demonstrate the usability of RPA with a low-complex process through a proof-of-concept (PoC) or pilot project. After learning more knowledge through initial implementations, auditors can apply RPA to more complex procedures.

3.2. Stage 2: procedure modification

After selecting the appropriate procedure, auditors need to consider whether to modify the current procedure to prepare the RPA-based audits. Alles et al. (2008) suggest that at the Siemens company, modification of the current audit process was necessary for the large-scale implementation of continuous auditing (CA) software. Consequently, the firm needs to examine the current procedure and modify the audit program, if necessary, to match the RPA software.³ Furthermore, because the limited processing power of human auditors is no longer a constraining factor, the accounting firm may consider extending the scale of “RPA-based” audits. For instance, with the adoption of RPA, auditors can expand the scale of some procedures from sampling to testing the entire population, avoiding sampling risks and deficiencies.

² RPA may be applied to semi-structured tasks as well after firms have sufficient knowledge from application to structured tasks.

³ The modification of current audit program should not involve changes on any core part of the standardized audit program (such as changing the nature of the designed tests).

Additionally, the data must be standardized. Auditors are likely to collect data from multiple sources, and [Moffitt et al. \(2018\)](#) suggest that labels for the same object may be inconsistent across various inputs. For instance, the vendor name extracted from the client's ERP system may be Amazon, but the official name listed on the contract may be [Amazon.com, Inc.](#) While human auditors can easily understand that Amazon and [Amazon.com, Inc.](#) are the same company, the RPA software may not be able to do so. Therefore, accounting firms need to check and confirm data consistency before implementation of the system.

3.3. Stage 3: implementation

For implementation, accounting firms may purchase licenses from RPA providers, including UiPath, Automation Anywhere, and Blue Prism, and build RPA programs in-house. The framework recommends building a program in-house for the following reasons. First, most RPA software comes with a user-friendly interface that simplifies the coding process. Auditors can easily learn how to build an RPA program using supporting materials (such as tutorial videos) provided by the software provider. According to a recent interview with RPA leaders from the Big 4, accountants can code the RPA program on their own and programmers are required only for complex coding ([Cooper et al., 2019](#)). Second, auditors' understanding of the underlying details of each client-specific audit procedure is essential for successfully programming RPA to perform the designed tasks and reduce implementation risk. Third, with in-house implementation, the accounting firm has a high level of control, and confidential information is better protected ([Lacity et al., 2015](#)).

3.4. Stage 4: evaluation and operation

In the final stage, the audit teams need to field-test the RPA programs to assess how well they perform the assigned tasks. Specifically, an RPA-based audit procedure needs to be performed independently by the RPA program and by the audit team. Auditors compare the outcomes between the manual audit and that of the RPA software to assess the effectiveness of the implementation. If the evaluation reveals that the program needs adjustment or improvement, the audit team needs to repeat steps 1 through 3— evaluate the selected procedure, modify the procedures, and adjust the implementation process—until the RPA software performs the procedure as expected.

In addition, practitioners suggest that audit risk is one of the main reasons for the delay in the adoption of RPA in assurance services ([Cooper et al., 2019](#)). Audit risk is a function of the inherent risk, control risk, and detection risk ([PCAOB, 2010](#)). Since the inherent risk and control risk are determined mainly by the nature of the client's business and the control environment, they are less likely to be affected by the RPA implementation. Therefore, the accounting firms need to evaluate the effect of RPA-based procedures on detection risk, which is the risk that the audit procedures will not detect a misstatement, and confirm that the audit risk will not be increased. Specifically, auditors need to use their professional judgment and consider the effect of audit procedure modification (in the second stage) and the performance of the RPA program on the detection risk. Once auditors understand that there is a reduction in the audit risk (or at least there is no increase), the RPA program can operate in a real audit engagement.

Finally, the audit team should manage and monitor the operation of RPA programs. A performance dashboard is usually embedded in RPA software. Auditors can obtain information regarding the accuracy (such as error rates as well as identified exceptions) and efficiency (such as processing time, the amount of time that the RPA program is not in use, and maintenance time) of an individual RPA program on a continuous basis ([Bharadwaj, 2018](#)).

