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Robotic process automation and its impact on accounting

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Abstract

The paper seeks to explain the concept of robotic process automation (RPA), the ways it impacts accounting, and suggest future research directions. A literature review of previous studies and state-of-the-art sources has been conducted to reveal research gaps. The results provide insights into the nature of the accounting transformation. The potential for automating accounting processes with RPA is high, and robots are predicted to replace accountants for a considerable part of their tasks. That could lead to the disappearance of entry-level accounting positions and, simultaneously, the creation of new accountant roles. Future accountants' responsibilities will go beyond bookkeeping and financial reporting towards business advisory and leading the RPA transformation. The change entails the need to improve their soft skills, and technology and data skills. It calls for more studies on an effective method to integrate these skills into the accounting education model. Further research is required to examine the potential negative effects of employing robots. These relate to the unnecessary human-robot competition, unintended organisational structure changes, deskilling, and building expertise and knowledge management. Finally, to obtain a more comprehensive view of the impacts of RPA performance, more in-depth research is needed to account for all the financial and non-financial effects of RPA implementation.

Keywords: robotic process automation, accounting.

Streszczenie
Zrobotyzowana automatyzacja procesów i jej wpływ na rachunkowość

Artykuł ma na celu przedstawienie koncepcji zrobotyzowanej automatyzacji procesów (RPA) i jej wpływu na rachunkowość, a także zaproponowanie przyszłych kierunków badań w tym zakresie. W celu wskazania luk badawczych posłużono się przeglądem badań naukowych oraz innych aktualnych źródeł (opracowań branżowych, środowiskowych). Przegląd pozwolił wskazać charakter przemian w rachunkowości. Procesy księgowe wykazują wysoki potencjał automatyzacji i przewiduje się, iż roboty zastąpią księgowych w znacznej części ich zadań. To może doprowadzić do zaniku niższych stanowisk w księgowości, ale jednocześnie stworzy nowe. Zadania przyszłych księgowych wykroczą poza księgowanie operacji i sprawozdawczość finansową i będą dotyczyć doradztwa biznesowego oraz zarządzania automatyzacją przy użyciu robotów. Zmiana ta wymaga podnoszenia przez księgowych kompetencji miękkich oraz związanych z technologią i analizą danych. Dalszych badań wymagają efektywne metody uwzględniania powyższych w systemie nauczania rachunkowości. Istnieje potrzeba dalszych studiów nad negatywnymi konsekwencjami angażowania robotów, które dotyczą niepożądanej rywalizacji człowiek-maszyna, niezamierzonych zmian w strukturze organizacyjnej, problemu utraty umiejętności i zarządzania wiedzą. Pogłębionym analizom powinny zostać poddane finansowe i niefinansowe skutki implementacji RPA.

Słowa kluczowe: zrobotyzowana automatyzacja procesów, rachunkowość.

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Introduction

Disruptive technologies play an ever-increasing role in all areas of modern business. The digital transformation is seen as one of the key factors changing the way companies create value and gain competitive advantages (Kotarba, 2018). The impact of technology development on the finance and accounting function is one of the most visible. Technologies seen as already or potentially disrupting the sector include artificial intelligence, machine learning, cloud computing, blockchain, and robotic process automation (RPA) (Moll, Yigitbasioglu, 2019; *Reinventing business*, 2019). The paper focuses on RPA as a relatively recent step in the development of automation solutions applied in accounting, and the central thesis is that RPA will significantly impact the profession. To date, much attention has been paid to other automation technologies, including enterprise resource systems (ERP), artificial intelligence (AI), cloud computing, and big data. The increased use of RPA, which can be applied together with all the above-mentioned solutions, requires more research on its impacts and the potential to transform accounting. The objective of the paper is: (1) to explain the concept of RPA and the various impacts it can have on accounting and accountants, and (2) to suggest future research directions on the challenges and issues, to fill discovered research gaps. A literature review has been applied to provide a brief overview of automation in accounting and to put RPA in context as an evolutionary (rather than revolutionary) solution. Some recent state-of-the-art sources have also been reviewed to explain the essential characteristics of RPA, as well as its actual applications and outcomes in accounting.

The paper begins with a short introduction to accounting automation to provide a background for RPA. The definition and advantages of RPA are then outlined. The following chapter focuses on RPA applications in accounting. The remaining part of the paper covers the challenges and impacts related to RPA implementation and operation. Potential issues are identified based on analogous, previously observed impacts of other automation technologies (mainly ERP and AI). As a result, future research suggestions on the RPA impact on accounting are proposed. The paper adds to the existing literature by considering the potential impacts of RPA on accounting and identifying research directions.

1. Robotic process automation

Searching for methods to efficiently perform accounting tasks can be dated back to the 1950s, when process mechanisation involved the use of punched cards to store and retrieve transaction data (Keenoy, 1958). The advent of electronic computers offered automatic comparisons and provided logical conclusions, which enabled further time and cost savings (Carlson, 1957; Harvey, McCollum, 1965). Since then, IT and automation have transformed the way accountants collect, store, process and share data through a variety of tools and (Ellis, 1986; Kaye, Nicholson, 1992; Rom, Rohde, 2007).

Accounting departments were the first to extensively adopt IT (Damasiotis et al., 2015), and they drove the computerisation of offices (Collier, 1984; Wilson, 1989). Accounting and IT have become closely interrelated. Simple transaction processing and bookkeeping were quickly computerised. Automation required using multiple applications and a lot of effort and time to program and input the necessary data (Carbone, 1980; Shiflett, 1983; Peterson, 1984). The 1980s offered the advantages of sophisticated expert systems and artificial intelligence (Baldwin et. al., 2006; Meservy et al., 1992), although their usage was limited to big organisations (Connell, 1987; Messier, Hansen, 1987; McCarthy, Outslay, 1989; Dijk, Williams, 1992). In parallel, some theoretical grounds for accounting robotisation have been discussed (Bytniewski, 1992, 1996). The introduction of enterprise resource planning systems (ERP) enabled cross-functional integration, centralised control over the system and higher automation, which facilitated further efficiency improvements (Scapens, Jazayeri, 2003; Matolcsy et al., 2005; Nicolaou, Bhattacharya, 2008; Kanellou, Spathis, 2013). ERPs allowed accounting transactions to be traced back to a particular employee on an assembly line or the event of scanning a barcode. Financial reports were increasingly generated automatically and resulted from encoded procedures rather than to be constructed by a team of accountants (Sutton, 2006, 2000). However, ERP systems still required links to other applications, which translated into the high complexity of the solution (Hyvönen et al., 2008). Achieving a higher accounting automation level was thus still hard (Gotthardt et al., 2019). Before RPA, automation was reached in multiple ways and applications: ERP, spreadsheets and macros, and screen scraping (*Accountancy Futures*, 2018).

