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The Future of Accountants – Emerging Technologies in Accounting

Ana Maria Ferreira

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Ana Maria Alves de Assunção Ferreira

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Emerging Technologies in Accounting

Coimbra, Outubro de 2023

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The Future of Accountants
Emerging Technologies in Accounting

Dissertation submitted to the Higher Institute of Accounting and Administration of Coimbra to fulfil the requirements for obtaining a **master's degree in Management Information Systems**, conducted under the supervision of Professor Isabel Maria Mendes Pedrosa and co-supervision by Professor Miklos A. Vasarhelyi, Rutgers Business School, USA.

Coimbra, October de 2023

STATEMENT OF RESPONSIBILITY

Declare that I am the author of this Dissertation, which is an original and unpublished work, which has never been submitted to another Higher Education Institution to obtain an academic degree or other qualification. I further certify that all citations are properly identified and that I am aware that plagiarism is a serious lack of ethics, which could result in the annulment of this dissertation.

" *The future depends on what we do in the present.*

— Mahatma Gandhi

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Completing this project is the ultimate achievement after two years of hard work, dedication, and personal growth.

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To my daughters, for their patience and love, to whom I dedicate this work.

ABSTRACT

Emerging technologies are changing the accounting paradigm. “It has always been done this way” will certainly be an old expression that will become outdated. More than ever, accountants need to acquire transversal skills to be successful. Technology with a purpose in accounting improves reliability, accuracy and adds value.

An important topic in the current conjuncture, this study aims to present and analyze the impacts of emerging technologies on the accounting profession through an exploratory study and interviews with accounting professionals.

The results of the interviews revealed that the relationship between emerging technologies and the role and skills of accountants has not yet been established. This work identifies the skills that accountants must have to be successful, the new professions that will emerge associated with accounting, and activities that can be automated, considering a guide to good practices to make the accountant's work more effective.

The insights presented in this study are highly valuable for those involved in the accounting profession, including professional bodies, regulators, and educational institutions. Researching emerging technologies in the context of accounting may yield valuable knowledge that could inform future modifications to university curricula and instructional approaches for accounting educators.

Keywords: Emerging Technologies; Robotic Process Automation; Accountant; Accounting Education; Skills; Artificial intelligence; Automation; Big Data; Blockchain.

RESUMO

As tecnologias emergentes estão a mudar o paradigma da contabilidade. "Sempre foi feito assim" será certamente uma expressão antiga que ficará ultrapassada. Mais do que nunca, os contabilistas precisam de adquirir competências transversais para serem bem-sucedidos. A tecnologia com um propósito na contabilidade melhora a fiabilidade, o rigor e acrescenta valor.

Tema importante na atual conjuntura, este estudo pretende apresentar e analisar os impactos das tecnologias emergentes na profissão de contabilista através de um estudo exploratório e através de entrevistas com profissionais de contabilidade.

Os resultados das entrevistas mostram que a relação entre as tecnologias emergentes, o papel e as competências dos contabilistas ainda não foi estabelecida. Este trabalho identifica as competências que os contabilistas devem ter para serem bem-sucedidos, as novas profissões que vão surgir associadas à contabilidade e atividades que podem ser automatizadas, considerando-se um guia de boas práticas para tornar o trabalho do contabilista mais eficaz.

As conclusões apresentadas neste estudo possuem um grande valor para aqueles envolvidos na profissão de contabilidade, incluindo órgãos profissionais, reguladores e instituições de ensino. A pesquisa de tecnologias emergentes no contexto da contabilidade pode produzir conhecimentos valiosos que podem potencialmente informar futuras modificações nos currículos universitários e abordagens instrucionais para formadores de contabilidade.

Palavras-chave: Tecnologias Emergentes; *Robotic Process Automation*; Contabilista; Educação em Contabilidade; Competências; Inteligência artificial; Automação; *Big Data*; *Blockchain*.

INDEX

INTRODUCTION 1

1 LITERATURE REVIEW 5

1.1 Framework of the Accounting Profession 5

1.2 Overview of Emerging Technologies in Accounting 9

1.2.1 Artificial Intelligence 13

1.2.2 Big Data 17

1.2.3 Blockchain 19

1.2.4 Cloud Computing 23

1.2.5 Automation 26

1.2.6 Robot Process Automation 27

1.3 Shaping the accountant for the future 32

1.3.1 Importance of Developing Skills 33

1.3.2 Changing Roles of Accountants 36

1.3.3 Ongoing learning and development for accountants 40

2 METHODOLOGY 46

2.1 Research questions and objectives 46

2.2 Research Methodology 47

2.3 Instrument Development and Testing 47

2.4 Data Collection 50

3 ANALYSIS AND DISCUSSION OF RESULTS 55

4 GUIDELINE FOR TECHNOLOGY ADOPTION IN ACCOUNTING TASKS 69

5 CONCLUSIONS 77

5.1 Main Contributions 78

5.2 Limitations 80

5.3 Future Work 80

REFERENCES 82

APPENDICES 89

APPENDIX 1. Informed Consent (EN) 90

APPENDIX 2. Informed Consent (PT) 92

APPENDIX 3. Interview Guiding Script (EN) 94

APPENDIX 4. Interview Guiding Script (PT) 96

APPENDIX 5. Article published in Magazine "*Contabilidade & Empresas"* 98

APPENDIX 6. Certificate of Participation 56th WCARS 99

APPENDIX 7. Paper published in CISTI 2023 100

ANNEXES 101

ANNEX 1. Automated accounting and finance tasks (Kokina & Blanchette, 2019) 102

ANNEX 2. Automated accounting and finance tasks (Kaya, C. T., Türkyılmaz, M., & Birol, 2019) 105

ANNEX 3. RPA implementation example with UiPath (Kokina et al., 2021) 107

FIGURES INDEX

Figure 1 - VOSviewer, Networking Visualization 10

Figure 2 - VOSviewer, Density Visualization 11

Figure 3 - Past vs. Present Models of Communication 24

Figure 4 - What RPA can do 28

Figure 5 - Viability of automation within back-office accounting and finance 30

Figure 6 - Knowledge and skills profile of Accountant 4.0 35

Figure 7 - Accounting information systems model curricula 44

Figure 8 - New accounting and finance professional hybrids 44

Figure 9 - Process of qualitative data analysis 54

Figure 10 - Word Cloud of interviews 68

Figure 11 - An Example of the Process Definition Document (PDD) 72

Figure 12 - 4-stage framework for RPA application 72

Figure 13 - App/Web Recorder Uipath 73

Figure 14 - Notebook function UiPath 74

TABLES INDEX

Table 1 - Co-occurrences by clusters 10

Table 2 - Accounting technology adopted in Korea and other countries. 12

Table 3 - Accounting process possible with combining new technology 12

Table 4 - Selected Applications Based on AI Technologies 15

Table 5 - Differences between ERP and Blockchain 21

Table 6 - Examples of RPA Tax Opportunities 29

Table 7 - Accountants skills now and in the future 36

Table 8 - Roles, related tasks, human and AI-based actors in accounting 37

Table 9 - Tasks and skills of current roles in an AI-based accounting 38

Table 10 - Impact of technology in roles and skills 39

Table 11 - Examples of future accounting job titles 39

Table 12 - Summary Overview of Participants 50

Table 13 - Summary of interview scripts 52

Table 14 - Overview of codes 67

Table 15 - An Example of Process Overview 71

Table 16 - An Example of Process Maturity Assessment Sheet 72

Table 17 - Bot Key Performance Indicators 75

List of abbreviations

ACCA - Association of Chartered Certified Accountants

AI - Artificial Intelligence

AIS - Accounting Information Systems

BI - Business Intelligence

CGMA - Chartered Global Management Accountant

ERP - Enterprise Resource Planning

ET - Emerging Technologies

EY - Ernst & Young

FTP - File Transfer Protocol

IFAC - International Federation of Accountants

ICAEW - Institute of Chartered Accountants in England and Wales

IS - Information Systems

IT - Information Technology

ML - Machine Learning

OCC - *Ordem dos Contabilistas Certificados*

OCR - Optical Character Recognition

PwC - PricewaterhouseCoopers

RPA - Robotic Process Automation

RDP - Remote Desktop Protocol

SMEs - Small and Midsize Enterprises

SOX - Sarbanes-Oxley Act

VAT - Value-added Tax

INTRODUCTION

The accounting of the past, surrounded by big and heavy books, papers, and even more papers, was a picture of passive and "analogic" accounting. Accounting, written in the present and anticipated in the future, is done by active, business-oriented accountants using digital tools. While some experts predict an uncertain future for accountants in a digital world, technologies such as cloud-based data management, robotic process automation (RPA), and advanced analytics present opportunities for accountants. The incorporation of automation and innovative technologies enables accountants to perform tasks more efficiently, and in less time, allowing them to perform more complex and higher value-added tasks.

The impact of technology on accounting is not a new phenomenon. Digitization is taking place, which means active involvement is necessary. As stated by Abad-Segura & González-Zamar (2020) the economy and its accounting underwent a transformation in the 1960s with the introduction of computers that could process large volumes of information at high speeds.

Abad-Segura & González-Zamar (2020) assesses corporate adoption of technology is currently linked to a paradigm shift in which technology is viewed as a complex and interconnected environment on a global scale.

Framework

The impact of current and future technologies is transforming the field of accounting, creating opportunities for new job descriptions and required skills. These fields are rapidly transitioning into the digital age, and there are predictions that in the next five to ten years, many areas in accounting may become completely automated, making human involvement obsolete (Kruskopf et al., 2020). In fact, in 2020, the COVID-19 pandemic accelerated the adoption of technology across industries, and accounting was no exception.

Emerging technologies are not only reshaping the daily lives of people worldwide but also redefining the roles of accountants. The rapid pace of technological progress is making this transformation increasingly evident. Several factors have played a part in

these transformations, such as swift technological advancements, growing globalization, enhanced internet communication, and legal and regulatory reforms (Kroon et al., 2021).

According to Atanasovski & Tocev (2022) in the future, the accountancy profession will continue to be important for companies and organizations in all sectors. With the advancement of technology, it is possible that some routine and repetitive tasks, such as coding accounting entries and compliance with financial reporting standards, will be automated through artificial intelligence (AI) and machine learning (ML) provide predictive analytics for compliance assisting specialists.

Despite the continuous advancement of technology, the role of a trained accountant will remain significant. While automation can assist in the accounting process, accountants will still need to possess analytical thinking and decision-making skills, comprehensive knowledge of accounting and tax regulations, and the ability to effectively communicate complex financial information to various stakeholders. These competencies will continue to make accountants valuable assets to businesses and organizations.

Therefore, in the future, the accountant will need to adapt to technological changes and develop new skills to remain relevant. Furthermore, the need for a reliable and experienced accountant will always exist, as companies will continue to need professionals who can help them make controlled decisions based on accurate and timely financial data. Technology adoption is inevitable, the definition of an accountant needs to be rethought, regarding the skills needed to be a successful accountant.

Motivation for study

An important topic in the current conjuncture, this study intends to determine which emerging technologies (ET) are most studied about their impacts on the role and skills of the accountant. Disruptive technologies in accounting represent a new phase of accounting affected by ET that are part of the industrial revolution 4.0. New accounting technologies have potential to disrupt work but require a revolution in thought to fully realize their potential. According to Kroon et al. (2021) paradigm shifts are necessary to understand new data and ways of working. Atanasovski & Tocev (2022) assesses that researchers and academic scientists must investigate and provide adequate theoretical basis to better help professionals and increase their awareness and confidence in technology.

Goals

The main goal of this study is to research the impact of ET on the work of the accountant and assess the necessary digital skills that Chartered Accountants need to develop, given the new paradigm in accounting, a result of the 4th Industrial Revolution.

Has specific goals:

Identify the ET on accounting

Identify accountants' familiarity with ET

Identify the skills and roles of future accountant

Identify the role of accounting education in the future of the profession

Identify the advantages and disadvantages of emerging technologies in the profession

Identify expectations/concerns in the adoption of ET

Identify tasks/processes that will change by technology adoption

A set of research questions were defined to prove the reality of this phenomenon in view of the problems presented.

Which ET is most often studied in accounting field?

What are the roles and necessary skills for accountants in the organization?

How can accountants improve the quality of their work and leverage the benefits of technology?

Methodology

The aim of this research is to identify disruptive technologies and the consequent impact on the accounting profession and education. The division of research into exploratory, descriptive, and explanatory categories is useful to establish a theoretical framework. To analyze the facts from the empirical point of view, to contrast the theoretical view with reality, it is necessary to elaborate a conceptual and operational model of the study.

Method

Literature review, one of the methods used were documentary research for, with the study of written documents disseminated with similar subjects.

The methodology adopted to respond to the objectives of this study and the research questions formulated, was an exploratory study with a qualitative approach, using semi-structured interviews.

Expected Contributions

With the advent of technology and the growing demand for financial expertise, accounting and finance professionals are in high demand. As the world becomes increasingly digital and data analysis becomes more important, accountants need to become more up to date with the latest software and technology to remain competitive. Additionally, as the global economy changes, accountants need to work more closely with clients to understand their businesses and provide financial guidance and advice. Finally, as companies adopt more socially responsible ways of doing business, accountants need to become more advisors, engaging in the business, sustainability initiatives and the ethical implications of their decisions. Overall, the future of accounting looks bright, with plenty of opportunities for those willing to get ahead.

Work structure

This Master Dissertation is structured as follows. The 1st Chapter is formed by the literature review, a theoretical approach involving the various concepts that make up the theme, analysing similar studies and related work. This topic includes: the framework of the accounting profession, the ET, the importance of skill and roles, and continuous learning. The methodology used is described in the 2nd Chapter. Research questions are addressed, the methodology used, followed by the presentation of method and techniques for data collection, data selection and objectives of the semi-structured interviews. In 3rd Chapter are presented and discussed the results that responded to the research questions posed, all the steps until the construction of the interviews responses results. The adoption of accounting technologies, particularly RPA, is guided in 4th Chapter, which is based on literature and interviews. Finally, the conclusion of the study is presented, potential limitations that may have existed and offering suggestions for future research.

1 LITERATURE REVIEW

In recent years, accounting has undergone substantial evolution. Within this context, the impact of technology on shaping the new perspective and advancement of accountants is clearly evident. Therefore, it is imperative to be aware that in addition to the technical skills, it is essential to acquire Information Technology (IT) skills, to develop the activity of Chartered Accountant efficiently. The accountants, when qualified also based on the most innovative technology, they will certainly be better prepared. It is so important to review the literature on the evolution of accounting, the framework of the accounting profession in Portugal, identify ET and understand the profile and skills of the accountant in the digital age.

> *"It is important to develop an in-depth understanding of the new emerging roles in the changing landscape of accounting work in order for the profession to engage in appropriate digital upskilling efforts"* (Kokina et al., 2021, p.3)

1.1 Framework of the Accounting Profession

Accounting has existed since the dawn of human civilization and is linked to the economic development and the sociopolitical and sociocultural transformations of each era. As a business language, accounting was first established by Luca Pacioli in 1494 (Y. Zhang et al., 2020), the father of the double-entry bookkeeping system. Its main functions are to measure the economic activities of an organization and to communicate this information to interested parties, such as such as company managers, vendors, costumers, and regulators (Y. Zhang et al., 2020).

The business environment where the accounting professional works has suffered significant changes in recent decades due to industrial revolutions (Kroon et al., 2021). The aftermath of the 2008 financial crisis has introduced new expectations for accountants, including the need for management support and advanced technological solutions. Nevertheless, it is critical not to overlook the ongoing challenges that come with the more traditional responsibilities of accounting. To develop efficient solutions that meet the demands of the field, it is necessary to address both the new and traditional responsibilities (Belfo & Trigo, 2013).

"Bookkeepers", "number crunchers", "spreadsheet slaves", are names that correspond to the stereotype that accountants have in society in general, a gray and boring profession. However, these professionals should be images of the past, as the accounting profession is undergoing a data-driven revolution that will forever change the role of accountants and the future landscape of the sector (Peace, 2021). The field of accounting is on the verge of significant changes due to ET. While these changes may create disruptions, they also offer numerous opportunities for the profession. The primary concern is how the profession will adapt to these changes and how skills needed in the field will transform (Kroon et al., 2021).

As we move towards the peak of the information economy, it is crucial for the accounting profession to understand the shift towards information professionals and their peak usefulness. There is a risk that accountants may become less important or even marginalized in the provision of business information services. Therefore, it is essential for accountants to adapt to these changes to remain relevant and valuable in the industry (Sangster, 2022).

A technological evolution has transformed day-to-day life, simplifying work, streamlining processes, and automating procedures, and requiring them to radical change in the exercise of their functions, as well as a quick ability to adapt (Cristina et al., 2019). The accounting profession is changing from less emphasis on recording operations to more involvement in management support and decision-making (Almeida & Carvalho, 2020).