4. The evaluation and the pilot project

To confirm its effectiveness, the framework depicted in [Fig. 1](#) and described above was initially evaluated by researchers and auditors and revised based on their feedback and comments. In addition, we worked with a CPA firm and were advised by two data analytics specialists to implement a pilot RPA program to automate an audit task—the confirmation process.

4.1. Stage1: procedure selection

4.1.1. Factor 1: RPA criteria

We first observed the financial statement audit engagement of one client in the retail industry. Based on observation and discussion with the audit team, two audit procedures that match the RPA criteria for implementation—being well-defined, repetitive, and mature—were selected.

The first procedure is the confirmation process, which validates that the bank account balances directly with a third-party intermediary. In general, evidence obtained from an independent source, such as a bank or a third-party, is considered more reliable than evidence obtained from an internal source ([PCAOB, 2010](#)). Based on the CPA firm's audit plan, this procedure contained the following steps:

- 1) prepare request form,
- 2) initiate confirmation requests through [Confirmation.com](#)⁴ based on the information provided by the request form,

⁴ [Confirmation.com](#) is a web-based audit confirmation solution that is relied on by more 10,000 accounting firms in more than 100 countries, bringing efficiency and security to the confirmation process for cash, debt, accounts receivable, and more than 40 other confirmation types ([Hanes et al., 2014](#)).

- 3) wait for the confirmations, and
- 4) download documents and extract the account balance for further audit tests.

This audit procedure is well-defined because none of the steps (sending requests, monitoring the results, downloading the confirmation, and extracting the balance) require professional judgment and all can be performed based on explicit rules. Additionally, this CPA firm confirms 100% of the cash accounts for all clients, performing 500 to 750 cash account confirmations every year, which makes the procedure highly repetitive. Also, the output of this procedure is generally predictable because once the request form is correct, this process should not produce errors.

The second candidate is the inventory cut-off test. In this test, the audit team checks whether the receiving date on the client's system is accurate. Specifically, auditors need to

- 1) extract the receiving date of each item from the client's inventory system,
- 2) retrieve the delivery date by searching for the tracking number on the carrier's website, and
- 3) compare these two dates across systems to determine the accuracy of the receiving date.

All the steps in this procedure are based on precise rules, and no complex judgment is needed. Furthermore, auditors do not expect many unusual situations, which suggests that this procedure is quite mature.

4.1.2. Factor 2: data understanding

After determining procedures that meet the RPA criteria, the research team and the audit team examined the data used in each procedure. For the confirmation process, the data (client information, bank information, and account information) are in digital format in the request form. Although not all the information in the [Confirmation.com](#) webpage is in a structured format, most RPA software is equipped with optical character recognition (OCR) and is able to transfer unstructured information (such as images) to textual format. Once the confirmation is downloaded, the account balance can be extracted from the PDF confirmation. Therefore, the data used in the confirmation process are all in digital format and can be handled by RPA software.

However, the data used in the inventory cut-off test is not currently usable for RPA software. The inventory system for this client is still paper-based. If auditors want to automate this procedure, all the paper-based documents need to be transferred into digital format, which may not be cost-effective. Additionally, the tracking numbers, which are used to retrieve the delivery history on the carrier's website, are not available for all received items. Therefore, the data for this procedure leads to the conclusion that the inventory cut-off test is not a good candidate for the pilot implementation.

4.1.3. Factor 3: complexity

As suggested in the framework, the audit team evaluated the complexity of the confirmation procedure, which involves importing local information to a third-party website and extracting the relevant data from the website to a local file. The complexity level was considered low, which minimizes the likelihood of implementation failure.

Overall, considering these 3 factors, the research team and the audit team agreed to implement RPA on the confirmation process as the pilot project. Fig. 2 displays the flow of the proposed RPA-based process.