Robotic process automation is a technology solution that allows end-users to configure a software robot to use existing applications to perform transactions, manipulate data and communicate with other systems (Introduction to robotic, 2015). Software robots can be easily programmed or trained to perform repetitive, rules-based, high-volume operations by replicating human actions when accessing multiple systems, applications, and documents (*Embracing robotic automation*, 2018). The robots can operate in the user interface the same way people do, which eliminates the need to modify applications (e.g. accounting, payroll, warehouse, ERP software) or the underlying information technology infrastructure (*Internal Controls*, 2018). The automata are assigned their own user accounts and credentials, and they can work in parallel with other robotic or human users. Each operation is tracked and logged to ensure data integrity and meet audit requirements. Typical office work operations that software robots can take over include:

- opening, reading and sending emails. Robots can send email notifications to inform employees about the completion of a task,
- searching, extracting, updating, validating and entering data across multiple applications – automata can log in to different programs (online and offline), search for specific information based on given criteria and then use it to create, update or validate records, and fill in forms in other corporate systems (ERP, CRM, Office etc.). Access to other systems can also be implemented via application programming interfaces (API). The data include both machine-readable formats (text files, spreadsheets,

XML, HTML) and those requiring further processing (e.g., scanned documents, PDFs, images) usually supported by character and image recognition solutions,
- data processing and formatting – robots may be taught to clean or format data, or make calculations based on it to provide standardised reports (e.g. financial),
- decision-making – robots use prescribed rules and decision paths to change their behaviour in response to variable conditions (data availability, communication errors, application exceptions).

RPA is an alternative to traditional (integrated, full) automation. Traditional automation requires programmers and software suppliers to develop dedicated software and to integrate it into existing systems. Multiple applications may need to be modified so that they can exchange information in a universally agreed format. The potential benefits of traditional automation are higher, but the implementation is more difficult and requires spending significant effort, time and money. RPA can be deployed as a non-invasive technology solution without the undesired interference with existing infrastructure, offering cross-functional and multiple systems operations (Lacity, Willcocks, 2016). It is particularly suited for business environments with numerous modern and legacy applications, whose operation is at least partially interrelated. RPA offers an opportunity to improve the performance of processes in companies, where traditional automation is either impossible or too complex, and thus too expensive to deploy.

The basic approach to RPA implementation (called standalone or attended) is to run the robotic software on the employee's desktop. Typically, robots use previously recorded or configured sequences of human actions. An automated agent takes control of the desktop to perform delegated activities. The solution offers direct feedback on the workflow and its progress. It proves useful for processes involving non-automatable steps that require human approval, decision-making or immediate exceptions handling (Mancher et al., 2018). The attended software robots act as virtual assistants (instead of replacing humans completely).

A higher level of automation is achieved when robots operate unattended. Automata work independently in their own environments (usually virtualised – on servers or in the cloud) and their deployment is managed centrally. An employee monitors multiple robots' performance and takes action only when issues arise. This approach is more suitable for high-volume operations that need to be performed continuously. Scalability is one of the key advantages here as robots can be easily cloned at times of higher workload and deactivated afterwards (An Introduction to Robotic, 2018). However, unattended RPA requires more time and effort to implement (*Embracing robotic automation*, 2018). The solution can also be further advanced to integrate other mechanisms that enable the robots to adjust their actions based on varying conditions and to learn from experience (Kaya et al., 2019). Integrating AI with RPA offers intelligent process automation (Lin, 2018). Implementing RPA in the unattended approach (especially when integrated with AI, the cloud or blockchain) is more expensive, complex and takes longer than in the attended version, but the cost and time are still lower compared to traditional full automation.

To date, the automation software solutions required a human to operate them, whereas RPA allows particular tasks to be completely taken over by automata. Therefore, the main advantage of RPA is not the technology itself but the release of human resources and the opportunity to focus on activities requiring judgement, making decisions or interacting with employees or customers. The most frequently mentioned benefits of RPA include:

- Cost reduction – savings depend on the nature of the operations to be automated and the type of RPA approach applied. Attended robots bring moderate returns, while unattended and centrally controlled robots yield higher returns. In particular, when deployed on a large scale, robots can significantly lower the costs of particular accounting and finance tasks (Le Clair, 2017). Typically, a single robot can replace two to five full-time employees (*Introduction to robotic*, 2015);
- Increased process speed – software robots perform routine tasks faster than employees would manage manually (Lacity, Willcocks, 2016). They do not get distracted or tired and thus avoid delays; cycle times decrease significantly;
- Improved process control and performance visibility – RPA enables efficient control over the automated tasks, as every operation is fully tracked and logged. The collected analytical information is much more detailed and can be used for audit and compliance checks. Measuring progress and predicting completion times is easier when all automation work is monitored centrally. The data gathered can be used to detect anomalies and bottleneck problems, and thus facilitate the optimisation of the existing processes. Moreover, RPA implementations meet the requirements for security, scalability, auditability and change management. Transaction integrity and continuity of service is also secured (Lacity, Willcocks, 2016);
- Higher quality data (accuracy, consistency, compliance) – software robots consistently and precisely follow prescribed rules and protocols (Lacity, Willcocks, 2016). This reduces the number of intentional and unintentional errors human make when manually entering and processing data (transcription, digit transposition errors) (Internal Controls, 2018). Robots can validate the data before reporting or using them further. Assuming that the appropriate rules and algorithms have been thoroughly tested beforehand, data inaccuracy and quality risk decrease. Full tracking and logging of robots' actions make internal and external audits easier and reduce compliance risks;
- Continuous operation (24 hours a day) – a robot can be configured to serve a single process or perform multiple tasks of various processes in sequence. The capability of working 24 hours a day, 7 days a week at least triples the available time for processing when compared to human employees shifts;
- Improved process flexibility for easier scaling – robots can work according to schedules, but they can also adapt to variable workloads. Temporary variations of required processing capacity may trigger robot cloning and deactivation on demand. Priorities can be set for robots to decide if they should switch to more urgent activities. Scaling up and down is achieved faster and cheaper compared to hiring and

training human employees and does not leave unused systems after the load decreases (as in traditional automation) (*An Introduction to Robotic*, 2018). Robots can easily switch between tasks of various domains, which is not achievable with a specialist human workforce (Lacity, Willcocks, 2016). After successful implementation, creating and automating new processes is easier as well (in contrast to introducing even a simple change in IT systems);

- The relative ease of implementation – robots can replicate human activities, which makes the automation of tasks less risky, as processes taken over by robots can remain unchanged and staff do not need retraining (Robotic process automation, 2018). Nowadays, employees use a larger number of different tools than in the past (ERP, CRM, project management software, spreadsheets and other company-tailored applications). In particular, legacy tools which were developed without future integration in mind make it difficult and often economically unjustified to introduce traditional automation. RPA can be applied on top of existing systems, and the degree of interference is minimal. Employees only require a few months of training to be able to configure software robots and automate manual tasks; they do not have to possess software engineering or programming skills (Fersht, Slaby, 2012; Lacity, Willcocks, 2016). Thus, RPA bridges the gap between manual interaction and full automation;
- Geographical and cultural independence – robots can be deployed on centrally managed servers and operate without breaks. They can serve multiple business locations during the day, eliminating issues resulting from time-zone differences, or cultural and language barriers;
- Positive impact on employees – repetitive, mundane tasks taken over by robots release employees' time. They can shift their focus to higher value-added tasks. That, in turn, reduces routine and improves job satisfaction (Lacity, Willcocks, 2016). There are more opportunities to take advantage of employees' knowledge and experience. Alternatively, delegating the control of robots to employees improves their morale and gives them the opportunity to find new ways robots can solve business problems (Edlich, Sohoni, 2017).