Carnegie et al. (2021) argue that accounting is more influential than people generally think and that the full potential of accounting as a technical, moral, and social practice is yet to be realized, calling for studies that enhance this new definition of accounting in order to create a world that is more consistent with the perspective of balance between people, profit and the planet.

> *"Accounting is a technical, social and moral practice concerned with the sustainable utilisation of resources and proper accountability to stakeholders to enable the flourishing of organisations, people and nature*" (Carnegie et al., 2021, p.69).

The accountancy profession in Portugal has enjoyed a great boost and recognition, especially since the 90s. However, the road to this point has not been easy.

The regulator body in Portugal is the *Ordem dos Contabilistas Certificados* (OCC), which places responsibility for the initial training of prospective accountants on higher education institutions. Referring to the standards of the International Federation of Accountants (IFAC), the OCC defines areas in which accountants should develop during their apprenticeship, based on which higher education institutions create their Curriculum. These IFAC standards were recently revised, and technical components were added. However, in the newly updated Profile for Accountants, the OCC defines dominant areas, such as financial accounting, taxation, management accounting and ethics and deontology that enter the profession, without reference to IT (Almeida & Carvalho, 2020).

The financial reporting requirements in Portugal include the preparation of annual financial statements, which consist of the balance sheet, income statement, statement of cash flows, and other reports. These statements must be prepared in accordance with the applicable accounting standards and provide a true and fair view of the entity's financial position and performance.

Professional accountants in Portugal play a vital role in ensuring the accuracy and reliability of financial information. They are responsible for recording and classifying financial transactions, preparing financial statements, and providing financial analysis and advice. The profession of accountant is of great responsibility, it is perhaps one of the most demanding professions from the point of view of knowledge and updating, however in Portugal it is not highly valued. Most of Portuguese companies are Small and Midsize Enterprises (SMEs), which has an impact on the work of the accountant, on the diversity of clients, on the rapid changes and tax changes, on the role in the financial literacy of SMEs owners, many of them family members or small entrepreneurs. And in turn, the profile of the accountant in Portugal is essentially the Chartered Accountant who performs the compliance from A to Z, from the function of the bookkeeper to the person responsible for tax reporting.

In recent years, the OCC has actively responded to the challenges of technology in accounting, recognizing the importance of digitization and automation in the accounting

profession. However, the OCC only requires the development of skills in three areas in common with higher education institutions, as mentioned above, emphasizing the development of technical skills, not specifically contemplating IT.

Paula Franco, the chairwoman of the OCC stated in a webinar on technology in 2022 that the multiplicity of tasks, very administrative and not very challenging, make the accountant's career not very interesting. To be a successful Chartered Accountant, it is necessary to minimize tasks that do not add value. Technology is extremely important in helping the business to offload paper-based and routine tasks, use and dematerialize IT mechanisms.

Until 2022, there was a lack of technology-focused training for accountants in Portugal. However, there have been some small steps towards offering online training on digital tools. Despite these improvements, there are still challenges that the accounting profession in Portugal needs to address. These include enhancing the quality of financial reporting, bridging the skills gap among accountants, and adapting to emerging digitalization and data analytics trends.

1.2 Overview of Emerging Technologies in Accounting

The aim of this research is to identify trends in ET and their consequent impact on the accounting profession and education. The division of research into exploratory, descriptive and explanatory categories is useful to establish a theoretical framework. To analyze the facts from the empirical point of view, to contrast the theoretical view with reality, it is necessary to elaborate a conceptual and operational model of the study.

To this was conducted a detailed bibliometric study, as explained in the following paragraph.

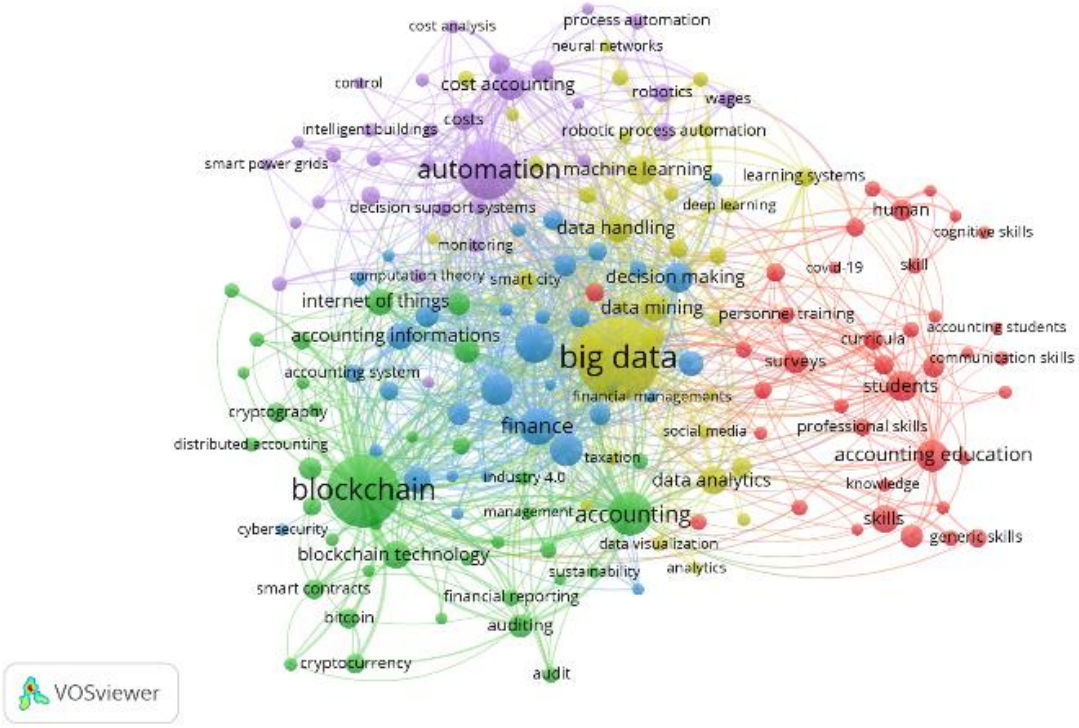
The collection of articles related to the topic to be analysed was done, according to their quantity, quality, and citations in the Scopus database, which ensures the value of the collected articles. According to the keywords identified by Kroon et al. (Kroon et al., 2021) in the systematic review were defined to link accountants or accounting with ET. To expand the research field of new technologies, were included terms marked with the help of the Boolean operator AND OR, to ensure the inclusion at least one term from the first part and one term from the second part, using the following query:

```
( KEY ( big&data OR blockchain OR artificial&inteligence OR automation
OR skills OR robotic&process&automation OR emerging&tecnhology ) AND
TITLE-ABS-KEY ( accounting OR accountant ) )
```

Filters related to the time period were applied, and only articles with an age of 10 years were selected, that is ”> 2013” and restricting the results obtained to articles written in English. This search returned 1595 articles, whose file was extracted on January 29, 2023.

To obtain a bibliometric relationship of the keywords, it was used the VOSviewer software, where were obtained the following maps. In figure 1, 5 clusters are illustrated: in red, related to “accounting education”; in green, related to “blockchain”; in blue, related to “accounting management”; in yellow, related to “Big Data”, and in purple, related to “automation”.

Figure 1 - VOSviewer, Networking Visualization



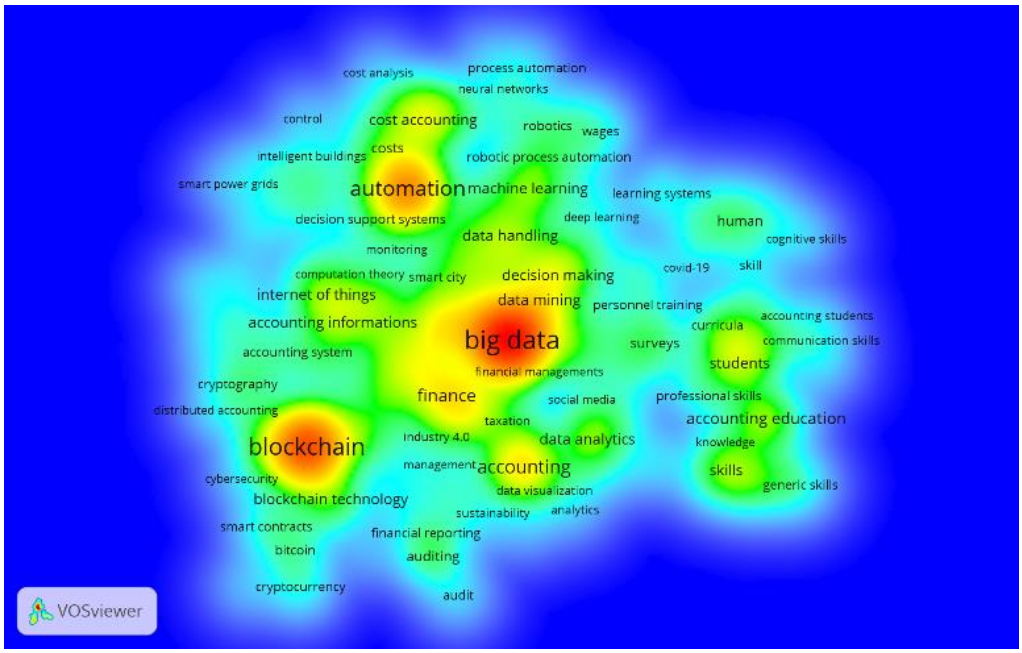
The following most identified co-occurrences in the clusters should be highlighted, as shown in table 1.

Table 1 - Co-occurrences by clusters

Red	Green	Blue	Yellow	Purple
Accounting Education	Blockchain	Information Management	Big Data	Automation
Students	Accounting	Finance	Artificial Intelligence	Cost Accounting
Skills	Auditing	Decision-Making	Data Analysis	Robot Process Automation

VOSviewer allows also to observe the density of the co-occurrences, which illustrated the importance of Big Data, Blockchain and Automation in the accounting field, as in figure 2.

Figure 2 - VOSviewer, Density Visualization



From on-going research, based on analysis of VOSviewer results it is important to review concepts associated with the topic of accounting and ET.

Looking to the future, technology is impacting both competencies and mindsets. In the finance function of the future, the technical capabilities of robotics and algorithms combine with the creativity and empathy of human accountants (Chartered Global Management Accountant [CGMA], 2018). By using technology, companies can access real-time data and make better decisions. This means that finance professionals must have a wide range of skills, not just crunching numbers, but also interpreting and examining data.

Among the technological innovations driving change, highlight the disruptive potential of cloud accounting, Big Data and data analytics, AI and ML, and blockchain, describing the accounting industry as one of the few that is constantly innovating and adapting (Kokina & Davenport, 2017). Ibrahim et al. (2021) point out Big Data and advanced analytics tools, cloud computing, and AI as technologies offering new opportunities and solutions to enhance and adapt accountant's ability to work through the complex and rapid journey of this digital age.

The accounting industry is rapidly adopting new technologies worldwide. Yoon (2020) research compares the accounting technologies adopted in Korea and worldwide by each

area of accounting and the literatures addressing these technologies as presented in table 2. The use of these technologies is transforming the accounting industry and helping firms operate more effectively in the modern business landscape.

Table 2 - Accounting technology adopted in Korea and other countries.

Areas	Korea		Other Countries	
	Technology	Literatures	Technology	Literatures
Financial accounting	Inter-business e-commerce fintech platform	Kim (2020)	Cloud service such as automatic accounting system	ACCA/IMA (2013)
	Automatic accounting system	Lee H (2020)		
	Inventory management using POS data	Lee H (2020) eBlueChannel (2020)		
	XBRL		XBRL	Deloitte (2017)
	Big Data-based accounting records	Kim A (2018)	Big Data-based accounting records	Warren et al. (2015)
Management accounting	AI-based Balanced ScoreCard	Yook (2019)	Blockchain-based Balanced ScoreCard	Warren et al. (2015)
	Performance prediction			
	Cost determination		Cost determination	Breiman (2001) Cutler et al. (2012)
Audit	AI-based fraud detection system	Cho et al. (2018)	Robotic process automation	Schatsky et al. (2016)
			Continuous audit	Vasarhelyi et al. (2010)
Taxation	Autonomous taxation system	Cho et al. (2018)	RPA Tax system	PwC (2017) Kira (2018)
	Big Data-based tax payment and tax investigation service	Song (2017) Korean National Tax Service (2016)		
Others	Blockchain-based Trade platform	Korean Customs Service (2017)	Smart Contracts	O'Neill (2016)

Source: (Yoon, 2020)

ET contribute to more advanced accounting information systems (AIS) providing higher quality information with less time and costs and making it possible to achieve more transparent accounting technologies are not separated from but rather intertwined with each other. The accounting process can be significantly improved by combining each element of the ET as following table 3.

Table 3 - Accounting process possible with combining new technology

Accounting Process	Cloud	AI	Big Data	Blockchain
Rapid processing	✓		✓	✓
Handle large volumes of data	✓			
Accounting process automation	✓	✓		✓
Efficient inventory management	✓			
Ensure accounting accuracy and efficiency		✓		
Provide higher quality of accounting information		✓	✓	✓
Achieve accounting transparency		✓		✓
Develop effective management control system			✓	
Continuous audit		✓	✓	
Prevent manipulation				✓
Data integrity	✓	✓	✓	✓
Simplify taxation process				✓
Control tax avoidance				✓

Source: (Yoon, 2020)

1.2.1 Artificial Intelligence

In the new digital technologies that are changing the face of accounting, it is inevitable to talk about AI.

> *"New technologies – especially artificial intelligence (AI) based – will have a major impact on the overall structure and processes in accounting and thus massively transform existing professional occupations and task profiles within a very short time (Neely and Cook, 2011)*(Leitner-Hanetseder et al., 2021, p. 540)

AI aims to make computers intelligent like humans using cognitive automation, ML reasoning, hypotheses generation, analysis, natural language generation, and intentional algorithm mutation (C. Zhang, 2019).

One of the pillars of AI is ML, an analytical approach that uses algorithms to aggregate, crosscut and process data to identify certain patterns and allow software to learn from the resulting models. This learning process is permanent and unlimited, meaning that, for example, an accounting firm could use chatbots for initial customer service, which will operate 24 hours a day, or consulting for companies (such as financing projects, support for the internationalization process, tax planning, etc.).

AI and ML have the potential to revolutionize the field of accounting. AI technology is a perfect fit (Kruskopf et al., 2020). These technologies can be used to automate the coding of accounting entries and ensure compliance with changing financial reporting standards. Additionally, AI and ML can enhance fraud detection capabilities by facilitating the development of sophisticated models. Software tools powered by AI and ML can provide compliance support professionals with predictive analytics capabilities, enabling them to cost-effectively review large volumes of contracts and other documents (Atanasovski & Tocev, 2022).

AI combines cognitive automation, ML, natural language processing, and analysis to produce human-level insights. The robotic automation maturity roadmap's next level will be AI (Kaya, C. T., Türkyılmaz, M., & Birol, 2019).

According to E. P. Stancheva-Todorova (2018) the impact of AI on the accountant's work can be summarized:

- Some tasks can and will be substituted by smart systems, but current research and implementation projects are insufficient considering recent AI advances.

- Bookkeeping is the most routine and time-consuming part of accounting work and can be fully automated using ML technologies.

- AI applications in fraud prevention and detection are desirable, as machines are not tempted by money or power and can easily model "normal" activities to identify fraudulent ones.

- Revenues forecasting is another area where AI can be beneficial, as predictive models based on ML algorithms can improve the accuracy of forecast data and the processes of budgeting and strategic management.

- Accountants must exercise due care when providing data for AI models to avoid inherent biases.

With AI-based digital technologies, tasks evolve as users interact with them and communicate with them, resulting in the development of new routines, while autonomous working tools increasingly take over some tasks (Leitner-Hanetseder et al., 2021).

AI results from using Big data and ML to analyze vast amounts of information. Research by Y. Zhang et al. (2020) identifies in Table 4 some AI applications, challenges, and opportunities.