4.2. Stage 2: procedure modification

After selecting an appropriate procedure, auditors need to consider whether to reengineer the current process to better match the software or change the scale of the procedure to collect more audit evidence. To help the RPA program more easily access the information, the team decided to change the request template from a Word template to an Excel file and to separate the items in the request information based on the interface of the electronic confirmation platform. For instance, the name of the signer from the client was divided into two attributes—first name and last name—because the online platform requires the first name and last name of the signer separately. Furthermore, three columns (Status, Confirm, and Balance) were added into the template to enable the RPA program to update the status of each request and to help the auditor monitor the entire process. Finally, data consistency

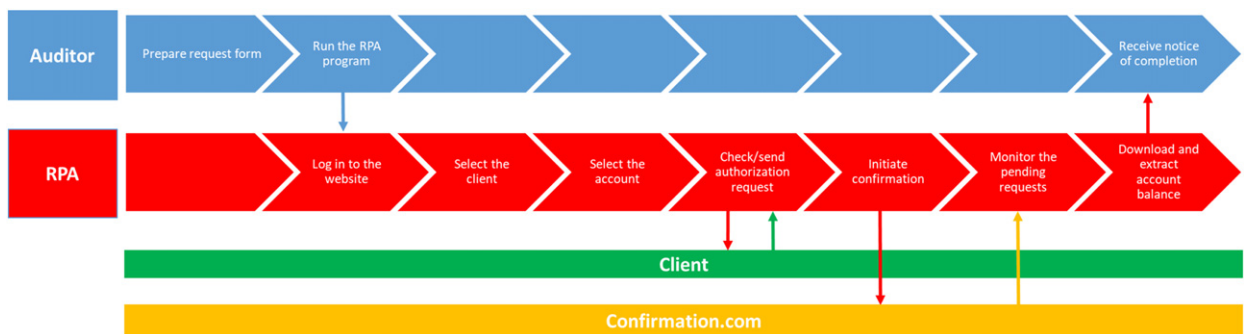


Fig. 2. RPA-based confirmation process. Note: Fig. 2 presents the flow of the proposed RPA-based confirmation process. It shows that most of the manual steps (including the corresponding interactions between RPA and client/confirmation.com) are performed by RPA programs.

Original request form	Re-designed request form
Company Information:	Client Simply Soups Inc.
SIMPLY SOUPS INC.	Signer Job Title Manager
177 WASHINGTON LANE	First Name Jennings
CHERRY HILL, NJ 08034	Last Name Lou
JENNINGS LOU	Address 177 Washington Lane
MANAGER	City Cherry Hill
lou.jennings@ssoups.com	State NJ
Phone: 609-555-5555	Zip code 8034
Bank Information:	Email lou.jennings@ssoups.com
FIFTH FEDERAL	Phone 609-555-5555
Checking Account Number:	Bank Name Fifth Federal
675-42223	Form Asset
Date for Confirm	Account ID 675-42223
(12/31/2016)	Date 12/31/2016
	Status
	Confirm
	Balance

Fig. 3. Original and re-designed request form.

was confirmed by checking the name of each attribute according to the field names of the confirmation platform. Fig. 3 shows the original and redesigned request templates.

4.3. Stage 3: implementation

As the framework suggests, the program for the implementation of this pilot project was prepared in-house. UiPath, a popular RPA software package that provides free licenses for individual developers, small professional teams, and education entities, was selected. Within approximately one week, researchers learned how to use the software by watching online tutorials provided by the software provider. Then the entire process was projected in a flow chart and split into the following eight steps:

- 1) log in to confirmation.com,
- 2) extract the information from the pre-prepared request form,
- 3) select the client company (first generate the client portfolio, if it does not exist),
- 4) select the bank account (first add a new account, if it does not exist),
- 5) check whether client authorization has been granted (if not, request authorization from the client),
- 6) initiate the confirmation request,
- 7) monitor the pending requests, and
- 8) download the completed confirmations and extract the account balances.

Appropriate activities in UiPath that mimic the way humans perform were chosen for each step. For instance, to perform the first step, “open browser and login Confirmation.com,” the following activities were selected: 1) open Internet Explorer browser, 2) go to URL: www.edu.confirmation.com,⁵ 3) type userID, 4) type password, and 5) click “Log in” button. Appendix A displays the activities for this step. For some steps, it is necessary to make a judgment, but these judgments can be made based on explicit, deterministic if-then rules. For example, to check whether the client portfolio exists, the program needs to search for the client name and read the output. If the output shows that no existing record for this client exists, the program will automatically trigger the activity of generating a new client portfolio.