The most convincing reasons for companies to consider RPA include the relative ease of implementation and its lower costs and skills required when compared to traditional, fully-integrated automation. Those two factors cause shorter deployment times and quicker returns. A survey by Capgemini revealed that RPA is the most popular technology to automate back-office and middle office functions. The payback period ranged from 7 to 12 months and ROI from 13% to 18%. Thirty-one per cent of analysed companies implemented automation in finance and accounting, where ROI averaged 12%, and the payback period was 11 months. Automation in finance and accounting recorded the highest cost savings (13% on average) compared to other back-office departments (*Reshaping the future*, 2018).

2. The application of RPA in accounting

Accounting and finance processes are among the most likely ones to be supported or taken over by software robots (Peccarelli, 2016). Recording accounting operations requires high accuracy, consistency, and many of them involve the manual handling of repetitive transactions. An employee usually collects information from multiple and fragmented systems and then processes the data (verifies, submits for approval) before finally saving them into an accounting system. Manual data collection and manipulation consumes much time and is error-prone (Tucker, 2017). Time can be saved, and the error ratio reduced when robots take over these tasks (Chui et al., 2016). Accounting processes use prescribed rules and procedures, which makes them relatively easy to automate (Moffitt et al., 2018). At the same time, automation provides tracking checks, approvals and document management. Audit logs of automated processes can include much higher detail levels than when done by manual handling. Accounting regulations and standards are subject to frequent changes (e.g. tax law). Robots can be quickly retrained (in a centralised way) to comply with the updated law (*Introduction to robotic*, 2015). Another reason to consider RPA is that legacy systems can be devoid of solutions allowing traditional automation (*Robotic process automation*, 2018). The simultaneous use of modern and legacy software and the repetitiveness of manual tasks make many finance and accounting processes suitable candidates for being taken over by software robots.

Many accounting processes are or have been outsourced to shared services centres. The key motivation for transferring operations outside the company is to reduce costs by running them in countries with lower salaries. Benefits from outsourcing, however, seem to have been realised by most companies already. The labour cost advantage is decreasing and is no longer the key reason to outsource. Traditional outsourcing requires more supervision than control of processes outsourced to robots. Another reason to shift transaction processing to automata can be retaining greater control of the data. Employees seem to be more open to the idea of RPA than to traditional outsourcing (*The robots are ready*, 2018). A 2018 survey of over 500 executives revealed that, currently, outsourcing is more about disruptive technologies (RPA, artificial intelligence, cloud computing) than labour arbitrage (Traditional outsourcing, 2018). Task automation is now the next alternative to improve productivity and gain a competitive advantage (Lacity, Willcocks, 2016). However, the shared services business sector is increasingly applying RPA as well, so it does not necessarily translate into bringing jobs back from offshore (Willcocks et al., 2017).

The accounting processes and tasks that can benefit from automation in terms of performance and accuracy include (Le Clair, 2017; *Robotic process automation*, 2015; *Internal Controls*, 2018):

- Period-end closing – general ledger, subledgers closing, validation of journal entries, low-risk accounts reconciliation, consolidation;

- Reporting – monthly, quarterly close, internal performance and management reporting (aggregating and analysing financial and operational data), external statutory and regulatory reporting;
- Accounts receivable and accounts payable – maintaining (updating, vetting) customer/supplier data, creating/processing/delivering invoices, automating approvals, validating and posting payments, collections, billing, matching invoices against sales and purchase orders;
- Cash management, general ledger accounting, intercompany transactions, inventory accounting, travel and expenses – reimbursement requests, audit and document expense reports, payroll, fixed asset accounting, tax accounting.

The processes most often chosen for RPA include purchase-to-pay, record-to-report and internal performance reporting (*Embracing robotic automation*, 2018), as they are routine-based and do not require judgement or complex decision-making. Some predict that up to 40% of current transactional accounting could be taken over by automata (Axson, 2015). Robots are expected to replace humans in manual bookkeeping and assist them in complex, multifaceted processes (such as the financial close) (*Professional Accountants*, 2016).

Table 1 presents selected cases from various industries of the robotic automation of accounting processes. They relate mainly to transactional accounting (invoice processing, payments), where the automation outcomes proved to be particularly remarkable. Processing times were substantially reduced (some by 90%) and accuracy improved. Employees could then be transferred to other tasks, or there was no need to hire a temporary workforce. Relatively short implementation times are noteworthy.

Table 1. RPA implementation cases for accounting tasks

Name, country, sector	Case description	Automation outcome	Implementation time
Professional services company	Manual invoice processing was time-consuming and error-prone. Different formats of invoices with frequent template updates required rules-based robots to be supported by cognitive document processing	80% of invoices processed automatically Invoice processing time reduced to 5 seconds from over 3 minutes	3 weeks
Fortune 500 tech company, Global, Technology	Quarterly financial report generation automated	70% reduction in effort and turnaround time Improved auditing capabilities thanks to detailed logs Reduced error ratio	

Name, country, sector	Case description	Automation outcome	Implementation time
Hewlett-Packard, Brazil, Technology	Tax accounting and reporting sub-processes automated	85% effort reduction for tax processes $100,000 annual cost savings	12 weeks
Quad/Graphics, USA, Printing	Automation of payments processing (billing reports) and other processes	Shorter collection time resulting in cash flow increase ($10 million per day)	10 weeks
An automobile manufacturer, Europe, Manufacturing	Automation of accounts payable, accounts receivable and general accounting processes, including: manual processing of 1000 journal vouchers per day, manual matching of 500 payments against pending invoices per day, manual expense management (handwritten claims processing)	90% reduction of journal vouchers processing time Reduction in errors Audit compliance due to real-time approvals 100% payments correctly matched 100% of claims verified correctly	2-month pilot
A food and beverage company, Food and beverage	Invoice processing within the accounts payable procure-to-pay process has been automated Other automated processes included internal financial reporting, the help desk, and order management	25 full-time employees refocused on higher-value tasks 100% reduction in errors	6 months (for end-to-end invoice process)
Fortune 500 storage provider for hybrid cloud data centres, Manufacturing	Order-to-cash process handled manually by 50 FTEs and required over 16 validations against data from the ERP system. Quarter-end peaks in order volumes required hiring a temporary workforce	20% of the order-to-cash process automated 8 FTEs moved to higher-value tasks $350,000 savings in 3 months on-demand scaling of the number of robots to handle variable orders volume	5 weeks
Walgreens, USA, Retail	Automation of various processes related to human resources and payroll	73% efficiency gain	
A medical technology company, Technology	Automation of procure-to-pay, IT system updates, data queries and analysis, and other processes	50 FTEs reassigned to higher-value tasks 89% reduction in cycle-time	3-5 weeks for end-to-end critical processes

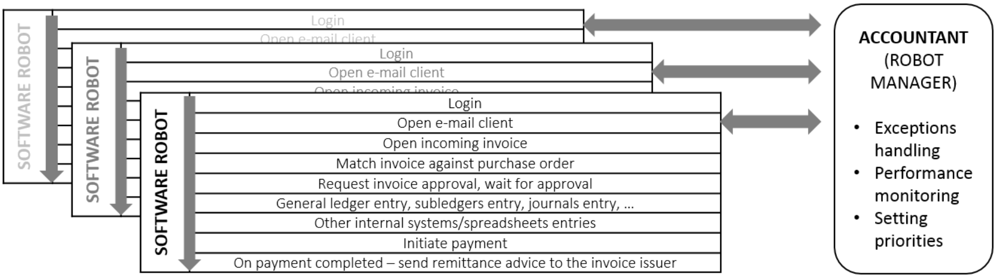
Tab. 1 cont.