Table 4 - Selected Applications Based on AI Technologies

Technologies	Applications	Financial Scenarios	Challenges	Opportunities
Natural language processing	Nuance	· Voice recognition · Conversation AI services · Phone fraud detection	· It has a weak ability to grasp the needs of ordinary users	· It provides basic voice technology services for enterprises
	Cortana	· Real-time demand and behaviour analysis	· People are still not accustomed to talking to their own computers; most Windows users want to get answers or prefer to type by text	· It utilizes the advantages of Windows data and resources to achieve random switching between work and life scenarios and providing users with integrated services
	Alexa	· Intelligent voice banking assistant	· Since Amazon's Alexa has not become a system-level feature of phones, it can be controlled only through applications or smart speakers, so the response to some command questions seems weak	· It can be used for ecosystems · It can be used for smart home application scenarios
	AlphaSense	· Intelligent financial search engine	· The product focuses only on financial professionals	· It searches for critical information across lots of disparate datasets
Machine and Deep Learning	TensorFlow (platform)	· Stock index prediction · Public sentiment information management system	· Distributed support is not yet mature, and the skills to implement custom code are strong	· It can be used to research, develop and iterate new ML architectures
	Kensho	· Financial decision engine	· Kensho can only verify the hypothesis of user thinking and make predictions for users based on ML algorithms. ML algorithms require input variables and tuning parameters. In this process, the algorithm is in the state of a black box, and users cannot guess the reason behind it based on the results	· It offers an underlying structured database, the middle-tier financial domain knowledge base, and the front-end Q&A technology
	Microsoft Cognitive Services	· Identification of the withdrawal customer on ATMs	· It has financial account security issues	· It is convenient
Artificial General Intelligence	Skymind	· Data analysis · Bank fraud detection	· It is currently mainly applied to small and medium enterprises (SME)	· It can store, process, and quickly analyse large amounts of data · It provides all-inclusive deep learning services for institutions
	IBM Watson	· Tax preparation	· Massive amounts of unstructured data need to be transferred into structured data	· It can be used to advise tax officials on different occupations, family economic conditions and personal circumstances · It can be used to advise taxpayers individually

Source: (Y. Zhang et al., 2020)

AI can perform tasks such as data entry account reconciliation and financial analysis much faster and more accurately than a human this has led some to believe that AI will eventually replace accountants. According to research Leitner-Hanetseder et al. (2021)

AI will perform intercompany reconciliation work and accountants will use new data sources (e.g. IoT, drones) for asset and liability valuation.

While AI can automate specific tasks, the truth is more complex. It cannot replicate the expertise and years of experience that accountants possess. AI may execute many tasks with greater speed and precision than a human, yet it lacks the capacity to make informed judgments and offer expert counsel. This is where accountants truly shine. They contribute not only their technical proficiency in accounting but also their wealth of expertise, practical know-how, and discernment. Accountants excel at interpreting financial data and offering valuable insights and recommendations to their clients.

It is likely that the accountant's role will change, involving different tasks, such as: using intelligent accounting mechanisms to monitor and (if possible) improve their performance and results; monitor the use of smart machines in external and internal audit processes and determine if more, less or different automation tools are needed; working with accounting firms and vendors to develop new AI-based technologies and support existing ones; perform tasks that AI-based computers cannot do today, including cultivating internal and external customers, interpreting audit and financial results, etc. for executives and boards; dealing with accounting tasks so limited and unusual that it is not cost-effective to build systems to automate them (Kokina & Davenport, 2017).

Because accountants will interact with intelligent systems and need to be appropriately skilled to take advantage of current technological advancements, the usage of AI capabilities poses certain obstacles (Scientific & 2018, 2018). Human accountants will still be needed, but the skills required for accounting and auditing may change, leading to fewer entry-level positions (Kokina & Davenport, 2017b).

> *"Accounting profession is on its way to make a great change of the role it plays in the organization and the functions it currently performs. The proponents of artificial intelligence revolution view this development as a step-ahead and embrace the challenges of the future. The opponents, on the other hand, consider it a step-back as many accountants will fail to adapt to this new business environment and will drop behind"* (E. P. Stancheva-Todorova, 2018, p. 126)

1.2.2 Big Data

Gartner (2016) defines Big Data as high-volume, high-velocity, and/or high-variety information assets that demand cost-effective and innovative forms of information processing that can provide for enhanced insight, decision making, and process automation (Atanasovski & Tocev, 2022). When dealing with large, complicated data sets from multiple sources that require cutting-edge methods for storage, management, analysis, and visualization, the term "big data" is employed (Kroon et al., 2021).

This enormous amount of data presents unique and unknown issues. To address these issues, big data techniques are crucial. Scale, parallelization, and agility are facilitated by big data systems, which use several processors processing and storing data simultaneously (Belfo & Trigo, 2013).

> *"The accounting profession is best placed to manage the big data function within organisations (Bhimani and Willcocks 2014; Brands 2014; Hagel 2013; Lawton 2015)"*(Cockcroft & Russell, 2018, p. 327)

Richins et al. (2017) discusses how big data analytics can provide opportunities for accountants to take a leading role in problem-driven analysis of structured and unstructured data. This is because accountants have a good understanding of business and are already familiar with working with structured datasets and performing data analysis.

Big data can help businesses maintain track of their expenses, enhancing their financial performance. Big data can better cost control, productivity, and other organizational aspects, which would then improve a firm's financial performance, according to Warren et al (2015) (Knudsen, 2020).

Digital technologies like big data will revolutionize work practices and create new jobs in industries like data analysis, app development, and software design (Oesterreich & Teuteberg, 2019). By implementing Big Data based methodologies, many jobs and tasks will become obsolete, which means a major shift in the way companies do business. To ensure that accountants have a place in the Big Data world, appropriate education and training must be provided at all levels, from college students to continuing education for practicing accountants (Cockcroft & Russell, 2018). "*Whether Big Data represents a threat or an opportunity to the accounting profession is up to accountants"* (Richins et al., 2017, p.34).

Accounting professionals have the opportunity to leverage on the new tools in the digital age to respond faster and at lower costs, hence allowing resources to be distributed to other areas that yield significant topline returns to the business (Pan, G., & Seow, 2016).

The expansion of accounting data sets allows for detailed transaction analysis, integration of internal and external data, soft integration of environmental Big Data, and transformation of accounting, business, and audit processes. Transaction-level data can be used for potential audit tests and automatic transaction correction, while aggregate trends serve as attention getters and transaction level analysis identifies exceptional transactions for examination (Vasarhelyi et al., 2015). Accountants can use big data analytics to monitor unstructured data and identify areas of improvement and opportunities, such as merging sentiment analytics with accounting data (Richins et al., 2017).

Free datasets and tools, including those from the Big 4 Accounting firms, are crucial for data analytics classes. Ernst & Young's (EY) Academic Resource Center is the top resource for Big Data (Janvrin & Weidenmier Watson, 2017).

Accountants add value by collaborating with data scientists, analyzing data, and interpreting results to help firms achieve financial objectives (Richins et al., 2017). The complexity of accounting and audit tasks can make even small datasets appear huge in terms of computational processing time. Some problems, such as pricing derivative financial instruments, are computationally intractable and require astronomical amounts of time to solve. Sampling is a common solution, but it diminishes the benefits of using complete data. As computational complexity increases, the proportion of data used in analysis becomes smaller (Vasarhelyi et al., 2015).

Big data improves decision-making and prediction accuracy. Unstructured data can be examined, and visualization software can transform data into useful information. The wisdom of crowds can detect corporate fraud (Y. Zhang et al., 2020). Big data offers business opportunities, but to generate value, firms need experts in data analysis, business strategy, and fundamentals (Richins et al., 2017).

Big Data has the potential to significantly improve accounting, enabling faster and more accurate analysis, greater efficiency, predictive analytics, and more transparency and

compliance. However, companies also need to be aware of the data security challenges associated with using Big Data.

> "*Both accounting academics and accounting practitioners will benefit from learning about the significant potential benefits of Big Data and the inevitable challenges and obstacles in the way of its utilization*." (Vasarhelyi et al., 2015, p. 381).

1.2.3 Blockchain

Blockchain technology was conceived and initiated by Nakamoto. "*He used a chain of blocks to create a decentralized, publicly available, and cryptographically secure digital currency system. The system, named Bitcoin, enables peer-to-peer digital currency trading. The Bitcoin blockchain can be viewed as a new type of accounting database that records the transactions of the digital currency into blocks*" (Dai & Vasarhelyi, 2017, p. 6).

Dai & Vasarhelyi (2017) mentions that Blockchain would play the role of the accounting information system, which distributes the power of transaction verification, storage, and management to a group of computers to prevent any unauthorized data changes.

The revolutionary blockchain technology has the potential to revolutionize the conventional financial transaction system. It works by grouping transactions into blocks and organizing them in a global network, enabling seamless and secure transactions. (Peace, 2021).

Blockchain is a series of blocks used to record asset ownership between parties (Y. Zhang et al., 2020). Blockchain simplifies secure, cost-effective transfer of any value in real time. Ideal for transactions needing multiple validations, contracts, and record validation (Y. Zhang et al., 2020). This implies that every node within the system possesses access to the complete transaction ledger. This access enables nodes to validate and subsequently add new transaction entries to blocks, which are regularly appended to the end of the primary blockchain, complete with timestamps. Additionally, the system can confirm the identities of all participants, both payers and payees, utilizing a public-key cryptography system. This security measure is in place to guarantee the permanence and integrity of recorded transactions, making it exceedingly challenging for an individual or a limited

group of malicious actors to manipulate any entries within the blockchain (Dai & Vasarhelyi, 2017).

The accounting industry can benefit greatly from blockchain, and its current paradigm may change thanks to this ET. Blockchain and associated smart contracts can be used to securely store accounting data, instantly share relevant information with stakeholders, and increase the verifiability of business data. Using blockchain technology, companies can generate new types of AIS that record verified transactions in a secure ledger (Dai & Vasarhelyi, 2017).

Data analytics and blockchain can work together to find anomalies and useful information. Collaboration among managers, accountants, business partners, and investors can verify transactions and provide reliable evidence (Dai & Vasarhelyi, 2017).

The blockchain technology provides a triple-entry ledger system (Schmitz & Leoni, 2019) that replaces the need for a trusted third party to verify transactions (Dai & Vasarhelyi, 2017). It establishes a shared ledger that documents accounting entries for all parties involved, constructing an interconnected and permanent system of accounting records. Trust transitions from an external authority to encompass all participants within the blockchain network. Every member of the network has constant access to an identical set of shared ledger records, rendering any alteration to the ledger apparent to all network participants. Amendments can only occur if they adhere to the rules established by the consensus protocol. Various consensus protocols are in place, encompassing public and permissionless blockchains, which are openly accessible to the public, and private and permissioned blockchains, which restrict access to designated individuals or groups. Private, permissioned blockchains are similar to traditional transaction ledgers, where only authorized users with granted permission can view the contents. External auditors have to be granted access to conduct audits on this type of blockchain (Schmitz & Leoni, 2019).

Blockchain improves accounting and auditing by enabling efficient transfers, increasing privacy and security, removing time-consuming tasks, and improving financial record accuracy (Kruskopf et al., 2020). Blockchain tech detects errors/fraud in accounting entries, automates transaction verification, and enables efficient control via smart contracts (Dai & Vasarhelyi, 2017). Blockchain is a trustless technology that self-controls

through its network infrastructure and cryptographic resources. No need for a third-party intermediary.

Blockchain has advantages over existing approaches. Dai & Vasarhelyi (2017) identify the advantages of blockchain technology compared to existing approaches, particularly in relation to databases and ERP. Blockchain can help avoid conflicts that arise from multiple modifications made simultaneously by different computers. It also offers benefits such as the ability to create self-enforcing contracts and ensure the security, confidentiality, and integrity of data stored in its ledger, as mentioned in table 5.

Table 5 - Differences between ERP and Blockchain

ERP	Blockchain
Centralized	Decentralized and distributed
High tampering risk	Low tampering risk
Many data operations	Append only
Relational database	Linear transactional database
Human labor-intensive	Non labor-intensive
Currently do not have self-enforcing contracts	Easier to create self-enforcing smart contracts
Controls are specially designed and in place	Controls could be set through smart contracts-smart controls
Accounting-specific modules	Currently no accounting-specific modules

Source: (Dai & Vasarhelyi, 2017)

Disadvantages in the use of Blockchain in the literature, (Schmitz & Leoni, 2019), Blockchain cannot replace accounting knowledge to ensure correct ledger entries. It cannot prevent asset misappropriation or errors in transaction measurement. Blockchain only confirms transactions, not their legality or authenticity. Auditors are still necessary to detect errors and fraud (Schmitz & Leoni, 2019).

The use of blockchain technology has wider implications beyond corporate use. It has the potential to bypass intermediaries such as lawyers and banks, and provide strong privacy for contract terms and payments, which may challenge the role of governments. For accountants, automatic contract execution and payment may lead to transactions being automatically recorded in the corporate ledger, potentially relegating the bookkeeping role of the accountant to a historical footnote (Marrone & Hazelton, 2019).

Blockchain is gaining attention in accounting. PricewaterhouseCoopers (PwC) sees it as next-gen software to improve shared practices. Deloitte expects it to improve collaboration, transparency, productivity, and sustainability (Dai & Vasarhelyi, 2017).

In Y. Zhang et al. (2020) research were identified several applications of Blockchain by the Big Four Accounting firms. Deloitte's labs work with international organizations for blockchain solutions, including food suppliers, banks, insurance, and car companies. They have developed over 30 models for various purposes. PwC's Blockchain Validation Solution uses risk framework and audit software to provide objective results for customers experimenting with blockchain technology. EY's Blockchain Analyzer audits cryptocurrency transactions and supports the auditing of companies using cryptocurrencies. Developed with Guardtime and Microsoft, it automates processes and reduces paperwork for marine insurance contracts. Platform connects core capabilities, shares real-time database with interested parties. KPMG and Microsoft create Blockchain Nodes for start-ups and developers to showcase blockchain's utility. KPMG's Digital Ledger Services streamlines operations and reduces costs for financial services companies.

Blockchain needs wide adoption for enterprise benefits, but requires substantial resources that may impede popularization, especially for SMEs. Large corporations may also refuse if it affects efficiency and performance (Dai & Vasarhelyi, 2017).

Blockchain technology can improve accounting accuracy and speed, but also poses a threat to the traditional roles of accountants and auditors (Dai & Vasarhelyi, 2017). Blockchain technology will require a new generation of accountants with expertise in operating within the blockchain environment (Kroon et al., 2021). In order for accountants and auditors to perform their tasks effectively, they must acquire technical understanding of blockchain-based smart contract solutions, as well as associated technologies like AI (Schmitz & Leoni, 2019).

Blockchain skills are important for future accountants' digital literacy. As mentioned by Dai & Vasarhelyi (2017):

- Emerging payment systems and virtual currencies are reshaping conventional notions of currency and business models.
- Cryptocurrencies present an opportunity for accounting firms to broaden their spectrum of business advisory services and establish fresh areas of expertise.
- Being the first to offer services compliant with legal regulations can confer a competitive advantage.

- Accounting regulatory bodies and standard-setting organizations must carefully evaluate the influence of cryptocurrencies and blockchain technology on financial reporting and formulate a regulatory framework to ensure dependable and transparent financial information.

Managers, accountants, and auditors need IT professionals' training and cooperation to use smart contracts correctly. They also need training to participate in their design and implementation (Dai & Vasarhelyi, 2017).

Lack of tech awareness and understanding is challenge for blockchain popularity (Deloitte, 2018). New payment systems and the use of virtual currencies are irreversibly changing people's traditional understanding of money, transaction methods and existing business models. Cryptocurrencies offer potential for growth as accounting firms can expand their business consulting services and new specialties can be developed in the industry. First-mover advantages can be exploited by providing services that comply with tax and other regulatory requirements, such as financial regulations to combat money laundering and terrorism. On the other hand, accounting authorities and standard setting bodies need to consider the impact of cryptocurrencies and blockchain technology on corporate accounting and financial reporting and develop an appropriate regulatory framework to ensure reliable and transparent information for users (Stancheva-Todorova, 2019).

1.2.4 Cloud Computing

Cloud computing provides computing resources as internet services, including data storage, application software, and infrastructure/platform services (Atanasovski & Tocev, 2022).

Use of IT to perform accounting functions has brought a chance for companies to progress toward paperless offices. Companies applying a production system may as well apply it more effectively if they use computerized systems (Kruskopf et al., 2020).

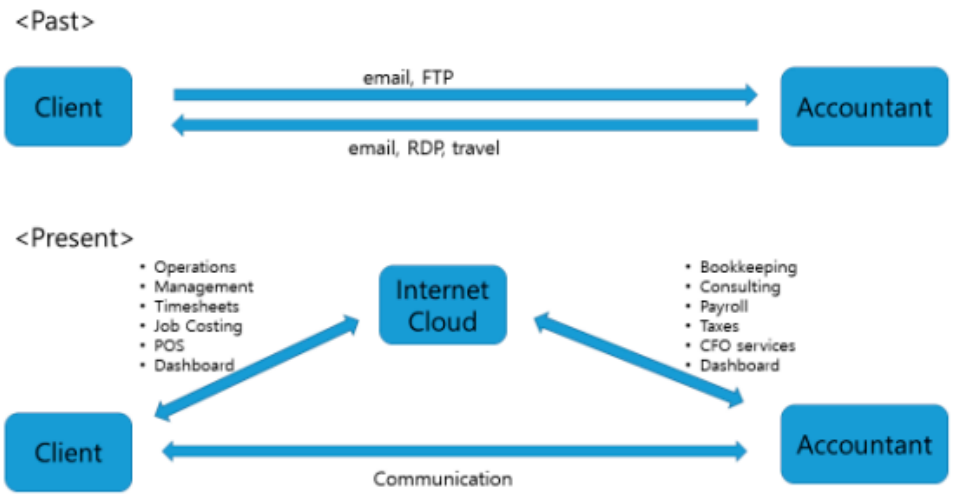
> *"Cloud computing is the c of computing resources as ready-to-use services over the internet instead of providing traditional IT infrastructure in terms of selling and installing hardware and software and building capacity within organizations"*(Atanasovski & Tocev, 2022, p.273).