The pilot RPA program that was implemented to automatically perform the confirmation process is able to handle multiple confirmation requests. Once a confirmation request is initiated, the RPA program starts to extract the next request from the request form, and repeats the request process. After all the requests have been submitted, the monitoring process checks the status of the confirmations until all of them have been completed and downloaded. Finally, the account balance is extracted to the

⁵ In this pilot project, we use edu.confirmation.com, which is an educational version of confirmation.com.

request form and the status is updated to “Completed.” Auditors only need to check the request form and follow up on any uncompleted confirmations, which will be labeled as “denied” or “more information needed.”

4.4. Stage 4: evaluation

This RPA pilot project was evaluated on edu.confirmation.com, which is the training version of confirmation.com for education and training purposes.⁶ The RPA software needs to complete the testing of Simply Soups, Inc.'s six bank accounts as of December 31, 2016, using edu.confirmation.com, to initiate confirmation and then to evaluate the responses received.⁷ Appendix B shows the account information. As designed, the pilot program logged into the electronic confirmation platform—edu.confirmation.com—sent confirmation requests, extracted the received account balances, and downloaded the completed confirmations. The same process was performed manually, and the documents and balances were compared with those collected from the RPA program to determine the effectiveness of this pilot program. The results show that all the information collected from the RPA program (such as client name, bank names, account numbers, dates, and account balances) match that from the manual process, supporting the effectiveness of this RPA pilot project.⁸

Finally, the detection risk of this RPA-based confirmation process was assessed. First, during the procedure modification stage, only the format of the request form and the label of each attributed were modified. Thus, the modification was believed to have no impact on the effectiveness of the confirmation process. Second, the field test results demonstrated that this RPA program was able to send out confirmation requests and extract account balances as designed. Therefore, this RPA-based confirmation procedure would not cause any additional detection risk or audit risk compared with the current audit procedure.

While maintaining the effectiveness of the confirmation procedure, this pilot RPA reduced the number of auditor working hours and saved cost. An accountant, on average, needs about 30 min to manually complete one confirmation request (including creating new client/account portfolios, requesting authorization from clients, initiating confirmation requests, monitoring pending cases, downloading completed ones, and extracting account balances). After the RPA adoption, less than 3 min was required to complete one request. According to the firm's estimation, more than 600 audit hours can be saved if this RPA program is performed automatically across different audit engagements. Once auditors have more knowledge and experience with RPA, they plan to apply it to other tasks (such as contract downloads, which take about 30 h per client) to save more audit hours on other procedures. Overall, the evaluation of this pilot RPA project demonstrates the feasibility of RPA in the audit industry.

5. Discussion

5.1. The benefits of RPA in auditing

With the application of RPA, software automatically performs the pre-designed RPA-based audit tasks, giving auditors more time to perform higher-level tasks which require professional judgment, such as evaluating contradictory evidence and designing and applying follow-up actions. Additionally, the scale of audit procedures performed by RPA software is no longer limited by human processing power. Currently, because of limited audit resources, sampling techniques (statistical and non-statistical) are commonly used in processes such as tests of controls and substantive tests of details (Christensen et al., 2014). With the adoption of RPA, auditors can, in certain instances, expand the scale of some procedures from sampling to testing the entire population, avoiding the risks and deficiencies related to sampling and collecting comprehensive audit evidence.

Another benefit of RPA is to minimize or avoid human errors such as mistakes when confirming amounts, errors in workpapers, and ignoring red flags. Once the RPA software is programmed, the tasks and analyses are performed in line with audit standards and pre-defined rules. A recent survey of major accounting firms shows that, compared with the 90% accuracy rate of humans, RPA accuracy achieves 99.9% (Cooper et al., 2019). For instance, one common human error for the confirmation process is that a request can mistakenly not be submitted, and a week or more may pass before auditors realize it never went through. With the RPA-based audits, the program never misses a request in the prepared form.

Finally, RPA may be a way to improve audit quality by reducing outsourcing and offshoring, which take up 10–20% of audit hours (Daugherty et al., 2012). Both regulators and researchers have expressed concern about the risk associated with outsourcing. The PCAOB (2012) has raised the discussion of whether certain offshoring arrangements or structures increase audit risk. Prior literature finds evidence that offshored and outsourced audit work comes with higher risk and lower quality. With the adoption of automation, practitioners suggest that the offshore and outsourced work could be largely replaced by RPA programs, which are better controlled and monitored by US firms (KPMG, 2016).