Name, country, sector	Case description	Automation outcome	Implementation time
Stant, USA, Manufacturing	Accounts payable team manually performed invoice matching, invoice information data validation. High workloads resulted in exceptions handling delays, reporting delays, and risk of overdue payments Invoice matching and data entry were automated by robots	80% invoice straight-through processing achieved No data entry errors 94% of invoices processed successfully Invoice matching backlog reduced from 3 weeks to 4 days	
npower, UK, Utility	Automation of invoice statement generation. The process required data from over 50 systems	Invoice processing time reduced from 20 minutes to seconds No need to hire an additional 21 FTEs	3 weeks

Source: Own elaboration based on cases published by RPA tools vendors (Automation Anywhere, Blue Prism, Option3): https://www.automationanywhere.com/images/casestudy/CaseStudy-Stant-Thirdware-AutomationAnywhere.pdf; https://resources.automationanywhere.com/articles/large-food-and-beverage-company; https://www.automationanywhere.com/images/casestudy/Case-Study-Storage-Provider.pdf; https://www.automationanywhere.com/images/casestudy/Large-Medical-Device-Company-CS.pdf; https://www.blueprism.com/resources/blog/walgreens-prescription-for-hr-services-efficiency; https://www.option3.io/wp-content/uploads/2018/10/JiffyRPA_InvoiceProcessing.pdf; https://www.option3.io/wp-content/uploads/2018/11/JiffyRPA-Finance-and-Accounting.pdf; https://www.blueprism.com/uploads/resources/case-studies/blue-prism-npower-case-study.pdf; https://www.sson-analytics.com/data-tool/intelligent-automation-universe-case-study-catalogue (accessed 25.04.2019).

Figure 1 demonstrates an automation example of an accounts payable process flow. Software robots log in with their own credentials, find new invoices, match them against orders, request and wait for approvals, perform accounting and other internal systems data entries, and finally release payment together with posting remittance advice. The process repeats as long as pending invoices remain. The previously manual operations are automated and require little to no human intervention. Extracting, validating and entering transaction data from and into numerous systems is faster and more precise than manual operations. One accountant can control multiple robots and only intervenes when exceptions occur. These relate, for instance, to data not conforming to the accepted format, network issues, or malfunctioning of other systems. The example explains the sources of decreased processing times and the reduced number of employees required.

Figure 1. Robotic automation example of a supplier invoice processing



Source: own elaboration.

There are several reasons to consider automating period-end closing and reporting processes in particular. Current regulatory and statutory reporting requirements (especially for public companies) are an increasingly demanding part of the modern accounting department's job. Closing the books, consolidating group results and publishing reports within tight timelines requires proper coordination and thus indicates not only a competent finance team but a company with good corporate governance. The period-end closing process has a direct impact on the reporting outcome, as the report's usefulness is a derivative of the accuracy, completeness and timeliness of the information. Ninety-seven per cent of CFOs surveyed admitted having some level of uncertainty about the elements and outcome of the reporting process. These mainly include doubts about updating the disclosures with the latest changes to accounts, the accuracy and integrity of the data and the inability to monitor the process all the time (*Future of Financial*, 2017).

In large corporations, month-end close activities include coordinating the collection and verification of vast amounts of data from multiple entities, which can lead to added delays or risk. Many of these tasks are still done manually (Tucker, 2017) and often involve using "shadow systems," i.e., individual employee's desktop files that are not a part of enterprise systems (Drum, Pulvermacher, 2016). Sixty-nine per cent of senior finance professionals admitted relying on spreadsheets to prepare financial reports (*Future of Financial*, 2017). A third of respondents reported having problems merging, linking or updating data from different sources that require manual data transfer, and 60% believed they spent too much time cleaning data (*Future of Financial*, 2017). Over half of the respondents admitted that while preparing the financial report, every time a change occurs, a great deal of manual checking is required afterwards.

The progress of the closing and reporting processes is usually measured by checklists, which include tasks, as well as their completion and approval statuses. The reliability of the lists, however, is fully dependent on the human factor. The need to use multiple information sources and programs (including legacy ones), task repeatability and the priority of accuracy, consistency and timeliness make period-end closing and reporting processes good candidates for automation. RPA implementation should lead to reduced error rates and solve the issues with disparate documents and the integrity of data. Embedding robotic automation of period-end tasks within day-to-day activities facilitates a continuous accounting approach, which distributes the workload more evenly over the month (Tucker, 2017; Parcells, 2016; Rezaee et al., 2001; Di Lernia, 2014; Borthick, 2012) and offers the advantage of simultaneous reporting and analysis.

Companies are still in the process of exploring and understanding the benefits of RPA and other automation technologies. A global survey of over 700 business leaders demonstrated that the automation of processes has not reached maturity yet. Only a minority of respondent companies admitted deploying automation in multiple use cases at scale. Most are at the pilot stage or have automated only a small part of their processes and functions (*Reshaping the future*, 2018). The absorption rate is, however, growing rapidly, and 72% of the organisations surveyed are considering or already in the process of RPA implementation (*Traditional outsourcing*, 2018). The RPA market is expected to grow at approximately USD 2.7 million by 2023, at 29% of annual growth rate (*Robotic Process Automation*, 2019). Over 60% of companies across various industry sectors, that have already deployed RPA, opted for the rules-based automation, which currently is a dominant solution. Intelligent, cognitive automation is still in the early development and adoption stage, with only 18% of organisations surveyed having implemented it (*Reshaping the future*, 2018). However, rule-based automation is likely to be only an intermediate step after macros and scripts and before artificial intelligence brings the advantage of optimising processes thanks to self-learning capabilities.

3. Challenges of robotic automation implementation

RPA offers considerable advantages over fully integrated automation. Deployment is faster and less expensive. There are, however, some preconditions, challenges and risks that affect the expected outcome of automation. According to estimates by EY, 30% to 50% of initial RPA implementation projects failed (*Get ready for robots*, 2016). Companies admitted having underestimated the time (63%) and costs (37%) when implementing RPA (The robots are ready, 2018). Possible reasons for that are IT issues, process complexity and unrealistic expectations (*The robots are ready*, 2018). Several elements add to the TCO of RPA. The initial phases of using RPA include the cost of purchasing the software and creating the initial processes. In the longer term (a few years), one needs to be aware of the costs of creating additional and updating the existing automated processes, executing processes, managing and scaling processes and securing and auditing processes (Chappell, 2018). All these costs are related to the implementation approach taken, and the preparations made beforehand.