In the past, accountants communicated with clients via file transfer protocol (FTP), Remote Desktop Protocol (RDP), email or in-person meetings. The process was inefficient, costly, time-consuming and highly complex. However, current accounting Systems via the cloud allow clients and accountants to perform tasks simultaneously and efficiently operations to ensure data security, improve data synchronization, and reduce the risk of data out-of-synchronization (Yoon, 2020).

One of the most popular cloud accounting systems is Enterprise Resource Planning (ERP). This is Co-management, including all information from the company and supply chain management and customer order information. Accounting forms the core of an ERP system due to accounting data. It is key information for integrated management of all levels of the company (Yoon, 2020).

The figure 3 illustrates the communication model between the accounting firm and the client.

Figure 3 - Past vs. Present Models of Communication



Source: Phillips, 2012:5, 6 (Yoon, 2020)

Especially invaluable in the context of the growing trend toward remote work, cloud-based software empowers teams separated by physical distances to seamlessly collaborate and effectively achieve their objectives (NetSuite, 2023).

Accounting teams leveraging technology are better able to adapt to changes and challenges, such as the 2020 unexpected supply chain and revenue disruptions. In addition to the ever-changing regulatory landscape and tax laws, keeping up with evolving technology can be a burden. There's a reason why cloud-based accounting software skills

are most in demand by accountants and financial professionals. Gartner recently predicted that by 2024, more than 45 percent of IT spending will shift to cloud-based technologies, which in many cases will include financial and accounting software (Kokina & Davenport, 2017).

Supported by cloud computing platforms allow the archiving, consultation and sharing of data from virtually anywhere on the planet and at any time of day, accounting is leaving paper behind and approaching the client. This step on the way to digitalization means that there is a reduction in costs and time, and the processes involved with less margin for error.

Cloud accounting software offers SMEs accounting practices greater flexibility at the workplace and improved efficiency in accounting processes, reducing the time spent communicating accounting information with clients. Additionally, ERP systems for larger companies are evolving, with vendors shifting their solutions from company-located relational databases to emerging cloud technology (Atanasovski & Tocev, 2022).

With obvious benefits in terms of cost reduction and work streamlining, the bet on digital cloud computing platforms is one of the pillars of what is called "collaborative accounting" (*A Importância Do Cloud Computing Na Contabilidade Colaborativa*, n.d.), the new form of relationship between accountants and companies, which aims to reduce barriers raised by physical distancing, facilitating the exchange of information and reducing operating costs for companies.

Cloud computing allows information and data to be stored, managed and processed on remote servers rather than on a local device. These remote servers are accessed over the internet and are often maintained by cloud service providers such as Amazon Web Services, Microsoft Azure and Google Cloud.

Cloud accounting offers opportunities for expanding services, increasing efficiency, and generating extra profits. It can also strengthen the relationship with clients by providing real-time access to financial information and allowing accounting practitioners to take a leading role in strategic planning. Digital services can improve practice and client satisfaction, but successful digitalization requires relevant skills and a digital culture. Accountants can benefit from technological breakthroughs by choosing and

implementing the right ones for accounting service improvements and business expansion (A. Stancheva-Todorova, 2019).

The role of cloud computing in the work of accountants is significant, as this technology offers several advantages, such as:

Remote Accessibility: Cloud computing grants accountants the ability to access their data and applications from any internet-connected device, providing the flexibility to work from virtually anywhere, at any time.

Expandable Storage: Cloud computing enables accountants to store extensive volumes of data without necessitating additional hardware investments, a particularly valuable asset for businesses dealing with substantial data loads.

Enhanced Security: Cloud service providers typically offer advanced security features, including data encryption and continuous monitoring, rendering cloud computing a secure choice for storing and managing accounting data.

Cost Efficiency: Cloud computing eliminates the necessity for costly hardware and software investments, while also reducing the demands for infrastructure maintenance and updates.

Furthermore, cloud computing can also help accountants collaborate with their clients and other team members more efficiently and in real time, as all data is stored in the cloud and can be accessed by all authorized users.

In summary, Cloud computing plays a key role in the work of accountants, offering advantages such as remote access, scalable storage, security and cost reduction. As a result, this technology is increasingly being adopted by accounting firms of all sizes.

1.2.5 Automation

Automation tech improves productivity, accuracy and efficiency (Fernandez & Aman, 2018).

Industry 4.0 will bring about significant changes in business processes, particularly in the areas of labor force and cost structure. Automation will impact accounting, sales, logistics, and management reporting processes. As a result, accounting will need to shift

towards strategic management accounting to adapt to this disruptive change (Kaya, C. T., Türkyılmaz, M., & Birol, 2019).

The role of accountants will change significantly with the introduction of automated accounting workplaces. Technology and robots will replace many time-consuming manual processes, allowing accountants to focus on strategies and analyses. Transactional tasks will be automated or eliminated by integrated business services solutions that use robotics, freeing up staff to spend more time on decision support, predictive analytics, and performance management. By 2020, up to 40% of transaction accounting work is expected to be automated or eliminated (Kaya, C. T., Türkyılmaz, M., & Birol, 2019).

Accounting automation eliminates mundane tasks, improves efficiency, reduces costs, and increases accuracy. Workflow software yields faster processing and better internal controls (Peace, 2021).

Accounting technologies facilitate the creation of new opportunities for innovative services and add-ons. By automating processes, the accountant can improve day-to-day efficiency and free up time for strategic work. Also, can concentrate on providing personalized client service while digital tools take care of the work (*The Pros of Accounting Services Digitalization for Accountants*, n.d.).

The automation of the financial close period represents a crucial area for transformation. The existing record-to-report model is characterized by reactivity, high costs, and a susceptibility to errors, leaving limited room for in-depth analysis. In contrast, Continuous Accounting revolutionizes operations by providing immediate access to real-time financial data, fundamentally reshaping the entire organization. By integrating automation and control into daily operations, company leaders have uninterrupted access to up-to-date information. Continuous Accounting places a strong emphasis on real-time processing and comprehensive analysis, revolutionizing business processes (Peace, 2021).

1.2.6 Robot Process Automation

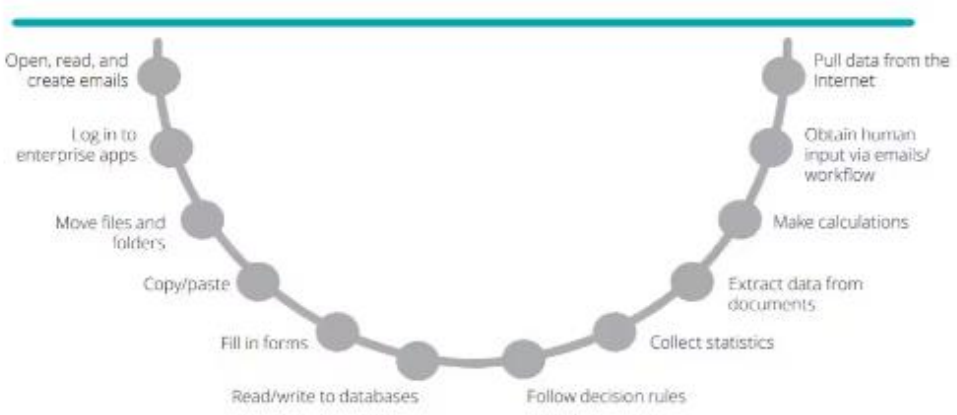
> "*Robotic Process Automation (RPA) is a technology that allows the automation of business processes and has a great impact on the transformation of Industry 4.0, which combines the strengths of traditional*

> *industries with cutting-edge Internet technologies (Schmidt et al., 2015)*" (Kaya, C. T., Türkyılmaz, M., & Birol, 2019, p. 235).

Accounting processes in organizations are prime candidates for RPA due to the repetitive nature of many of these tasks. RPA is ideal for repetitive digital tasks across multiple systems with minimal human interaction, but not for paper-based or externally changing processes (Kokina & Blanchette, 2019). According to Y. Zhang et al. (2020) automated system mimics human behavior, performs tasks like emailing and data entry, but lacks ability to adapt to changing conditions. As opposed to managing large-scale IT projects, RPA governance needs more flexibility and agility (C. (Abigail) Zhang et al., 2022).

Accounting is the area where the application of RPA is best suited (Deloitte, 2017). Figure 4 presents some general tasks than the RPA that can be applied in accounting tasks. For example, extract information from a website, save files, make calculations, log in to the ERP, make the booking and send email to confirm.

Figure 4 - What RPA can do



Source: (Deloitte, 2018)

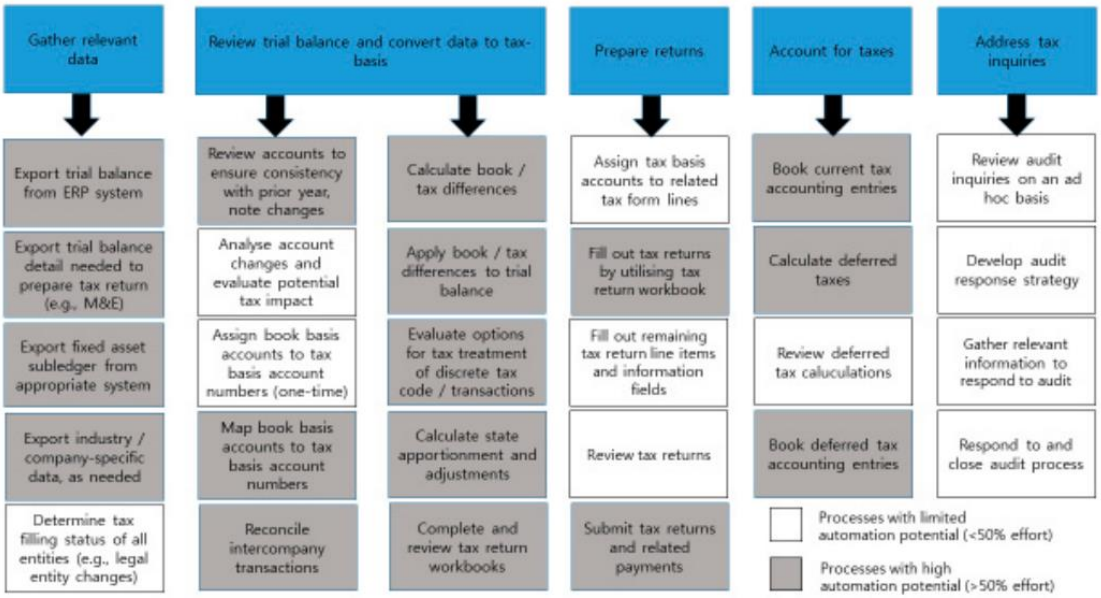
The financial close period is a crucial area where automation can bring significant transformation. The record-to-report model, which is commonly used, involves compressing a large amount of work into a short time period and delaying processing and reporting until the end of the period. This approach is reactive, expensive, and prone to errors, and it does not allow enough time for actual analysis (Peace, 2021). Therefore, automation can help to streamline the financial close process, reduce costs, and improve accuracy and efficiency.

Organizations can automate activities like accounts payable and receivable, financial reporting and analysis, regulatory compliance, and audit procedures by utilising RPA technology (Kaya, C. T., Türkyılmaz, M., & Birol, 2019).

RPA streamlines planning and budgeting in controlling, offering quick scenario generation for effective decision-making. Long and short-term plans benefit from advanced forecasting (EY, 2017) (Kaya, C. T., Türkyılmaz, M., & Birol, 2019).

The use of RPA in the accounting field is particularly useful for tax-related tasks. Automation software can be configured to perform repetitive processes, such as submitting applications to a tax authority portal, freeing up corporate tax teams to focus on higher-value work. The table 6 presents examples of RPA tax opportunities.

Table 6 - Examples of RPA Tax Opportunities



Source: PwC, 2017 (Yoon, 2020)

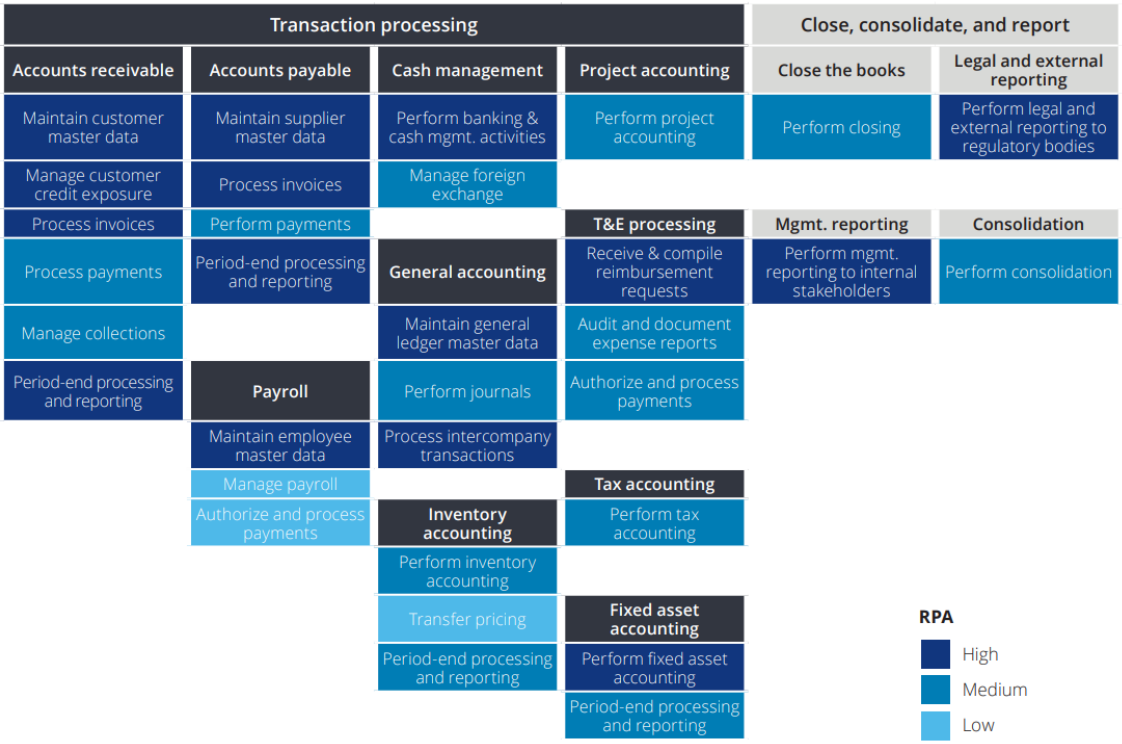
RPA can further streamline the reconciliation of invoices and accounts receivable among manufacturers, retailers, and consumers by maintaining up-to-the-minute updates in inventory databases and banking systems. In countries like China, where invoice validation is a prerequisite for confirming tax benefits, Optical Character Recognition (OCR) scanning technology can be employed to instantly scan and record paper-based invoices. RPA technology can also conduct real-time invoice verification by establishing continuous communication with government tax office databases, ensuring ongoing

validation across multiple databases and fostering real-time business communications (Y. Zhang et al., 2020).

Kokina et al. (2021) identifies the cash reconciliation is another example process that can be automated using a bot, which can download and convert bank statements to text files, access the company's general ledger system, and compare data to perform the reconciliation. During an external audit, the accountant managing the bot will need to explain its activities to the auditor, including security and compliance measures. The bot has its own login credentials to ensure an audit trail of its activities.

The Big 4 accounting firms, Accenture, Capgemini, and others are working with RPA companies such as UiPath and Blue Prism (Tadros, 2016) (Kruskopf et al., 2020). The figure 5 identifies the viability of automation within back-office accounting and finance researched by Deloitte.

Figure 5 - Viability of automation within back-office accounting and finance



Source: (Deloitte, 2018)

According with Kokina & Blanchette (2019) research collaboration between process owners, accounting, finance, IT, and internal audit is needed to determine if a process can be automated or improved. In this research based on interviews were documented

accounting and finance tasks, organized by order-to-cash, procure-to-pay, and report-to-record are presented in Annex 1.