⁶ The training version was used in the evaluation stage for the following reasons. First, during the development, the RPA-based confirmation process was performed, modified, and tested multiple times and each time client involvement was needed (the client needed to grant authorization). It is not necessary to get the client involved in the development process. Second, there is a \$23 initiation fee for each confirmation request, while the training version is free of charge. Developing the pilot project on confirmation.com will significantly increase the implementation cost. Third, the interface for edu.confirmation.com, the training version of confirmation.com, is identical to the interface for the real confirmation platform and a training audit engagement case is provided. Therefore, once the pilot project is developed and tested on this platform, the accounting firm can use the program for the real audit engagement.

⁷ Simply Soups, Inc. is the auditor's client in the training case provided by edu.confirmation.com.

⁸ A video of this pilot RPA program is available as supplementary material.

5.2. Errors and exceptions

During the evaluation of the pilot project, two exceptions were encountered. First, one bank was no longer included in the network, so the RPA program was not able to send an electronic confirmation request. The second exception was that the information about the authorized signer was incorrect, which is not uncommon for the confirmation process because clients sometimes forget to update the information to auditors. Broadly, RPA can start leaving exceptions off and progressively incorporate the most common ones. Then, two solutions to deal with errors or exception are discussed.

The first solution is to automate the normal and routine process and leave all errors and exceptions to human auditors. For example, during the confirmation process, it is possible to receive feedback that the request cannot be completed because the bank no longer exists in the network. In this case, the RPA software only identifies the uncompleted request and leaves the follow-up for auditors. Specifically, the type of error (such as request denied, more information needed) and the comments (such as invalid date or invalid contactor) are sent to auditors, and all the follow-up is performed manually.

However, if the errors or exceptions happen regularly, leaving them for the manual process may not be efficient. The solution is to first classify errors/exceptions into two groups, common and uncommon errors, and include follow-up procedures for the common errors in the RPA automation. Once this type of error is detected, the follow-up process will be triggered automatically, and auditors need to deal only with uncommon errors, enhancing the efficiency of the RPA application.

5.3. RPA's next step - IPA

Although RPA can potentially make significant improvements to auditing practice, a key limitation currently is that the software is able to perform only routine tasks and to make decisions based on explicit rules. Therefore, current RPA software is not adaptable to audit procedures requiring professional judgment that cannot be transformed into structured instructions.

Recently, there has been progress in the evolution of technology for applying artificial intelligence (AI) in the industry, with large accounting firms launching numerous projects (Kokina and Davenport, 2017). For instance, KPMG is working with IBM Watson to apply cognitive computing technology to its professional services offerings (IBM, 2016). Deloitte is collaborating with Kira Systems, a contract analysis system, to create cognitive models that examine large numbers of complex documents, extract textual information for better analysis, and assist auditors with the difficult task of document reviewing (Deloitte, 2016). To take advantage of AI developments and address the limitations of current RPA, practitioners have proposed Intelligent Process Automation (IPA), which refers to combining AI, cognitive automation, deep learning, and machine learning with RPA (e.g., Berruti et al., 2017; UiPath, 2018).

Instead of only mimicking the way people perform routine business processes, IPA leverages the advantages of AI to learn how people make decisions and may be able to perform complex tasks faster and better. To further improve audit quality, accounting firms may eventually consider applying IPA to help auditors perform complex and unstructured audit procedures and make professional judgments.

6. Concluding remarks

This paper introduces an emerging automation technology, robotic process automation (RPA), to the auditing practice. RPA is a methodology that performs routine business processes by automating the way that people interact with multiple applications or systems through an overlay user interface and also by following simple rules to make decisions (Deloitte, 2017). Although the benefits of RPA have been documented in different industries and many audit tasks (such as reconciliations, internal control testing, and detail testing) are ideal candidates for RPA, applications of RPA in auditing remain relatively unexplored.

This study takes into consideration the unique nature of the audit industry and proposes a 4-stage framework to guide auditors in applying RPA. Specifically, accounting firms need to 1) select appropriate audit procedures, 2) modify the current procedure, 3) implement it in-house, and 4) evaluate the performance. Finally, the study demonstrates the feasibility of RPA in audit practice using a pilot RPA implementation which automates the confirmation process.