Process design is one of the key prerequisites for a successful implementation. RPA does not improve processes as such, as the automation operates at the tasks level that creates the processes. Poorly designed processes with unnecessary activities will not be improved because of the automation itself. Automating processes without their prior analysis and review may lead to implementation failures or reduced savings. All the tasks and activities of the process intended for automation should be identified and documented. Aiming at an end-to-end view of the process is advisable, as it makes it possible to learn the possible impacts of the automation on other business functions or processes. The main objective is to obtain a highly detailed list of all the actions an employee performs to complete a particular task. All the workflows and decision paths should be predicted. Process mining methods may prove highly advantageous here, as they enable the discovery of the actual flow of processes (and not the assumed ones) by exploring logs from available information systems (*Process Mining Manifesto*, 2011; Sonnenberg, Brocke, 2014). Process mining is reported to significantly facilitate RPA adoption (Geyer-Klingeberg et al., 2018). All procedures and document formats have to be fully specified; otherwise, robots encountering an unforeseen case or data format will raise exceptions that need to be handled manually (see Figure 1.). To achieve the expected efficiency gains, the exception ratio has to be low. The analysis is an opportunity to gain a deep insight into processes and find inconsistencies and inefficiencies within them. Questioning the relevance of the process or its elements, followed by a potential redesign, should enable their standardisation and optimisation (*Reshaping the future*, 2018).

In many cases, the existing process documentation is incomplete or outdated, and the actual approach of employees to a particular task is not formalised in any way. Even well-documented processes are subject to slight differences when performed across countries or business units (*The robots are ready*, 2018). Some rules or steps might not have been reviewed for a long time; they may not match the current business environment and can be safely removed. Additionally, some steps that have been deemed to require judgement can be modified to use prescribed rules. Furthermore, steps that improve efficiency or which are value-adding can be added or restored if they had been previously removed due to a lack of time or workforce (when handled manually).

The review increases the overall RPA implementation time and cost, but the return on investment can be higher when compared to introducing automation of the processes as they are (Davenport, Brain, 2018). Another advantage (a positive side effect) is the need to collaborate with other departments, which can motivate employees to think in a more integrated way (instead of the silo approach). Finally, even when subsequent RPA trials fail and a company cancels the implementation, it will still take advantage of the reviewed and optimised processes (Edlich, Sohoni, 2017).

The valid process design and its detailed documentation are key success factors for automation. There are, however, other challenges and risks to consider before RPA implementation. The main issues mentioned by the RPA adopters are:

- Operational risk – a single robot can replace multiple full-time employees, which causes additional operational risk concentration. Overlooked process design faults result in unforeseen cases and processing errors. Fast-paced automated robots can magnify the inefficiency (Tucker, 2017). Moreover, removing bottlenecks does not necessarily translate into optimisation, as they may be just moved further down or up the process (*Internal Controls*, 2018). It is recommended to start introducing automation with low to medium complexity processes through pilot projects. The decision to automate should be initiated and driven by interested and knowledgeable business units (accounting, finance, human resources) and not by the IT department (*Accountancy Futures*, 2018). It is equally essential to understand that robotic automation of the whole process is not always justified (it may be too complex, costly or time-consuming). Companies need to remember that RPA is not a replacement for dedicated, fully-automated systems;

- Financial and regulatory risk – insufficiently tested and invalid algorithms used by robots may lead to financial losses (e.g. registering improper transactions, overdue payments) and impact the integrity, validity and accuracy of internal and external financial reporting. Currently, there are no regulatory standards for automated bots, which may result in robots inadvertently violating laws (*Internal Controls*, 2018);
- Organisational and cultural aspects – cultural impacts of automation are yet to be explored. Robots replacing human employees is likely to decrease staff morale. Alternatively, employees can display excessive optimism after a short period of training and successful trials of automating simple processes, whereas configuring resilient and scalable automated processes requires significantly more training and coaching. A shortage of candidates with skills and experience in RPA is another challenge (*Embracing robotic*, 2018);
- Technology selection – robots, especially deployed at scale, may negatively impact a company's IT infrastructure. A detailed review of the IT infrastructure and preparation (usually a setup of virtual environments) are crucial (*Get ready for robots*, 2016). The robots' capacity has to be estimated in advance. Failover servers and sufficient storage should be secured for a backup plan. The IT department's support is crucial here. There are different types of RPA (the basic attended approach and the advanced unattended enterprise-level solution) and multiple vendors. The decision to choose a particular tool should be preceded by a thorough analysis of its features and of one or more pilot or proof-of-concept projects (*Successful implementation*, 2017);
- Governance – existing controls should be reviewed and enhanced if necessary, before introducing robotic employees. Bots should be configured to raise exceptions and report errors to allow human employees to take corrective actions. A lack of proper control over bots may induce reputational risk. Ownership and responsibility for running robots should be clearly defined (*Successful implementation*, 2017). There needs to be a cross-department understanding of the roles on the IT side (developers, support) and end-users from other teams (e.g. accounting, HR, finance) (Gotthardt et al., 2019). Robots, like humans, require adequate oversight and control, especially when processes change or new ones are created (Internal Controls, 2018). Additional resources should also be allocated to robot maintenance, updates and security protocols. The underlying platforms tend to change, and robot configuration may require adjustments, which adds new tasks for the IT department;

- Cybersecurity – RPA (also enhanced by AI) requires that previously manual actions be transformed into their digital equivalents. As a result, the business logic is accessible via digital channels and thus potentially exposed to hackers. Gotthardt (2019) notes that intelligent robots can also be employed to hack or crack.

The challenges mentioned do not undermine the advantages of RPA as a technology. Shifting large amounts of human tasks to high-performance robots is a disruptive, transformational change and its impact and scope can be considerable. Automation can be applied in multiple parts of a value chain and influence many employees' work. Therefore, RPA implementation requires proper preparation of infrastructure, processes and governance mechanisms. Mistakes or shortcuts taken at that stage result in failures to meet the expected automation outcome (*Successful implementation*, 2017). That dependency demonstrates areas where human will remain irreplaceable, as the responsibility for the organisation of processes (whether automated or not) still lies with them.

4. The impact of robotic automation on accounting

4.1. Performance impact

As new automation technologies have appeared in accounting departments, researchers studied their impacts and consequences at organisational and individual levels. All successive automation solutions (early computer accounting software, computer networks, ERP, AI, RPA) appeared to steadily reduce the burden and costs of monotonous tasks, improve accuracy, and save time thanks to faster processing (Carlson, 1957; Wilson, Sangster, 1992; Ghasemi et al., 2011; Kanellou, Spathis, 2013; Kokina, Davenport, 2017; Marshall, Lambert, 2018). Much attention has been dedicated to studying the impacts of ERP systems. Researchers mostly observed positive relationships between ERP implementation and operational efficiencies (Matolcsy et al., 2005; Nicolaou, Bhattacharya, 2008; Chen et al., 2012; Kanellou, Spathis, 2013), although barriers and challenges (financial, organisational and technical) have been recognised as well (e.g. Saatçıoğlu, 2009; Arnold, 2006). Since the introduction of computers, the applicability, benefits and drawbacks of artificial intelligence in accounting (especially in auditing) have been studied (McCarthy, Outslay, 1989; Baldwin et al., 2006; Meservy et al., 1992; Kokina, Davenport, 2017; Sutton et al., 2016; Omoteso, 2012; Issa et al., 2016; Moll, Yigitbasioglu, 2019). The evidence and conclusions on the performance impacts of AI in accounting are not unequivocal. AI might introduce more unintended effects (compared to other automation solutions based on rules), which relate mainly to cognitive biases (e.g. Whitecotton, 1996; Schneider et al., 2015; Arnold et al., 2004).