Kaya, C. T., Türkyılmaz, M., & Birol (2019) presents illustrations of how to automate several tasks, for example: automatically extracting and reformatting data into reports or dashboards; automatically extracting structured data from documents, formatting any data; making automatic bookings in accounting; making auto-monitoring and auto-corrections on accounts. The use of RPA in general accounting can handle allocations and adjustments, as well as perform closing and consolidation activities after reconciling bank, credit card, and intercompany transactions. Kaya, C. T., Türkyılmaz, M., & Birol (2019) research identify a extend but not limited list of RPA applications can handle following manual and routine functions, presented in Annex 2.

The challenges and Risks of RPA are need for collaboration in process screening, areas best and least suited for automation, changes in Application Screens and Security Risks, bots breaking when external websites made changes to their site (Kokina & Blanchette, 2019), lacks ability to adapt to changing conditions (Y. Zhang et al., 2020) and fragmented processes hinder automation, such as varying invoice processing methods across countries (Kokina & Blanchette, 2019).
Low automation suitability were process dependency on scanned image interpretation, lack of integration with OCR, and task components requiring judgment and analysis (Kokina & Blanchette, 2019).

Organizations use ROI metrics to measure RPA performance impact, including efficiency, effectiveness, and quality. RPA value is multi-dimensional and evolving, with qualitative benefits such as process improvement and elimination of unnecessary process (Kokina & Blanchette, 2019). Company should develop RPA-specific controls and documentation, engaging Sarbanes-Oxley Act (SOX) Controls and internal audit teams for software development and process controls (Kokina & Blanchette, 2019).

While the potential benefits of RPA in this field are vast, it is important to have a careful assessment process in place to avoid excessive bot maintenance and to ensure that the bots being implemented provide significant benefits to the organization (Kokina & Blanchette, 2019).

> *"Although RPA is in general easier, faster, and cheaper to implement than traditional large-scale IT systems (e.g., ERP and CRM), it is also more prone to changes in business processes as such changes may render the bot obsolete and need to be reprogramed (Lacity and Willcocks 2015)"* (C. (Abigail) Zhang et al., 2022, p. 38)

In summary, the advantages of RPA in Accounting and Finance encompass automating routine tasks, boosting efficiency and accuracy, saving time and costs, enhancing financial reporting and analysis, transforming the financial closing process, providing an alternative to customizing ERP systems, especially in organizations with slow IT change procedures, and offering a cost-effective and expeditious solution for implementing changes in specific applications such as NetSuite and Workday.

1.3 Shaping the accountant for the future

The accounting profession is undergoing a significant transformation in terms of its role within organizations and the tasks it currently performs. Proponents of the AI revolution view this development as a step forward and welcome the challenges of the future. However, opponents see it as a setback, as many accountants may struggle to adapt to this new business environment and fall behind (E. P. Stancheva-Todorova, 2018).

Technological knowledge will differentiate the profile of the accountant of the future.

> *"The role of accountant in business during the last years has changed and transformed from manual accounting to computerized accounting"* (Damasiotis et al., 2015, p. 539)

The digital age has brought new challenges and opportunities for accountants. It has transformed the way accountants approach their work, shifting their focus from looking backward to looking forward, and encouraging them to calculate and forecast the future. Accountants are no longer solely focused on resolving issues related to back-end accounting processes. They now can propose solutions and drive strategic decision-making (Pan, G., & Seow, 2016).

Developing digital skills is crucial for accountant (Stancheva-Todorova, 2019). Future accountant roles will require a unique combination of technical and interpersonal skills.

Those with the right skills and mindset are well positioned to seize the opportunities that technology presents and lead their organizations into the future.

The ability to think critically and strategically will be essential as finance professionals will be called upon to consider the implications of their decisions and provide innovative solutions. Additionally, soft skills such as communication, problem-solving and collaboration will be key to the future of the finance function, as professionals need to work in teams and interact with various stakeholders.

1.3.1 Importance of Developing Skills

The skills and knowledge valued today have a rapidly decreasing shelf life. Accountants will need to become adaptive learners, requiring more frequent skills and knowledge upgrades. A fixed mindset is one where intelligence is considered static and "qualities are carved in stone", which "creates an urgency to prove yourself over and over". A person with a fixed mindset is likely to avoid challenges, give up easily when faced with obstacles and ignore useful feedback (Chartered Global Management Accountant [CGMA], 2018).

A growth mindset, on the other hand, is where "intelligence can be developed and leads to a desire to learn". As technology increasingly disrupts the world, the ability to continually learn, unlearn and relearn, while operating at speed and scale, is a key challenge for the finance professional. In a complex world, the only way to learn is from our mistakes, failures and errors – in science, in business, in technology, in politics. A growth mindset is also linked to own curiosity and ability to continue to question long-held assumptions (Chartered Global Management Accountant [CGMA], 2018). The constant need to fail fast and relearn in a complex world, and the frequent upgrade of skills, plays to the strength of the lifelong learning philosophy of the finance professional. It highlights the ever-growing importance of continuing professional development and education on the quest to finding out what we don't know (Chartered Global Management Accountant [CGMA], 2018).

> *"For accountants there are certainly potential downsides of this technology, but also, with the right combination of technical skills and moral persuasion, the chance to contribute as never before, and perhaps even to create a little magic"*(Marrone & Hazelton, 2019, p. 687)

Everyone who is either preparing to be or currently is an accountant needs to evaluate their job functions and their ability to adapt to the oncoming technology changes, as many of the transaction processing and data entry roles are likely to be replaced by automation. It is crucial to take technology classes, gain experience through hands-on technology projects, engage in technology webinars and discussions, and proactively embrace the opportunity to take on a new accounting role (Peace, 2021).

Moreover, humans can still create value despite automation. Continuous learning of new skills is necessary to keep up with advancing technologies and meet future demands (Kruskopf et al., 2020). Demand for digital skills is increasing in various professions beyond the technology sector, requiring a range of abilities from basic ICT to advanced analytics and programming (Berger and Frey, 2016) (Oesterreich & Teuteberg, 2019).

Accountants need data analytical skills for decision-making, risk management, and strategic solutions. Also need new skills in robotics and AI, particularly in ML. They must understand data quality and implement internal controls to mitigate risks associated with AI biases and limitations (A. Stancheva-Todorova, 2019).

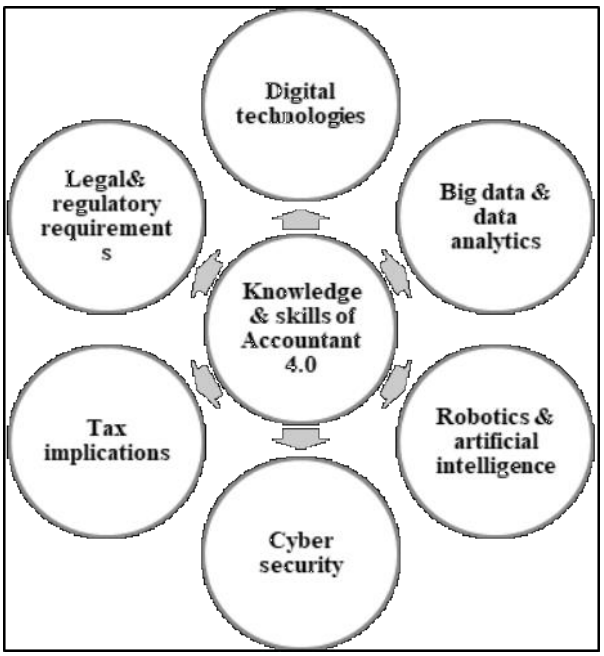
Skills related to blockchain technology are also related to the digital competencies necessary for future accountants. Professional accountants need to develop a new set of skills, including advanced analytical skills (e.g. data visualization, programming logic, and analytic modeling), personal skills (e.g. resilience, communication, and agility), open and critical mindsets, and the understanding and application of disruptive technologies (e.g. RPA, AI, and Blockchain). The Big 4 are attracting talent with these "accounting plus skills" (Rozario, A. M., Zhang, A., & Vasarhelyi, 2019).

With these skills, accounting professionals can leverage blockchain technologies to improve the accuracy and efficiency of financial processes. Skilled individuals use technology to expand their client base, indicating a bright future with the right skills (Kruskopf et al., 2020).

Indeed, is important for accounting profession to have IT knowledge apart from traditional finance and accounting skills. Instead of expecting to use the same tool for the next decade, accountants today must be ready to use new technology every year. This requires not just a basic understanding of the technology itself, but the ongoing cultivation

of adaptability (Fernandez & Aman, 2018). Figure 6 illustrates the knowledge and skills required by future accountants engaged in the finance function of a 'digital enterprise.

Figure 6 - Knowledge and skills profile of Accountant 4.0



Source: (Stancheva-Todorova, 2019)

The role of accountants as knowledge professionals/business solution professionals requires not only the ability to interpret information systems (IS), but also highly developed creative and social skills. Interpersonal and communication skills are crucial for accountants to effectively interpret and explain information to decision makers. Accounting education should focus on developing these skills to ensure graduates are fit-for-purpose in their roles (Sangster, 2022).

While technical or “hard” skills have always been considered important, soft skills have become equally valuable as they enable individuals to bridge the gap between machines and humans. Technical skills are more about learning how to interact with programs, AI, robotics, and generally with digital processes that take over everyday tasks.

In Summary, table 7 presents the main skills mentioned in the literature review.

Table 7 - Accountants skills now and in the future

Technical skills	Social skills
Knowledge of industry specific regulations	Strong communication
Knowledge of International Standard	Emotional intelligence, ethical
Business understanding	Conflict solving
Mathematical and statistical skills	Adaptability, tolerant of uncertainty
Understanding the capabilities of software	Leadership skills
Basics of coding / programming and scripting language	Sales knowledge
Data and business analytics	Risk management
Fintech software knowledge	Innovative/creative
Data visualization	Strategic decision making
Data security, forensic tools	Customer service orientation
Data warehouse management	Teamwork skills
ERP (Enterprise resource planning) experience	Systemic thinking
Basic knowledge of Emerging Tecnhologies	Problem solving
Data modelling	
Data mining	

Source: adapted authors based on the literature review

To conclude, the changes in the accounting profession may lead to the disappearance of certain jobs. However, these changes will also create new opportunities for both newly graduated individuals and those who are willing to develop new skills.

1.3.2 Changing Roles of Accountants

There is no doubt that the accounting and auditing professions will change because of the digital revolution (Kruskopf et al., 2020). World Economic Forum (2023) predicted that almost a quarter of jobs (23%) are expected to change in the next five years and that the fastest-declining roles relative to their size today are driven by technology and digitalization, with data entry clerks, accounting, bookkeeping and payroll clerks.

The first impact on the accounting profession will be changing tasks or the way they are performed. These changes may impact accountants' functions; they may have to complete existing tasks differently or even perform new tasks. As the accountant's role is closely related to the tasks performed and the functions assumed, all these changes may ultimately affect the accountant's role (Kroon et al., 2021).

It is worth noting that the integration of AI with human intelligence could lead to the emergence of several new and important roles and jobs. The fear of losing jobs due to automation seems to be more of a myth than a future prospect. The accounting profession is now shifting its focus from concerns about automation of accounting tasks to leveraging AI capabilities for its benefits (E. P. Stancheva-Todorova, 2018).

Leitner-Hanetseder et al. (2021) research trough Delphi study found that cloud computing and blockchain technology are driving technological advancements in accounting. AI-based technology, such as smart robots and Business Intelligence (BI) tools, will have the biggest impact on the roles and tasks of accounting employees. The study identified eight core roles of accounting in 2030, with AI-based technology replacing humans in routine tasks and supplementing human actors in decision-making. However, there are tasks that will be exclusively done by humans, such as training and monitoring AI-based technology. The core roles of humans in AI-based accounting are to ensure effective collaboration with technology to fulfill accounting roles. Table 8 details the roles, related tasks, human and AI-based actors in accounting.

Table 8 - Roles, related tasks, human and AI-based actors in accounting

Roles	Tasks	Current actores	Actores in 2030
Transaction recorder	recording transactions, posting to account and reconciling and balancing accounts	Humans screen documents, post them to the correct account and manually reconcile and balance accounts supported by software tools (for example, booking software)	AI-based technology (for example, a smart software robot) which extracts information from machine-readable digital data formats as a self learning system, posts it to the correct account; humans will supervise the results and take care of exceptional cases the AI-based technology is not able to solve
Data and information manager	collecting and selecting data for information gain	Due to their expertise, humans collect and select the data used for valuation, forecasting, risk mitigating ..., they use mainly internal data from historical transactions and/or selected external structured data	Free data exchange standards enable AI-based technology such as automated feature tools to collect and suggest internal/external and unstructured/structured data relevant for the task; humans decide about the usage and/or supervise the selection of data
Data miner	data mining (analysing) to optimise costs, generate sales, forecast, mitigate risk or detect fraud and guarantee compliance	Humans fulfil this role by analysing mainly historical internal structured data using spreadsheets and descriptive analytics	AI-based technology (such as business intelligence tools) uses predictive analytics tools to analyse and recognises anomalies, interrelations, trends and patterns within big data; humans can focus on major incidents
Dashboard designer	reporting and visualisation of data	Humans use software tools (such as Excel, PowerPoint) and standardised formats to report and visualise the data on a regular basis	Humans design interactive dashboards with AI-based tools, which meet the needs of the user in an iterative way in nearby real time
Advisor	interpret the data and decide or advise/communicate to stakeholders	Humans interpret the data due to their individual experience in the field	AI-based technology suggests data-driven decision options based on prescriptive analytics, humans interpret the AI outcome and understand the overall engagement process and have to weigh up options and decide or communicate to stakeholders and advise due to their expert knowledge and experience
AI technology expert	training and supervising AI-based digital technologies	Not necessary right now	Humans train and supervise AI-based technologies, such as a trainee, in a specific task and how to interact with humans to provide human and AI-based technology collaboration
Process manager	selecting processes for automation and the corresponding AI-based technology or components	Not necessary right now	Humans using AI-based process mining tools identify processes for automation, select the relevant AI technology or component and make sure that the collaboration of AI-based technology and humans work
Legal and ethical supervisor	guiding and monitoring legal and ethical requirements	Not necessary right now	Humans are responsible to guide AI-based technology and monitor whether the data-driven decisions made by humans meet legal and ethical requirements

Source: (Leitner-Hanetseder et al., 2021)

For the current roles such as bookkeepers, accountants, controllers, business data analysts, treasurers, risk managers, and financial systems and process managers were explored in Leitner-Hanetseder et al. (2021) research show the tasks and skills connect and potentially change in these occupations (table 9).

Table 9 - Tasks and skills of current roles in an AI-based accounting

Roles	Roles and tasks descriptions	Skills
Bookkeeper	Advancements in digital technologies such as B2B transactions, OCR technology, and smart bots will automate routine tasks and improve the quality of financial data. Bookkeepers will be responsible for ensuring that all business transactions are accounted for by smart accounting software and will play a key role in the implementation phase of AI-based accounting software.	Know-how, IT-user skills, better problem-solving competences, and an understanding of processes.
Financial accountant	AI will replace financial accountants in performing reconciliation work and data collection. Accountants will still be responsible for compliance, interpretation, and expert assessment, with AI-based support. They will oversee processes, reporting, monitoring, and audits.	Good communication, process management, and IT-user skills
Controller (management accountant)	Controllers' role in AI-based accounting is evolving from information providers to business partners. They will use digital technologies to support management in decision-making, process optimization, and reporting. Controllers will guide management in strategic planning and investment decisions.	Combine business partner skills with data analytics. Digital technologies forecasting techniques, and data visualization
Business data analyst	The role of data analysis in accounting has shifted from being performed by controllers, treasurers, and risk managers to business data analysts who have domain knowledge and use BI tools to analyze data, discover patterns and trends, and draw conclusions. Business data analysts are responsible for Big Data and analytics in accounting, but they do not make the choice for the algorithm the tool uses. They support controllers, treasurers, and risk managers with dashboards that visualize data effectively.	Analytical thinking, innovation, reliability, curiosity, and a willingness to learn. Continuous training is necessary due to the continuous change in tools, methods, and new technologies.
Treasurer and risk manager	Treasury and risk management are crucial due to changing economic conditions, big data, and new financing instruments. Treasurers and risk managers must be versatile in managing liquidity, ensuring compliance, creating AI-based liquidity forecasts, and supporting fraud detection. Integrated treasury management systems and RegTechs are essential for compliance and reporting. While the job is complex, it offers unique and highly rewarding opportunities for domain experts.	know-how, technological savviness, and soft skills.
Financial systems and process manager	The financial systems and process manager coordinates AI-based digitalization and automation initiatives, evaluates their efficiency, ensures ethical compliance, and promotes collaboration between humans and AI-based technology. They also oversee authorization concepts, quality assurance, and work with the IT department on applications, data storage, interface programming, and security.	Communication, a holistic understanding of processes, basic accounting knowledge, project management skills, and soft skills (motivational capabilities and empathy).