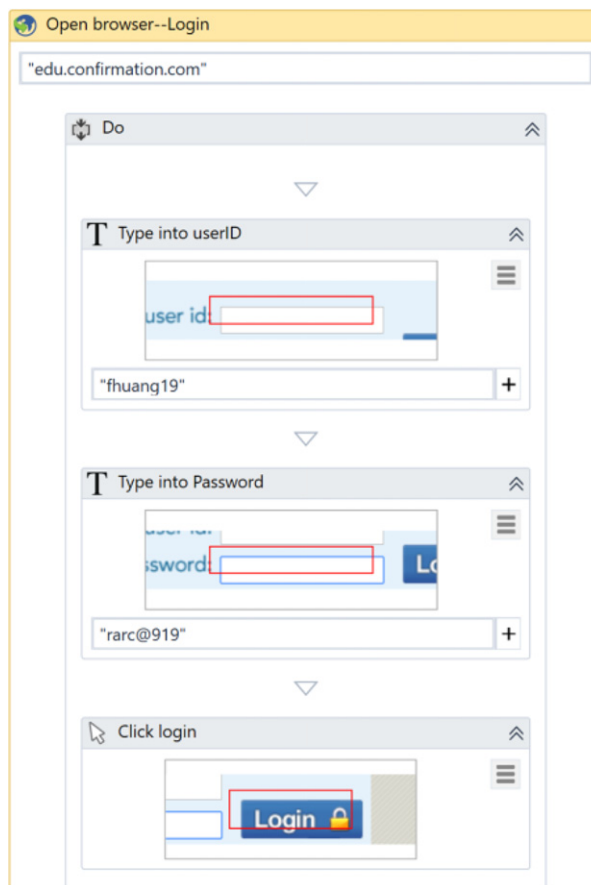
This paper is not without limitations. First, the pilot project was built on edu.comconfirmation.com. Even though edu.comconfirmation.com provides an interface that is identical to that in confirmation.com, slight modifications may be needed when transferring this pilot project to the real platform. Second, this pilot RPA program is designed to perform the confirmation process via the third-party website confirmation.com. The effectiveness of the demonstration is limited to the confirmation process via confirmation.com. Nevertheless, confirmation.com is a leading and widely-adopted confirmation platform, providing confirmation services for more than 10,000 accounting firms across 100 countries (Hanes et al., 2014). Third, the RPA software used in the pilot project has a limited capability for dealing with errors. It could be important for future studies to design follow-up RPA-enabled audit procedures to minimize manual intervention from auditors. Finally, the accounting firm plans to apply this RPA program to the actual audit engagement shortly. Then, this study provides limited insight on the human and technology-related challenges along the way, the long-term benefits of RPA implementation in cost-saving over multiple audit engagements, and improved audit quality. It would be an area that offers great potential for future research.

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Appendix A. The activities in the “Open browser and login” step



Appendix B. Key account information

Audit Firm:	Putnam and Jacobs LLP
Year End Date:	December 31, 2016
Client Address:	177 Washington Lane Cherry Hill, NJ 08034
Client Phone Number:	609-555-5555
Client Contacts:	Lou Jennings Lou.jennings@ssoups.com Chuck Rogers Chuck.rogers@ssoups.com

Bank Accounts – 2016

Bank Name	Bank Address	Bank Manager	Account Name	Account Number(s)	Authorized Signer
Fifth Federal	73 Union Street New York NY 10001	George Williams	Checking	675-42223	Lou Jennings
Sparkasse-Frankfurt	Landstrasse 89-21 Frankfurt 60326 DE	Helga Jones	Checking	44-322711	Lou Jennings
American NorthWest Bank	234 Market Street Milwaukee WI 53202	Richard Johnson	Checking	05-198305	Lou Jennings
BNY Federal	3621 Ave De Lafayette Boston MA 02111	Betty Smith	Savings	061-22031	Lou Jennings
Tenth National Bank	313 S. Chadwick Street Philadelphia PA 19103	Greg Fordham	Savings	26-798422	Lou Jennings
Bank of Citizens	3621 Union Ave Denver CO 80220	Denise Bentley	Checking	89-123661	Lou Jennings

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