The concept of software robots replacing accountants has been discussed for a long time now. However, only recently has it become both technically and economically viable. The literature on RPA in accounting and its impacts on the profession seems to grow slowly compared to research on other technologies. Most publications by accounting experts focus on explaining the general concept and principles of the solution (e.g. Yedavalli, 2018; Appelbaum, Nehmer, 2017; Parcells, 2016; Tucker, 2017). A. Asatiani and E. Penttinen (2016) and L. Willcocks et al. (2017) presented teaching cases focussing on the technical and practical aspects of RPA implementation.

There are several in-depth studies that investigated the actual cases of RPA adopters, where a reduction of work, and time-saving and performance improvements have been observed (Fernandez, Aman, 2018; Lacity, Willcocks, 2016; Lacity et al., 2015; Cohen et al., 2019; Cooper, 2019). M. Gotthard (2019) conducted interviews with accounting professionals to explore the societal and technical contexts of RPA implementation, with a focus on its practical aspects. The articles mentioned delivered invaluable insight into the nuances of RPA implementations and shed light on the issues and risks to avoid. Automation limits are yet to be explored. Is there a degree of automation which, when reached, can bring more negative than positive effects? For instance, time savings should be confronted with the frequency of human interventions. More empirical studies on the nature of automated processes would be recommended. The research should identify key factors (e.g. complexity, scalability, update frequency) that allow ordering processes by their cost-benefit ratios.

The case studies mentioned were mainly limited in scope (industry, regional) and covered multiple advantages of employing software robots as accountants. Many of them applied the qualitative approach (interviews). The quantitative analysis of benefits versus costs of RPA implementation and its operation could be valuable. Further studies are needed to provide a comprehensive view of RPA's TCO elements to investigate one-time costs of automation development and the ongoing costs of change and management. Next, the relationships between costs and different variables defined by the approach to RPA should be analysed. These could include RPA type (e.g. attended or unattended), software/hardware choices, the fact of engaging external consultancy or full reliance on own IT teams, decentralised or centralised management of robots. The ability to examine the TCO requires long-term observation. Additionally, a longitudinal study is recommended to confront selected efficiency parameters before and after the RPA deployment. Gotthardt (2019) noted that robots may entail employment increases in compliance and security, which needs to be taken into account when assessing the efficiency impacts. Parameters to watch could include financial (ROA, ROI, ROS) and non-financial ones (e.g. headcount reductions, employee productivity, increases in employee satisfaction, changes in processing times, changes in client-satisfaction measures). The impact of the size of the organisation on the economic viability of RPA implementation should be investigated. ERP systems have been mainly targeted at bigger organisations. The question remains if RPA is suitable for SMEs or is it justified when launched at scale (big corporations, shared services centres).

4.2. Labour market transformation

There is an expectation that most of today's jobs will be affected (eliminated, redefined or new ones created) by the introduction of digital employees (Frey, Osborne, 2017). Six out of ten current occupations are estimated to have at least 30% of activities that could be automated and about half of the current work activities have the technical potential to be automated. The McKinsey Institute estimates that the actual proportion of tasks that will be displaced by automata by 2030 is around 15%, which translates into 400 million full-time equivalents globally (*Jobs lost*, 2017). The study on OECD countries has shown that 56% of jobs are susceptible to significant changes in the way they are carried out due to automation (Nedelkoska, Quintini, 2018). In the finance and insurance sector, 43% of jobs will potentially be automated (*Jobs lost*, 2017). According to a study by the World Economic Forum, jobs expected to be increasingly less in demand are routine-based, middle-skilled, white-collar roles, including data entry clerks, accounting and payroll clerks, and auditors (*The Future of Jobs*, 2018). Surveys by ACCA and McKinsey showed that more than half of the employees questioned were aware that some entry-level accounting jobs would not be performed by humans any more (Kokina, Davenport, 2017; *Accountancy Futures*, 2018; *Jobs lost*, 2017). Some isolated opinions even suggest that human may be perceived as an impediment to the growth of the accounting industry (Tschakert et al., 2016).

Predictions about automata taking over human tasks or replacing whole positions may seem alarming, and the change in the work process may increase employees' reluctance to learn new technologies and create technology acceptance issues (Fernandez, Aman, 2018; Gotthardt et al., 2019). However, surveys show that the actual resistance to automation and innovation is not significant (*Professional accountants*, 2016). Nonetheless, research on the issue is not extensive yet, and some recent studies point at real challenges posed by RPA implementation. Employees are afraid that RPA will weaken their positions (Gotthardt et al., 2019), while clients are reluctant to adopt it because of data protection and transparency issues (Cooper et al., 2018).

The overall impact of RPA is seen as positive, and technology advancement is regarded as an opportunity rather than a threat (*Professional accountants*, 2016). However, robots taking over complete accountant roles requires further research. So far, humans have needed to compete with each other for jobs; now they may need to compete with robots. D. Kedziora and H.-M. Kiviranta (2018) suggest this fear materialises if employees are not properly engaged and made aware of RPA implementation. Employees who previously performed manual and repetitive tasks and who are now responsible for implementing, managing and controlling robots find their job more satisfying and their doubts and resistance to innovation decrease (*The robots are ready*, 2018). D. Fernandez and A. Aman (2018) imply that people cannot be completely replaced by robots, yet the reduction of jobs is inevitable, so employees' fears seem justified to some extent (Spencer, 2018). P.R. Daugherty and H.J. Wilson (2018) think the man-versus-machine view is old-fashioned and short-sighted, and more attention should be paid to human-machine collaboration. Robots are not substitutes for humans but resources. They serve as digital or virtual assistants that will support humans in mundane and routine activities that might otherwise remain undone. With AI now automating unstructured accounting tasks, researchers perceive it as an opportunity for synergy and to receive support in decision making rather than only replacing humans (Marshall, Lambert, 2018; Kokina, Davenport, 2017). Robots may replace some human positions, but they will not replace the tasks and processes themselves, and their design and configuration are still the domain of humans as these activities still require judgement (Kathmann, 2017).

4.3. Future accounting roles

The transformation of the future accountants' work scope will be mainly shaped by two key factors: collaboration and coexistence with automata and the released time for employees. Those phenomena could be observed immediately after the introduction of computers in accounting (Wilson, Sangster, 1992). Their intensity (enabled by technology advancements) has been increasing ever since.

The major areas of accounting activities include keeping track of day-to-day transactions and preparing financial reports. Accordingly, transactions need to be processed and recorded to produce accurate financial reports afterwards. Most of these operations, once their rules and workflows are well-known and documented, are repetitive and predictable, and thus automatable.