Source: adapted (Leitner-Hanetseder et al., 2021)

Also Kroon et al. (2021) research resumed the following roles, tasks and skills of the current roles, as table 10.

Table 10 - Impact of technology in roles and skills

Roles	Roles and tasks descriptions	Skills
General Accountants	Collaborating with IT experts, accountants take part in the creation and upkeep of information systems that are precise and efficient. They craft data mining and analytics models, while blockchain technology ensures the legitimacy of digitized process policies. With the aid of AI-powered accounting machines, accountants are able to delegate certain tasks and devise novel tools utilizing AI. Additionally, they excel in handling specialized accounting duties.	Analytical skills (free text, images, and videos); understanding of the data; Creativity, and communication skills; understand the basics of programming.
Auditors	Auditors in blockchain development should focus on risk management and advising on internal control solutions. Blockchain enables continuous auditing through data analytics, freeing up resources for consulting services. With standardization of blockchain systems across industries, new roles for auditors such as auditor of smart contracts and oracles, service auditor of consortium blockchains, administrator function, and arbitration function may emerge.	Blockchain technology and data expertise. Soft skills (intuition, creativity, and communication). Judgment, supervision, and insight are more critical.Risk assessment, predictive auditing, and fraud detection.

Source: adapted (Kroon et al., 2021)

In the future the accounting tasks will be more precise and detailed because of the computer's abilities to collect and gather the information that is needed for managers to make the right decisions. This task can't be done without an expert in the field. As time passes and robots are part of the daily tasks of accounting and audit professions there is going to be a need for someone at the user level support as well as someone who is capable of solving the technological problems related to the systems (E. P. Stancheva-Todorova, 2018). In resume, based on literature review, a plenty of future job titles will take place, as presented on table 11:

Table 11 - Examples of future accounting job titles

Examples of future job titles	
Advisor	Fintech Accountant
Analytics Guru	Fintech City planner accountant
AT technology expert	Healthcare Accountant
Blockchain Accountant	Historical Accounting Analyst
Cloud Accounting specialist	Legal and Ethical supervisor
Cybercrime Accountant	Process Manager
Dashboard designer	Strategic Accounting Analyst
Data and information manager	Systems Integrator
Data miner	Transaction Recorder
Data Security Accountant	

Source: adapted authors based on the literature review

> *"Using AI to drive innovation and enhance traditional roles will boost their productivity and overall employment rather than reducing it"* (Bughin, 2018) (Leitner-Hanetseder et al., 2021, p.551)

In Summary, the evolving landscape of organizational roles for accountants is driven by the growing utilization of bots to execute tasks traditionally handled by humans. This shift introduces a level of uncertainty concerning the future responsibilities of human employees. Nonetheless, there exists a valuable opportunity for accountants to broaden their expertise in business processes, exception analysis, and the development of robotic software. Future research should delve into how automation is reshaping the accounting profession, the distinct functions of accounting and finance experts in the context of digital transformation, and the competencies necessary for effective collaboration with digital counterparts.

1.3.3 Ongoing learning and development for accountants

Accounting academics are now more concerned with what are the future models for accounting higher education. The accounting profession has been speaking out vehemently about the substandard design of accounting programs that prioritize redundant technical subjects and neglect to provide adequate training in the skills that are highly sought after by employers (Sangster, 2022). Enabling future accountants with the necessary digital knowledge presents a real challenge for accounting educators. They must prepare graduates for the new demands of the curriculum labour market. Accounting procedures should be interdisciplinary, teaching content delivered by different people department.

The fourth industrial revolution is changing economies and universities have a new role. Accounting programs can join technology clusters to address emerging issues and interdisciplinary solutions require academic expertise (A. Stancheva-Todorova, 2019).

According to A. Stancheva-Todorova (2019) research, accounting higher educators gain limited benefits from participating in clusters, summarised as:

- Providing access to authentic case studies that can be integrated into accounting modules to enhance their technical depth.

• Enhancing and expanding practical research by publishing materials on current and relevant subjects derived from accounting practice.

• Closing the divide between accounting education and practical application.

• Enhancing the university's reputation.

Also A. Stancheva-Todorova (2019) point out prerequisites for an efficient and effective collaboration with the other cluster partners:

- Establishing a conducive business environment within the university, potentially including the creation of a dedicated administrative unit within the organizational structure as necessary.
- Employing qualified personnel equipped with the requisite knowledge and skills to oversee and manage business communication and collaboration within the cluster partnerships.
- Providing training for academic staff on how to cultivate and maintain effective working relationships with other cluster members.
- Developing the necessary technological infrastructure, including well-equipped computer labs and enabling remote access to cluster partners' information systems and databases.
- Formulating and routinely reviewing internal university policies and control procedures pertaining to data privacy and security in order to minimize the risk of sensitive personal and business data breaches.

In addition to the favorable outcomes for universities engaged in technology clusters, there are undeniable advantages for the other cluster members. Some of these benefits include:

• Access to the expertise and skills of academic experts.

• More cost-effective solutions for accounting, financial reporting, and tax matters in contrast to the conventional utilization of external consulting services.

• The potential to attract academics for conducting in-house training sessions for other cluster partners.

• The opportunity to draw in accomplished graduates and talented students during their university studies.

As AI continues to influence and will continue to shape the role of accountants, there is a pressing need for accounting educators to shift their perspective and cultivate the essential skills and competencies relevant to intelligent technologies and their advanced business applications. Significant effort lies ahead in revising accounting curricula and equipping graduates with the skills needed for a prosperous career.

Entry-level accountants will likely be the hardest hit in the job market, due to automation. As a result, some fear that entry-level workers will not be able to gain the appropriate experience early in their career (Kokina & Davenport, 2017). They fear that they will not be able to retrain enough to remain competitive in the field.

By other hand Kruskopf et al. (2020) point out that employees over the age of 50 on average will also face challenges related to new technologies and automation, and therefore fear that young people will take their place.

Pan, G., & Seow (2016) suggest the accounting industry needs to emphasize the significance of IT in accounting-related jobs, particularly in the areas of forensic accounting and business analytics. This requires individuals with data mining and forensic IT investigative skills, as well as exposure to SAP R/3 for example. Public accounting firms should prioritize hiring students with these skills and job advertisements should clearly indicate the need for them.

Currently, the education sector is facing a deficit in IT, resulting in inadequately equipped students for the future accounting workplace. The question that looms large is how the profession will respond to technological advancements and how it will impact the conventional methods (Kruskopf et al., 2020). As the business landscape evolves, there is a growing demand for accounting professionals who possess a unique combination of educational qualifications, professional credentials, and skill sets that include data analysis and business intelligence. With technology rapidly advancing, accountants who not only have basic IT skills but also demonstrate flexibility and adaptability will always be ready to integrate new, more efficient tools into existing processes. This will enable businesses to stay ahead of the competition and make more informed decisions (Fernandez & Aman, 2018).

Janvrin & Weidenmier Watson (2017) mentioned the 2015 Pathways Commission survey identified ERP systems as important for students to learn due to their generation of Big

Data. Instructors can incorporate ERP systems into their classes using books with ERP software access or through ERP software vendors such as GP, NetSuite, Oracle, and SAP, which offer free or low-cost access to their software for academic purposes.

- GP (free via Microsoft Dynamics Academic Alliance)
  `http://www.microsoft.com/en-us/dynamics365/academic`
- NetSuite (free via SuiteAcademy)
  `http://www.netsuite.com/portal/services/suiteacademy.shtml`
- Oracle (free via Oracle Academy)
  `https://academy.oracle.com/en/oa-web-overview.html`
- SAP (via SAP University Alliances)
  `http://www.sap.com/training-certification/university-alliances.html`

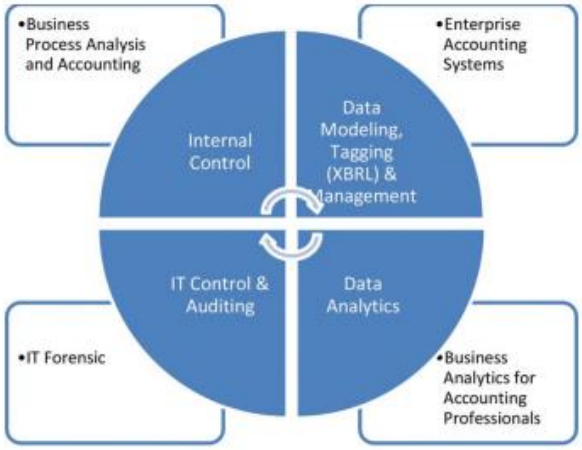
ERP providers offer datasets for educators. These datasets can be adapted for Big Data exercises and incorporated into current case studies or educational scenarios. Analyzing datasets is particularly suitable for this purpose.

Several professional accounting organizations, such as the Association of Chartered Certified Accountants (ACCA), the Institute of Chartered Accountants in England and Wales (ICAEW), and the Chartered Global Management Accountants (CGMA), have begun to update their qualification modules' content. ACCA and CGMA including Big Data analytics in their courses. ACCA exams in Business Reporting and Strategic Business Leader cover topics such as Big Data, disruptive technology, and cyberattacks. Accounting educators are under pressure to increase the technological content of accounting courses. They are doing so by integrating information technologies and data analytics into their syllabi (A. Stancheva-Todorova, 2019).

In Pan, G., & Seow (2016) research is discussing the importance of technology-related concepts in accounting education. However, some accounting students misunderstand the scope of technology and believe they can learn it after graduation. To address this, a clear curriculum structure and relatedness between accounting and IS is necessary. IS courses should be customized to the accounting background and be business and non-technically oriented to better fit students' needs and strengthen their confidence in acquiring relevant knowledge. Figure 7 represents a model curriculum for undergraduates in accounting,

based on the needs of the profession. Includes knowledge areas such as IT control and data analytics.

Figure 7 - Accounting information systems model curricula



Source: (Pan, G., & Seow, 2016)

The accounting profession will become a hybrid due to finance, technology, and information skills. Predicted by two professional bodies in 2013 ACCA & IMA figure 8 presents the future accounting profession.

Figure 8 - New accounting and finance professional hybrids

Source: (E. P. Stancheva-Todorova, 2018)

The interdisciplinary approach should be applied across the curriculum and accounting educators should prioritize knowledge and skills in AI and data science. Collaboration and partnership between accounting educators and industry are necessary for successful accounting careers. The School of Accountancy at Texas Tech University has already integrated big data and analytics into their accounting coursework with a module called "Data analytics for accountants" (E. P. Stancheva-Todorova, 2018).

(http://www.depts.ttu.edu/rawlsbusiness/about/accounting/courses.php)

In resume, professional accountancy organizations need to support universities in preparing students for the future of accounting, which requires interdisciplinary knowledge and diverse skills. This can be achieved through surveys, guidelines, teaching materials, and workshops for academics. Collaboration between academia and industry through cluster partnerships can also lead to solutions for emerging accounting, financial reporting, and tax issues related to Industry 4.0 (A. Stancheva-Todorova, 2019).

The significance of quality accounting education cannot be overstated as it directly correlates with the success of employees and organizations alike. To equip graduates with the essential skills needed to thrive in the industry, it is imperative to restructure accounting education in accordance with industry requirements (Fernandez & Aman, 2018).

> *"Educators should also encourage a philosophy of lifelong learning and teach students to learn new things and adapt to the changing environment cultivating accountants who are prepared for the future."*
> (Zhan et al., 2018, p.26)

2 METHODOLOGY

This chapter is dedicated to outlining the research problem, objectives, methodological framework, and data collection methods employed to obtain the requisite information supporting this study.

Research involves reflecting on a reality from different perspectives to contribute to knowledge. It starts with a question from the researcher's social context and guides all decisions made during the process (Flick, 2022). The research process as being composed of several phases and characterized by a common thread that connects all of them: research questions, research groups, design selection, scientific method selection, data collection, analysis of results and conclusions (Flick, 2022).

2.1 Research questions and objectives

Formulating the research question represents the initial and crucial phase in the research process and must be important, specific and without obvious or routine answers (de Souza, 2011). Thus, the research question for this study is:

What is the impact of ET on the work of accounting professionals?

To provide an answer to the research question, the following specific research questions were defined:

RQ1: Which ET is most often studied in accounting field?

RQ2: What are the roles and necessary skills for accountants in the organization?

RQ3: How can accountants improve the quality of their work and leverage the benefits of technology?

The objectives of this study are:

SO1 Identify the ET on accounting

SO2 Identify accountants' familiarity with ET

SO3 Identify the skills and roles of future accountant

SO4 Identify the role of accounting education in the future of the profession

SO5 Identify the advantages and disadvantages of ET in the profession

SO6 Identify expectations/concerns in the adoption of ET

SO7 Identify tasks/processes that will change by technology adoption

2.2 Research Methodology

In the elaboration of an empirical study, it is necessary to define the research methodology to be applied in the study, which always depends on the phenomenon to be studied (Serapioni, 2000).

According to Yin (2009) the methodology investigates a contemporary phenomenon in the real-life context where the boundaries between the phenomenon to be studied and the context are not clear. The literature distinguishes between two types of research, quantitative and qualitative (Daymon & Holloway, 2010) (Yin, 2009).

In this case, to answer the research questions and the objective of the study, an exploratory study with a qualitative approach was carried out in order to obtain a deeper knowledge about the subject.

This research does not aim to establish a predictive relationship between accountants' actions and ET, which is commonly assumed in traditional decision-making theories. Rather, it examines their complex interplay in modern business environments to inform the development of more effective decision-making strategies(Eppel, 2017). The research follows an inductive logic in the process of theory development, so it is based on the qualitative paradigm, assuming the existence of several realities which are sought to be understood through the experiences of the interviewees.

The qualitative method proposes to investigate descriptive data of a situation or phenomenon, involving the direct contact of the researcher with the situation studied (Batista *et al.*, 2017). On the other hand, the quantitative methodology intends to carry out an investigation based on quantitative data, starting from a theory that already exists, and aims to validate hypotheses formulated and can be generalized to other groups within a given community (Serapioni, 2000).

2.3 Instrument Development and Testing

As for the data collection technique, it is important, as suggested by Yin (2009) to evaluate alternative tools and approaches to support decision-making.

Within the framework of the different techniques and tools validated in the literature, interviews, the Focus Group method, or the survey approach were considered for this comparative analysis. Selecting the most suitable approach for the specific context under investigation should consider the pros and cons associated with various methods.

A research method can be defined as a method of collecting data and information from the characteristics and opinions of the results obtained can be extrapolated to the entire field of study. The strengths of this approach lie in addressing the fundamental issues required by the target audience, the possibility of using current and real data and the real characteristics of the Portuguese business and educational structure. The disadvantage is that responses to these same surveys can take time and some answers may not be conscious and enlightening.

The focus group method did not prove to be a viable option, given the difficulty in bringing together a panel of professionals from different geographical areas at the same time and location.

Compared to the survey, the interview offers greater advantages, as the interviewer can clarify the doubts that may arise in relation to a question, in addition to being able to capture the verbal and non-verbal expressions of the interviewee.

The interview is most frequently used in qualitative research, as it is recognized as a quality technique for data collection. This is due to the fact that interrelatedness, everyday experiences and the language of common sense at the time of the interview are a fundamental condition for the success of qualitative research (Batista, E. C., de Matos, L. A. L., & Nascimento, 2017).

It's imperative to contemplate the utilization of semi-structured interviews, as they have been demonstrated to be the most effective approach for collecting data. This approach shouldn't be viewed as a final solution to offset the drawbacks of other methods. Quite the opposite, semi-structured interviews offer a flexible dialogue that empowers the interviewee to guide the conversation towards the areas they deem most significant, thus expanding our insight on those particular aspects.

In addition, the choice of interviews also reflects the design of the research, as it assumes that the closer the researcher is to the field or knows the participant, the more knowledge about the participant's knowledge is possible to obtain (Creswell & Poth, 2016).

The advantages of applying this data collection technique are vast, as summarized by Barriball, K. L., & While (1994).

- It helps to overcome the common low response rates when applying other techniques;
- It allows you to capture attitudes, values and motivations;
- It allows you to confirm the validity of the answers through non-verbal expressions;
- Facilitates comparative analysis; and
- Ensures that the insights captured are actually those of the target respondent and not influenced by others who can help them formulate the answers.

Face-to-face interviews are characterized by a type of synchronous communication in terms of place and time (Opdenakker, 2006) and advantages are pointed out, namely the fact that the reaction and response of the interviewees is more spontaneous.

Conducting interviews, however, has disadvantages related to the interviewer's budget, time and travel constraints. The decision must therefore take account of the resources to be spent. These can be mitigated when telephone conferences (via Zoom for example) are an option for both parties and should be equipped with image and sound in order to mitigate the risks of non-capture of data inherent to digital techniques, namely electronic messaging systems (Opdenakker, 2006).

A semi-structured interview was used, as it follows a script used by the interviewer in order to support him/her. In this type of interview, although there is a script, there is greater freedom to speak freely and lead the interviewee to a more open conversation (de Souza Minayo, M. C., & Costa, 2018). A correct and adequate interview script is essential considering that, right after the environment and the interviewee's state of mind, the script is a factor considered decisive for the success of an interview. The interview script was built on the basis of researchers' opinions and experiences, discussions among researchers, and the academic literature (Umeokafor et al., 2018).

2.4 Data Collection

The data in this research study were collected through individual interviews with actively practicing accounting professionals. These professionals were deliberately selected from diverse backgrounds, industries, and positions. The responses were analyzed and categorized based on similarities, and the final section of this report organizes these findings within the sample population. In this section, were synthesized key themes from the results to elucidate the respondents' perspectives on current ET and their implications for the accounting profession.

After an analysis of the constraints, such as the availability and time of the participants to be interviewed, the research strategy was defined and the process was continued.

The interviews were held from March to April 2023 and invitations were made via phone/WhatsApp/email, as well as scheduling. Several professionals were invited, with different professional profiles from Chartered accountants, accountants, university accounting students, Big 4 accountants, university teachers, trainers, and ERP consultants'. The invited professionals are from different generations, genders, and areas of residence. Of the thirteen people invited, ten agreed to give the interview. Going forward, participants are referred to by codes that were assigned, as shown in Table 12.

Table 12 - Summary Overview of Participants

Participant Code	Age	Gender	Residence	Training Area	Profile	Business Sector	Interview Date
I1	41	M	Coimbra	Accounting	Chartered Accountant	Accounting firm	2023-03-01
I2	34	F	Barreiro	Accounting	Teacher and trainer	Higher Education Institution	2023-03-02
I3	33	F	Alverca do Ribatejo	Accounting and Administration	Lead accountant	Software Company	2023-03-02
I4	46	M	Luanda	IT management	Software consultant	Software Company	2023-03-04
I5	48	M	Santa Maria da Feira	Economics	Chartered Accountant and economist	Financial and Tax Consultancy	2023-03-09
I6	43	M	Lisboa	Management	Manager	Consulting Big Four	2023-03-24
I7	53	F	Coimbra	Accounting and Audit	Chartered Accountant	Accounting firm	2023-03-28
I8	21	M	Marinha Grande	Accounting and Audit	Accounting Student	Higher Education Institution	2023-04-06
I9	23	F	Évora	Accounting	Accountant	SME Accounting firm	2023-04-11
I10	46	M	Leiria	Business Sciences (Accounting)	Teacher	Higher Education Institution	2023-04-13

The interviews were conducted via zoom, with an average duration of approximately 45 minutes. Although the first interview lasted more than 1 hour, which led to the adjustment of the list of questions initially planned.

All interviews were only attended by the researcher and the interviewee. The interviews were audio-recorded through the zoom platform, and the researcher indicated their confidential nature and only for data processing use, with no objection from the interviewees.

The interview questions were based on the literature review, to:

- to ensure that the questions are aligned with the research questions;

- that the conversation was fluid and that the answers could align more constructively

- Receiving feedback and final contributions.

As summarize in Table 13, the interviews were semi-structured and the questions were developed to research:

- the interviewee's familiarity with terms related to ET and digital transformation;
- training and experience in ET;
- the limitations/difficulties they experienced with the implementation of new technologies;
- the associated advantages and disadvantages;
- the impact of technologies on smaller companies;
- whether professionals are prepared for the adoption of these technologies;
- the relationship between academic study and practical application;
- the challenges and futures roles for accounting professionals;
- the skills that professionals must have;
- the contribution of technologies in relation to tasks and processes in the profession;
- future expectations about the profession

Table 13 - Summary of interview scripts

Section	Objective
Ethical and Legal Considerations	Presentation of the objectives of the interview and issues related to confidentiality and data disclosure
	Identifying the interviewee
Auto-Perceptions and Personal Opinions	Familiarity with emerging technologies
	Motivations for the adoption of technology
Experience	Challenges and adjustments faced during the accounting practices
	Identify incorporating technology in accounting work
	Limitations/difficulties and advantages and disadvantages of implementing ET
Training and Skills	Skills for accountants in the digital era
	Training and experience in digital transformation
Perceived Contributions	Incorporating technology for improved efficiency given the full picture of Portuguese companies
	Continuous learning and accounting education
Expectations	Impact of technology on the accounting profession, taking into account factors such as company size
	Expectations of the profession in the face of digital transformation

The interviews were structured into three distinct phases. The initial phase encompassed an introduction in which the research objectives and ethical and legal considerations, such as confidentiality and data disclosure, were addressed. The second phase involved the actual interview, during which a series of predefined questions were posed in accordance with the interview script (see appendix 3). The final phase consisted of expressing gratitude and engaging in an informal conversation about the subject under investigation. With the open-ended questions, the challenge will be to encode the discourses of the interviewees into common codes and themes, as they may be saying the same thing through different words (Iarossi, 2011).

Iarossi (2011) assess to ensure accuracy, care was taken not to develop an interview script that was too long that would lead the interviewee to reach a situation of fatigue. Under no circumstances did the interviewee rush to answer the questions posed. On the contrary, the interviewer stressed the importance of accurate answers for the rigor of the research and respected the interviewee's response time, showing willingness to continue the interview in another period when this would contribute positively to the accuracy of the answers.

After all the interviews, conducted in Portuguese language, the process of transcription, translation, analysis and interpretation of the data was initiated.

It is relevant to design an analysis protocol that seeks to ensure the rigor of the investigation in terms of data processing. Brownell (1995) identifies this phase as critical, suggesting that it is the moment when more problems arise in research because it is

required that a systematic analysis and interpretation of the data be conducted, without bias and credible.

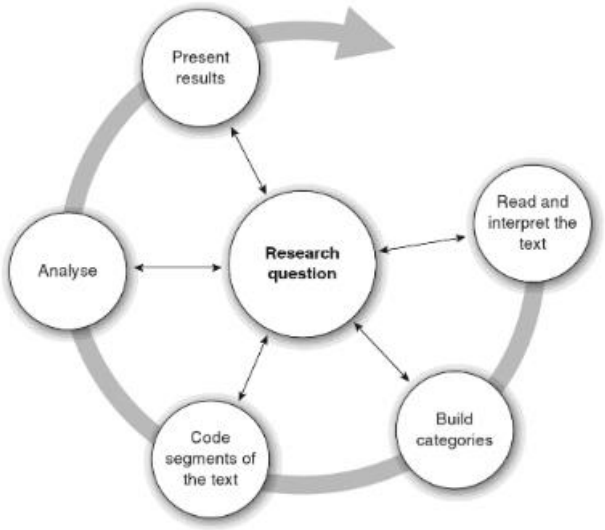
The purpose of coding is to classify all but superfluous information for each interview conducted. This coding involves analyzing the transcripts of the entire interview.

This procedure involved the repetitive reading of the information collected, to obtain the meaning of the interview as a whole (Graneheim, 2004). Hence, the analysis concentrated on both the evident content, which pertains to the visible and readily apparent elements of the text, and the implicit content, which involves the relational aspects and the interpretation of the text's underlying meaning.

The common conceptual parts were identified, a process that required the reading of the texts word by word to derive the units of meaning and construct themes (Graneheim, 2004). Thus, the texts were shortened to condense the main meaning through codes, categories and themes, and these dimensions were understood in the context in which the project is inserted.

Similarly, to the option taken by other researchers (Liket & Simaens, 2015), in this process the MAXQDA program was considered useful in the coding and categorization of the interviews, as well as the data collected from secondary sources. The use of the computer program made it possible to generate a sheet for each interview and summaries of citations for each type of code or theme. The figure 9 represents the workflow of the MAXQDA software.

Figure 9 - Process of qualitative data analysis



Source: MAXQDA

3 ANALYSIS AND DISCUSSION OF RESULTS

In this chapter, the results of ten interviews conducted at the time of data collection of this study are presented.

The analysis of the interviews implies the synthesis and categorization of the answers given by the interviewees. This analysis, supported by the MAXQDA software, facilitates the integration of the interviewees' perceptions, and makes it possible, with greater reliability, to conduct the matrix analyses that are presented below for each research question.

The codification process involved reading through the answers provided by the interviews and assigning codes to segments of data that were relevant to the research objectives and questions. The codes were chosen based on the themes and patterns that emerged from the data and were intended to capture the key concepts and ideas expressed by the participants. The goal of this process was to organize the data in a way that allowed for easier identification of relationships and trends, and to support the generation of meaningful insights and conclusions based on the findings.

The presentation of the results of the interviews is structured in three subsections. In all subsections, the expositions of the interviewees are presented, accompanied by quotations and the main comments included directly throughout the text, which help to support the result of the analysis. Throughout the analysis, the category codes and sub codes are placed for better identification and characterization.

1. With the research question **(RQ1)** Which ET is most often studied in accounting field? it is intended to achieve two specific objectives**: (SO1)** identify the ET on accounting and **(SO2)** identify accountants' familiarity with ET.

A. Familiarity with Technology

This codification aims to highlight which technologies were identified by the interviewees.

Interviewees highlighted ET in accounting in general, such as Robotics, Cloud computing and OCR.

> *"There are many technologies that are having an impact, such as Cloud computing and AI. Are information and communication technology tools that are changing the daily lives of professionals."*
> Code: ● Technology Identified I10

However, in the interviews it was possible to verify that most of the interviewees do not have specific knowledge about ET, such as blockchain, big data, many of them know that they exist but do not understand well how they work. In general, respondents recognize the importance of technology in accounting but admit to lack of knowledge regarding technologies such as blockchain and others.

> *"…I know the concepts, what impacts they're going to have on the profession, but if you ask me specifically, I understand everything about all of these topics, I don't."*
> Code: ● Lack of knowledge I10

Most of the participants still a lot of talk about tools such as excel and ERP's as technologies. It is noteworthy the lack of knowledge of some accountants in relation to the programs they use, even in relation to the potential of the ERP they use.

> *"Some accountants have an ERP, they pay for a license and they don't know they can use it and that it's powerful"*
> Code: ● Lack of knowledge I2

According to the interviewees, the implementation of technological solutions in accounting is a progressive reality, with automatisms and automatic integrations for accounting.

> *"Robotics will be very important to automate processes and take away the daily routines that are getting bigger and bigger."*
> Code: ● knowledge I5

Although there is not yet much AI, there are programs that digitize invoices and record accounting automatically. Digital accounting and the integration of invoicing directly through the finance portal have a lot of impact. The digital signature facilitates the process and the introduction of the technologies in accounting departments is a progressive reality, with large companies already developed and small businesses depending on service providers. Dependence on technologies is transversal to the whole of society.

According to the interviewees, technology is increasingly present in the day-to-day of companies, with the robotization and automation of processes. Visualizing data in dashboards allows to predict the future with more certainty.

The implementation of robots can help take away daily routines and automate processes, but it is important that people are still needed to ensure the reliability of information.

2. With the research question **(RQ2)** What are the roles and necessary skills for accountants in the organization? it is intended to achieve two specific objectives: **(SO3)** identify the skills and roles of future accountant and **(SO4)** identify the role of accounting education in the future of the profession

B. Training and Skills

In this code, the interviewees demonstrate their perception of the skills, the state of education, and the need to invest in training.

In general, the interviewees identify that the education system at undergraduate level must be adapted to the new reality of the digital age and the demands of the world of work. One of the interviewees said that research in education is one step behind the economy when it comes to knowing and using cutting-edge technology.

> *"I absolutely agree. Teaching must be changed... at this moment we are suffering from a paradigm that the university, academic study, was always at the forefront, it is not what happened in practice today. Today we have the Big 4 at the forefront of academic study, then the academic study what the Big 4 are doing and then pass it on to the others, I mean, there is a triangle here, a bit weird."*
>
> Code: ● Training and skills I5

The interviewees agree that universities should adapt their curricula to include more digital practices and technological tools, in addition to promoting interaction between universities and companies to train professionals who are better prepared for the job market. Technology should already be part of the curriculum. It is essential for accessing information and guarantees efficiency in various tasks.

> *"In the curricular units to have access to the Order, we have Taxation, Accounting and Management Accounting. The curricular unit of new technologies should also be because effectively, they are the guarantor of much of what we do."*
>
> Code: ● Training and skills I5

The student should leave college knowledgeable about digital tools and ET. To this end, the curricular plan should be readjusted, in a hybrid way, between the creation of new curricular units or the interconnection of the theme of technologies in the existing curricular units. One of the interviewees conveyed that he agrees that the curriculum in the first two years should be to learn accounting in a traditional way, but suggests that the

technology can be applied later, since in practice it will be all computerized through ERP's and other technologies.

> *".. the curricula themselves, the faculties themselves, without a doubt, have to adapt, because this would force the professors themselves, to also have this change on their side. Not only to have to investigate more about those topics, to have to adapt, maybe the way they teach the classes would probably even make the classes more interesting, therefore, it would captivate more people to study. In order to create even better prepared people, there is no doubt that curricula have to be tangent to evolution."*
>
> Code: ● Training and skills I3

Other interviewee mentioned that Universities should produce professionals with broader perspectives and stronger competencies, rather than narrow specialists with little practical knowledge. There is a lack of interaction between universities and companies.

> *" it would be the obligation of the faculties to produce future professionals with broader visions and with more reinforced skills in certain aspects. When an entry-level goes out into the market (...) There's no doubt about it. The bases will have to be there, but, they will no longer know how to work in terms of automation methodologies, they will not know how to connect with some legal aspects, they will not know how to make or develop tools, they are not aware of the development or use of computer tools that they may have on a daily basis, therefore, I think that there is still very little interaction between what universities are and what companies need."*
>
> Code: ● Training and skills I6

It was also highlighted that the large companies themselves should create colleges to train their employees, since in practice this is what happens, that is, the students who are admitted to the companies do not have technological knowledge, which ends up being the companies to teach and finance.

> *"I go even further than I think companies should be given the possibility and we are talking here about companies like the Big Four and large Portuguese listed companies. Why don't these companies have their own university, train their own resources with, obviously, with approved curricular plans and, with the approval of the authorities?"*
>
> Code: ● Training and skills I6

Even other interviewees mentioned that if nothing is changed in the teaching of undergraduate degrees, the student will become technologically illiterate.

> *"I think it has to be a hybrid. At the moment I don't know how the curriculum is if it's just accounting, but if there is it, the people who are there will be technologically illiterate."*
>
> Code: ● Training and skills I4

> *"... transversal skills at all levels and one of them in the technological area, without a doubt, an accountant today, without having skills in the technological area, has no chance"*
>
> Code: ● Digital Skills I5

In addition, the interviewees mentioned the challenge of introducing subjects such as programming, data security, big data, blockchain and AI in core degrees and cutting less relevant skills is discussed.

> *"... Data, security, fundamentally no programming, knowing how to move in areas in the cloud, blockchain, artificial intelligence and knowing how to make a connection between what is a company's strategy, financial strategy and digital strategy, all of this is important (...). I'm not sure where do we add them, in a 3 out of 3 year plan, we have to change the paradigm."*
>
> Code: ● Digital Skills I5

The bottleneck from 5 years to 3 years in integrated master's degrees and the importance of maintaining technical training, but also acquiring new skills, to change the paradigm of training in a three-year plan is mentioned.

Finally, the importance of internships and continuous training to update and improve skills is highlighted. In terms of training, it is seen as being continuous and necessary for the accountant to be able to adapt to new technologies.

> *"We're always learning (..). I think it made sense to invest in that, the more investment in ourselves and our wisdom we have, the better we will be in our profession."*
>
> Code: ● Training and skills I9

The need for investment in knowledge and the importance of learning how to use technological tools efficiently are also mentioned.

One interviewee believes that accountants should not wait for new software to be introduced, but instead should anticipate and prepare for it by working on their mindset. This will help them become more efficient and have more time for detailed work. The interviewee encourages proactive behavior in seeking information and taking courses to prepare for the changing world. The preparation should be positive and not based on fear.

> *"... make an anticipation in terms of mindset preparation and above all, also proactivity in the search for information in today's research, there is something that did not exist in the past, several online courses even LinkedIn has many courses with tools already to support these areas, for example, financial which I think are very interesting. And they are free, especially what is very good and there are others that are not free but are economically bearable."*
>
> Code: ● Identified Improvements I2

> *"In the case of newer technology, there should even be special sessions or the possibility of taking intensive courses for learning and handling tools."*
>
> Code: ● Training and skills I6

- **Technical Skills**

This codification aims to highlight the importance of technical skills in the accountant's profile and which technical skills to highlight.