However, those rules and workflows have to be thoroughly designed to comply with accounting standards and audit requirements. An accountant's biggest asset is his/her professional expertise. Applying IFRS/GAAP, income tax/VAT regulations, and listed companies disclosure obligations needs interpretation and requires experience which has been accumulated over the years. Regulations are subject to frequent changes, and their volume and complexity are growing (Chychyla et al., 2019). Accounting and financial reporting standards require accountants to exercise professional judgement, and make assumptions and estimates (e.g. with valuation models, impairment or provisions measurement). Shifting predictable accounting tasks to robots allows accountants to focus more on a detailed analysis of the scope of regulations and the impact they have on accounting operations and financial reporting. The proportion of employees' time spent on routine tasks and those requiring judgment and discernment will reverse, and thus, time will be used more productively.

The released time can be spent on acquiring new skills and higher value-added activities. Workload related to traditional data input and compilation has decreased since the introduction of computers. The decrease progressed through the introduction of ERPs, and now because of robotisation. The transformational effect on the accountant's role was recognised after the implementation of cross-functional integrated ERPs. The position of accountants was raised to information providers and analysts (Desormeaux, 1998; Scapens, 1998). If robots are to automate another part of the accounting work, accountants could use the released time to turn themselves into strategic business advisers, fraud and compliance experts, or technology or RPA leaders (Parcells, 2016;

The Future of Talent, 2017). The centre of their activity will shift from accounting operations, audits and preparing reports and statements towards data analysis and interpretation, leading to more informed decision making. The amount of data generated by robots and automata will require proficiency in extracting the essential relationships and facts, describing their context and the ability to concisely present the findings (McKinney, 2017; Borthick, Pennington, 2017). Finance teams are expected to devote much more time to decision support, predictive analytics and performance management (Axson, 2015). There will be more opportunities to gain informative insights and draw valuable conclusions out of the data, which accountants already are well prepared for, but they had to use to most of their time to prepare the data (Richins et al., 2017). The accountants could, to some extent, work as data scientists, which will require both core accounting expertise and a theoretical and practical understanding of data and analytics (Warren et al., 2015).

Accountants have a natural competitive advantage compared to other professionals as they understand the interrelationships between different business segments (Howieson, 2003). They realise how data build financial statements and how they relate to strategy (Richins, 2017). To act as business advisors, they will need to intensify cooperation with different corporate functions and departments. Therefore, good communication and collaboration skills will be increasingly sought-after. The cooperation will offer the opportunity to abandon the silo approach and enable an integrated one. There are estimates that most traditional financial services will be delivered by cross-functional teams, and their activity will go beyond accounting and transaction processing (Axson, 2015).

Robots can take over repetitive and predictable operations, but they need to be previously trained and tested. Accountants can take advantage of their knowledge to prepare, monitor, and optimise robots operation and act as RPA consultants or managers (Kokina, Davenport, 2017). The employees that used to perform the tasks are the best source of expertise and have a perfect understanding of all the nuances of the tasks or processes to be automated (*Embracing robotic automation,* 2018).

Their responsibilities could include designing step-by-step instructions that follow business rules, and which are then used to configure or train robots. Every time regulations or business requirements change, the robots will need to be retrained and retested (Robotic process automation, 2015). Audit and compliance protocols for automated processes have to be implemented, as well. The robots already in operation need to be supervised (usually in a centralised way). Employees will need to intervene manually in cases triggering exceptions that stop robots from completing their tasks. Non-technical anomalies (e.g. fraud related) could also require an in-depth analysis (Appelbaum, Nehmer, 2017). Humans are responsible for assigning tasks and governing processes in terms of priorities and the available robot capacity. Task completion and audit logs have to be verified and monitored. In addition, employees must track the robots' performance and collect feedback from other departments to identify bottlenecks and spaces for process optimisation. These observations are useful during periodic reviews of robot algorithms (*Internal Controls*, 2018).

The new roles (and those which do not yet exist) of the future accountant, combined with the presence of co-working robots, may result in changes in the organisational structure. Automation solutions have been found to produce various social effects. D. Desormeaux (1998) found that ERP implementation raised the accountants' role, while V. Arnold (2006) pointed to the unexpected impact they have on the role of managerial accountants. Now, the change in the structure may be a derivative of the degree to which the robots blend into human teams and whether they act as assistants rather than competitors. A question arises if the organisational structure becomes flatter, as observed after ERP implementation (Davenport, 1998). Further research is also needed to investigate the effects of human-robot collaborations and potential consequences on employee motivation and satisfaction. The research could explore those areas from the perspectives of regular accountants, managers, and IT professionals.

Future accountants will be responsible for three major areas. Firstly, some will handle the core accounting but with the focus shifted from recording transactions towards the application and interpretation of accounting and reporting standards. Secondly, they will use their knowledge and problem-solving skills in cross-functional teams to deliver strategic advice. Finally, their expertise will be crucial by managing robots and implementing other emerging automation solutions for accounting tasks.

4.4. Future accountants' skills

The ever-increasing adoption of technology performing lower-order processing work is predicted to shift employees' resources to more complex and higher-value tasks (Millman, Hartwick, 1987). The low-skill tasks may eventually be completely taken over by robots. Thus, the work of an accountant will need to go beyond bookkeeping and reporting towards activities that require interpretation, judgement or evaluation (Parcells, 2016). There is a threat that finance departments will need fewer but highly skilled members (Tucker, 2017). Employees will need to focus more on continuously acquiring new skills and improving those they already possess. The World Economic Forum predicts that by 2022, the demand for basic technical skills and the management of financial and material resources will continue to decline. In the financial services and investors sector, around 40% of the skills currently needed to perform well in the profession may become redundant. On the other hand, the need for innovative problem solving, communication, active learning and learning strategies, and creativity is expected to grow (Howieson, 2003; *The Future of Jobs,* 2018).

In the era of ERP and information systems, it was anticipated that accountants would display a blend of information technology/information management skills with mainstream accounting knowledge (Ahmed 2003). However, future accounting professionals will be increasingly expected to develop soft skills (apart from technical and data expertise) that discern humans from automata. A survey among accounting employees pointed at communication and collaboration to be the most important skill (*The Future of Talent*, 2017). ACCA emphasises that emotional intelligence (understood as identifying, regulating and managing one's own emotions and those of others) will be vital, as artificial intelligence will take over the tasks requiring memorisation and logic (*Accountancy Futures*, 2018). Modern accountants will need to demonstrate creativity, which historically was usually not associated with the profession. Using existing knowledge to find new solutions will be essential in the fast transforming business environment. Soft skills and emotional competencies will be crucial to cope with the disruption and to manage the accelerating change. Additionally, those skills are less likely to be replaced by technology, and that is where humans will still have the advantage over machines.

At the same time, the ability to work with data and the latest technology will become indispensable (Huerta, Jensen, 2017). Employees will have to continuously adapt their skillset and competencies to apply emerging technologies into existing processes effectively (Arrowsmith, 2018). Accountants have long been expected to extend their skills beyond using various types of software towards elements of computer science: database design and programming (Kaye and Nicholson, 1992), system evaluation in terms of its requirements, performance and implementation (Heagy, Gallun, 1994; Kutsikos, Bekiaris, 2007). Programming skills empower logical thinking. Together with system design competencies, they become of great value on the ever-growing RPA market. A relevant advantage of the skills mentioned is their easy transferability across roles and industries.

In terms of knowledge transfer and skills, the robotisation of accounting tasks may pose a serious challenge. Successive waves of new technologies employed in accounting departments have increased the importance of transparency. As more and more accounting operations are done digitally, employees may find it hard to properly understand their workflows. Accounting departments are witnessing a multi-layered environment with ERPs, other interlinked systems, and individual employees' spreadsheets. On top of that, the newly adopted robots will work using all those systems and operate parallel to humans. Sutton (2000) raised the issue of transparency in the context of ERPs, yet the advent of intelligent software robots seem to make it even more important for the profession. As long as ERP or RPA automation is limited to procedural, rules-based solutions an employee should be able to track down the details of every operation and understand the relationships between inputs and outputs (Kokina, Davenport, 2017). However, if robots are enhanced through AI and offer intelligent process automation, accountants may find it impossible to decipher a so-called "black box", which describes a system where the internal workings are hidden from the user.

The automation of repetitive and low-skill tasks is likely to eliminate entry-level accounting positions, which deprives profession entrants of an opportunity to learn (Kokina, Davenport, 2017). And accountants are expected to take advantage of their broad expertise and offer more data interpretation, advisory services and judgement. These two may thus stand in contradiction. Accountants' expertise is acquired over time. Now, when many tasks have been shifted to robots, it may be challenging for new employees to understand the way business operates in detail, which is fundamental if they are to expand their knowledge to offer strategic advice. RPA increases the risk of deskilling (Tucker, 2017). V. Arnold and S.G. Sutton (1998) pointed at the Theory of Technology Dominance, which posits that the reliance on intelligent systems has a negative effect on building expertise as well as decision-making, especially in the early years of an accountant's career. Low experience employees fail to learn from the systems, and the experienced ones lose confidence and/or skills (Sutton et al., 2018; Sutton et al., 2008). C. Dowling et al. (2008) and I. Stuart and D. Prawitt (2012) presented findings in line with this theory. The deskilling effect poses a threat that, over time, users become low expertise users and have to rely on systems (Sutton et al., 2018).

As new, more advanced technologies are applied, further research is needed to examine the degree of opacity and the deskilling effect introduced by intelligent robots taking over more and more accounting tasks. The research could recommend approaches to counteract it (in terms of system design, implementation and operation). Experts on AI, cognitive computing, RPA and behavioural aspects of knowledge management could provide guidelines and best practices on system design that would promote skills and knowledge development. Alternatively, as S.G. Sutton et al. (2018) suggest, studies could be directed at rethinking the definition of expertise, which probably should not be demonstrated solely by the human brain but which would result from close collaboration with intelligent automata.

4.5. Accounting education

The requirement for accountants to possess new skills implies a transformation of the education model, which has been acknowledged by academics and business for a long time now (Ellis, 1986; Kaye, Nicholson, 1992; Ahmed, 2003). There have been several research attempts to develop a competency framework that will address contemporary business needs (Damasiotis, 2015). Although the necessity to update curricula is commonly recognised by educators, several studies have concluded that education has failed to properly address the issue (Ahmed, 2003, Chang, Hwang, 2003; Tschakert et al., 2016; Kruskopf et al., 2019). The lack of necessary technology and data analytics skills displayed by graduates is mostly evident in environments with a high adoption of RPA and AI (Zhang et al., 2018). The need to further integrate technology-related skills with professional skills was recently highlighted by IFAC in the updated educational standards (Handbook of International, 2017, International Education Standard, 2018). ACCA, AICPA, CIMA have updated their certification programmes to cover topics on human intelligence, data analytics, cybersecurity, blockchain, RPA and strategic thinking[1].

[1] In 2018, ACCA replaced the previous certification "Professional level" with "Strategic professional" (as the highest qualification level), https://www.accaglobal.com/russia/en/student/changes-to-exams1/professional-level.html). The updated learning materials by AICPA, CGMA can be found at: https://certificates.aicpastore.com/#explore-all, https://www.cgmastore.com/products/disruption, https://www.aicpa-cima.com/disruption.html.

The increasing adoption rate of robotics and AI calls for more research on the accounting education model. If repetitive and low-skill tasks are to be performed by robots, the methods of training and education should acknowledge that. The question is whether and to what degree content on traditional bookkeeping should be reduced. It poses a real challenge in terms of the aforementioned deskilling effect of automation. A. Güney (2014) suggests the focus should be put more on evaluating information and interpreting and taking advantages of information and communication technologies. Undoubtedly, the profession needs further research on the education process to offer guidelines on the optimum structure of accounting courses, balancing accounting and technology knowledge.

Conclusion

The article explored multiple ways RPA transforms contemporary accounting to address the first objective of the paper. Automation solutions have been present for a long time now, but it is only RPA that has made automation widely affordable and applicable at scale. The evolution progresses at the organisational and individual levels. RPA offers faster processing, improved accuracy, lower costs, and it reduces the burden of monotonous, repetitive and predictable (mainly transactional accounting) tasks. Future accountants have the opportunity to focus on more complex tasks. RPA will entail the creation of new roles for accountants, and it will simultaneously result in the disappearance of other (mainly entry-level) positions. Accountants will be able to focus on using their expertise to make professional judgements, interpret financial data, and put it in context across the whole value chain. Their activity is expected to go beyond traditional bookkeeping and preparing financial reports and will involve strategic business advice and leading the RPA transformation. To retain the advantage over robotic employees, accountants will need to improve the skills that machines are less likely to develop. Communication and collaboration skills, emotional intelligence along with critical thinking and complex problem-solving will be in high demand.

Robots bring a paradigm shift to the relationship between accountant and technology. Machines are no longer merely tools; they are able to completely replace some human roles and tasks. RPA will be increasingly integrated with cognitive platforms and be transformed into intelligent process automation (Sackett, 2017). Artificial intelligence, self-optimisation and self-learning will enable robots to solve more sophisticated problems and make complex decisions. Computers can already recognise images and handwriting and, most importantly, they can learn from experience. Robots will not only be able to mimic human actions but also improve their performance and accuracy over time. The significance and the challenges of the new human-machine interaction will be even more pronounced when natural language recognition and processing become highly reliable and universal (Chui et al., 2016). The technical potential of automation will continue to increase.

The disruptive nature of innovative technologies (RPA, AI, cloud, blockchain) results in uncertainty about the overall impact they have. That is usually only observable in the long term. To meet the second objective of the paper, previous studies on RPA has been reviewed to suggest future research directions. Actual performance gains have to be further investigated to account for unpredicted costs/expenditures and non-financial factors. The limits and barriers of automation need to be explored, as well. The consequences of human-machine collaboration should be examined to develop methods to counter the potential negative effects (human-robot competition, unintended organisational structure changes, deskilling and building expertise, knowledge management, knowledge biases). New roles and skills require further research on the accounting education model and methods to implement its change, as prior attempts to change it have not been successful.

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