In this code was undoubtedly highlighted the necessary knowledge about accounting, and taxation. Know-how will continue to be very important, even when IT systems may fail or fail to respond. In fact, someone must do this parameterization, which will necessarily have to have knowledge of accounting.

In terms of digital skills, Excel was highlighted as a basic tool but that many students and accountants do not know how to use in an advanced way, the same applies to ERP.

It's important to automate routine tasks to focus on delivering value to the customer. Excel is a fundamental tool, but many students struggle to use it.

> *"Excel, which is a tool that is generally used a lot in the area of accounting and people know how to do sums and little else. They can set up various mechanisms in the faculties to help with controls. People don't have this knowledge, we can say that it's relatively basic knowledge. People also need to have more ERP knowledge."*
>
> Code: ● Training and Skills I6

> *"Nowadays students, as everything has been made easier, end up not knowing how to do research and then they don't know how to work with word and Excel which are fundamental, especially Excel, there are a lot of people working and they do the basics"*
>
> Code: ● Soft Skills I7

Regardless of the brand, an ERP system boasts a plethora of features. However, accountants typically only have familiarity with the transactions and reports they commonly use. They may lack the time or capacity to explore techniques for streamlining tasks or adapting to evolving demands.

> *"You have to have digital skills to automate routine tasks as much as possible to be able to focus (...) in adding value to the customer from a perspective of analyzing trends and identifying areas for improvement and areas in which they already have good practices."*
>
> Code: ● Digital Skills I2

Databases, Power BI are other very prominent tools, which have not yet been explored much by accountants. Digital skills are essential for accountants, who must know how to use tools and analyze data to provide insights for business decision-making.

> *"Another area that accountants should be interested in, not only knowing how to use tools, but also knowing what data is there, what are the databases, the metadata and then analyzing them. And give insights for business decision-making."*
>
> Code: ● Digital Skills I2

AI, big data, cloud computing and blockchain were technologies that were little addressed.

- **Soft Skills**

In this codification, it is intended to highlight the importance of personal skills in the accountant's profile. The interviewees highlighted the interpersonal relationship with customers, communication, sense of responsibility and problem-solving.

> *"... I think he has to be very adaptable, in the sense that any problem that may arise, he can always find a solution, even if sometimes it is a bit complicated."*
>
> Code: ● Soft Skills I8

> *"... The main competence is to enjoy being with people and customers"*
>
> Code: ● Soft Skills I1

The main personal skills for an accountant include enjoying being with people and clients, having communication skills and generating consensus in meetings, being adaptable and able to solve problems, having availability and patience, being organized and able to work under pressure, and having commercial and relational skills to understand clients' needs and interact with other entities.

> *"An accountant has to have a lot of availability, patience. Yes, we do, without a doubt you have to be a person who is honest and hardworking and who enjoys what you do, because in my opinion, I think that to be an accountant you really have to like what you are doing"*
>
> Code: ● Soft Skills I9

In addition, it is important to have an open mindset and not be limited by rules, and to maintain values of compassion and empathy even in a technological age. Personal skills are as important as technical ones and must be brought by the professional, as they cannot be taught by superiors.

> *"The superiors will be here to give the instructions to the juniors to teach, to review or deepen technical topics, but your soft skills and your personal skills, if you don't bring them with you, no one will be able to teach you later."*
>
> Code: ● Soft Skills I6

These statements are aligned with the literature, since the gap is not new, and it is time to accounting programs must change to keep up with evolving entry-level positions. Failure to do so risks graduates being unable to find jobs or perform as expected (Sangster, 2022).

3. With the research question **(RQ3)** How can accountants improve the quality of their work and leverage the benefits of technology? it is intended to achieve three specific objectives: **(SO5)** identify the advantages and disadvantages of ET in the profession, **(SO6)** identify expectations/concerns in the adoption of ET and **(SO7)** identify tasks/processes that will change by technology adoption.

C. Impact and Expectations on the Profession

This codification covers the accounting profession and the expectations and impacts on the career where it is intended to highlight the opinion that the interviewees have about the accounting profession itself, both at the present and future levels.

In the interviews, it was possible to verify that there are several perspectives on the profession. Some take pleasure in what they do and feel valued. Others see accounting as a basis for progressing to less monotonous, more valued and value-added professions, such as management or auditing-related roles.

> *"The accountant has to turn to a more management area, taxation and support companies in managing clients' businesses. That is, you have to change this chip, if they continue to do the same, they will be out of work in a while, in my opinion."*
>
> Code: ● Identified Improvements I4

Some interviewees consider the profession monotonous and repetitive but recognize the importance of technology and constant updating to make the job more attractive. Others highlight the importance of accounting as a formal information system and an interconnecting element of financial and tax aspects. There is also mention of the need to diversify the areas of activity and seek complements to make the profession more attractive and well-paid. The interviews highlight the potential of accounting as a

competitive advantage for professionals and companies but highlight the resistance to change and the need for training and motivation to face the challenges.

Focus on market needs, provide services to clients, and emphasize the value of information. AI and big data are essential for creating value, and accountants must demonstrate this to clients.

> *"The work of accountants here also must be in the sense of showing the client, particularly in small companies, what the medium-term potential will be, I don't say in the short term, of this paradigm shift. I think there's still a lot of work to be done here."*
>
> Code: ● Identified Improvements I4

Scanning tools can help with classifying documents, but it still takes someone to check that they are correctly classified.

> *"I want to digitize as much as possible, and this even allows me to spend more time working from home."*
>
> Code: ● Identified Improvements I1

It's important for accountants to understand what's behind technology tools and not just rely on them to generate Value-added tax (VAT) returns.

> *"I have clients who need me more to sit down with them and think about the company in the medium and long term than complying with accounting and tax obligations, which I think is the focus of most of my colleagues' work."*
>
> Code: ● Identified Improvements I1

Accountants must be attentive to the needs of clients and businesses and offer services in addition to accountability to the tax authority. It is important to sell the importance of information to customers and show the medium-term potential of the paradigm shift.

> *"If the accountant is able to use digital tools, the time that will be left will be useful for planning, so that clients have more tax optimization, can better parameterize their systems and have enough data for later at the end of the year, when they make compliance have a more accurate compliance."*
>
> Code: ● Identified Improvements I2

Cooperation between accountants and technology consultants is key to adapting to change, and specialization in business management and tax consulting can offer differentiated services.

> *" The literature speaks of a paradigm shift of success, ie. Adopts a cooperative strategy rather than a competitive strategy."*
>
> Code: ● Identified Improvements I2

In the interviews, it was possible to gather insights that the accountant will excel/survive with the resistance to change, and with the adoption of technologies. The accountant will reduce repetitive tasks that do not add value, standing out as a consultant, supporting management decisions, using data, dashboards that allow the client/entrepreneur to value the accountant's role more.

> *"We're going to give another kind of quality of service, we're going to give some fiscal pedagogy, some financial pedagogy. We are going to explain to customers, how some procedures work, who do not know what a withholding tax is, what a social security is, basically what is going on with the company."*
>
> Code: ● Identified Improvements I1

Continuous training is essential to develop technical and accounting skills, especially for newer technologies. Training should include technical and relational skills, and accountants should play a management support role.

> *"The accountant will be able to help further by supporting, for example, the parameterization of management accounting. For after compliance is more correct and that creates tax optimization."*
>
> Code: ● Identified Improvements I2

> *"There has to be a proactivity and an initiative on the part of accountants in trying to understand that technology is coming and try to anticipate a little the entry of accountants into this world and prepare a little in this sense, but in a positive wa.y"*
>
> Code: ● Identified Improvements I3

- **Negative Influence of Technology on the Profession – Threat/Disadvantage**

This codification aims to show whether the adoption of technologies has/will have a negative influence on the accountant's role, and whether it can be seen as a threat.

In the interviews, it may be evident that technology will reduce some jobs, since fewer accountants will be needed to do the same work, on the other hand it will be necessary more profiles linked to robotics for the elaboration of automation robots. The age profile of accountants may also be an obstacle to the adoption of technologies, due to resistance to change.

> *"Many older colleagues are at that stage of life, already kind of walking to 60 thinking I will now be worrying about digitization? so in 5 or 6 years I retire."*
>
> Code: ● Threat - Negative influence I1

Many older accountants are worried about digitization and automation, fearing they will lose their jobs. Some customers prefer paper over digital, which can affect the transition to technology. Automation can lead to job losses and reduced staffing in accounting offices. Reliance on technology can lead to a loss of analytical and information processing skills. Data protection is a major concern. The training and updating of professionals are important to deal with these changes.

> *"We are not able to solve for us when there is a bug, when the application holds, we will still be in a phase of much dependence on the House software or on who develops the technology. That is my first fear."*
>
> Code: ● Threat - Negative influence I6

> *"A major concerns is that, when we are heavily dependent on technology, there are other aspects that are relevant, which is the question of how you will say about safeguarding the data of the security issue, data protection and other aspects, therefore, I think that there are concerned challenges."*
>
> Code: ● Threat - Negative influence I10

- **Positive Influence of Technology on the Profession – Opportunity/Advantage**

This codification aims to highlight whether the adoption of technologies has/will have a positive influence on the role of the accountant, and whether it can be seen as an opportunity.

In the interviews, it can be assessed that the interviewees understand that technology will be an opportunity for accountants to evolve, within their own functions, to stop being mere tax deliverers, having technologies that allow them to process data, automate tasks and perform tasks that without the use of technologies would not be possible to perform.

> *"It is time consuming that we are doing, we can effectively dedicate the time to tasks that are of the greatest added value, such as, for example, the review of the periodic declaration, and not so much afterwards be concerned with what is the physical filling and submission."*
>
> Code: ● Opportunity - Positive Influence I6

> *"It's going to make the role of the accountant more attractive honestly as a profession. And I think it's going to take away some of that label of not being the boring people on the financial side, the boring ones, the ones who always have the pencil behind their ear... I think it's going to break that side and make the profession more attractive. But for the people who want it."*
>
> Code: ● Opportunity - Positive Influence I3

The impact of technology on the accountancy profession is seen as an opportunity for accountants to become consultants and provide more value to their clients.

Financial literacy is seen as an important skill for accountants, who can help their clients with strategic planning and decision-making. Adapting to technology is seen as essential for survival in the profession, and accountants who adapt to new technologies have a competitive advantage.

Automating routine tasks allows accountants to focus on more value-added tasks, such as data analysis and consulting.

> *"The accountant has the most difficult thing, which is the data. Don't they say that data is the gold of the future? Accountants have all the data. They have the power to use them, they have to do more consulting in the planning and in the end look back and see the good practices."*
>
> Code: ● Opportunity - Positive Influence I2

Digitalization and automation are seen as positive challenges for the profession, but accountants need to prepare themselves to stay relevant.

> *"I think, without a doubt, that covid was a starting point here for companies to start developing more automatisms and not depend so much on the paper issue. I think companies have a key role to play in changing the mindset here and I think they should definitely invest in automation."*
>
> Code: ● Opportunity - Positive Influence I3

These statements are in line with the literature, technology can be seen as a threat, but it also offers opportunities (Kroon et al., 2021).

Summary Results

Table 14 represents the overview of the codes, the number of text segments that were coded and their corresponding percentages for each code. The highest proportion of codes, at 22,40%, is associated with identifying various ways in which technology can be utilized to improve the work of accountants.

Table 14 - Overview of codes

Color	Code	Cod. seg.	% Cod. seg.
	Threat - Negative influence	42	16.80
	Technology Identified	17	6.80
	Identified Improvements	56	22.40
	Digital Skills	14	5.60
	Training and education	39	15.60
	Lack of knowledge	5	2.00
	Opportunity - Positive Influence	48	19.20
	knowledge	14	5.60
	Soft Skills	15	6.00

Source: MAXQDA

From the analysis of the interviews, the impact of ET on the work of accounting professionals is that the accounting profession is changing its role and functions with the rise of ET as AI, Big Data, Cloud Computing, RPA. The relationship between accountants and technology is seen to make the accountant's job easier and provide more value to clients. Supporters see it as progress, while opponents fear many accountants will struggle to adapt.

It arises from the analysis of the results that *the link between emerging technologies and accountants' role and skills has not yet been mad*e as per Kroon et al. (2021) research.

Automating routine tasks allows accountants to devote more time to data analysis and tax planning, as well as offering consulting services in financial planning and business management. The standardization of digital tools is essential to facilitate the work of accountants, but it is important to have strong technical support for externally acquired applications and technologies. Familiarity with technology is essential to the evolution of the accounting professional.

Digital transformation and automation have improved the quality of life of accountants, as it allows the reduction of repetitive, non-value-added tasks, reducing hours and hours of work. The robots require organizations to rethink work, support employees, and invest in ongoing skills for success. As per C. (Abigail) Zhang et al. (2022) *RPA has the potential to change the way boring work and repetitive tasks are*.

To excel in accounting, it's not enough to simply have technical skills. It's equally important to have the ability to communicate complex ideas with clarity and precision.

Along with this, it's crucial to maintain a strong sense of ethics and professionalism, stay up to date with the latest legislation, and possess the analytical skills required to accurately analyze accounting treatments. By building a foundation of technical knowledge and developing new skills that meet the demands of the ever-evolving market, we can set ourselves up for success in the world of accounting. Overall, the interviews results are in line with the literature, there are certainly potential downsides of the adoption of technology in accounting (Marrone & Hazelton, 2019), however the human-machine cooperation is crucial for a promising future. Those with the right skills will thrive (Kruskopf et al., 2020).

Figure 10 presents the big picture of the 10 interviews scripts, which brings together the words referred to with the most occurrences.

Figure 10 - Word Cloud of interviews

Source: MAXQDA

4 GUIDELINE FOR TECHNOLOGY ADOPTION IN ACCOUNTING TASKS

This section makes recommendations based on the literature review and the results of the interviews presented in the previous chapters. In general terms, we can say that the interviews carried out in Portugal are align with what has already been mentioned in the literature, bearing in mind that the literature review is essentially from outside Portugal.

To answer the question:

How can accountants improve the quality of their work and leverage the benefits of technology?

are given examples to provide ideas on best practices, potential challenges, and strategies for overcoming obstacles.

RPA Readiness Assessment:

This study also responds to the demand for the creation of more practical and relevant research within the field of accounting. It accomplishes this by illustrating the practical application of attended automation, particularly with the utilization of RPA, within real accounting environments.

As per the case study outlined in the C. (Abigail) Zhang et al. (2022) article, the automated processes employing RPA include billing, bank reconciliations, and order entries. Tasks that adhere to well-defined rules are amenable to automation, while those requiring advanced skills and cognitive capabilities are better suited for human intervention in the workplace.

Process Identification and Prioritization:

First, companies start RPA robots with simple, low-risk processes to gain confidence and prepare for scaling up (Kokina & Blanchette, 2019). Automation of accounting tasks is an exciting development in the industry. Processes being automated include approval workflows, bank reconciliation, journal entries, and more (NetSuite, 2023).

Kokina & Blanchette (2019) refers to examples of simple robots:

Audit: A bot has been created for invoice retrieval during state audits, eradicating the need for manual extraction of invoices from the ERP system. This not only saves time but also enhances the overall quality of work life.

Consolidation: The system processes journal entries, particularly those pertaining to intercompany transactions, and automates reconciliation reviews for the consolidation team. It also facilitates the monthly and quarterly presentation for FP&A team, as well as the handling of tax payments for the treasury department.

Several: Back-office processes and gradually moved to a customer-facing process in which a bot assembles materials based on customer meetings scheduled in the calendar; Journey in finance and accounting by automating contract management on the procurement side, specifically, their services procurement area and it was planning on automating all reconciliations and activity around entering payments.

A suggestion of a simple robot to eliminate unnecessary work that can consume a lot depending on the ERP that is available and the number of accounting clients or subsidiaries, can be extract and save on folder financial statements on a monthly or periodic basis, such as the Trial Balance or the Balance Sheet.

Data Quality and Standardization:

According to Kokina & Blanchette (2019) the use of RPA can bring benefits to organizations even if they decide not to pursue it. Pre-RPA work can lead to questioning and improvement of processes, as well as the elimination of unnecessary ones. For automated processes, RPA offers improved visibility and measurement, which can aid in audit and compliance efforts and minimize risks. Additionally, RPA can help manage peak times for transactional work by allowing bots to work around the clock. Table 15 below can be an example of discriminating a process overview.

Table 15 - An Example of Process Overview

Area	Sub-area	Process
Operational accounting	Billing and collections	Create credit note for type x
		Create periodic bill for type y
		Create interim bill for type z
	Accounts receivable	…
General accounting	Allocations and adjust	…
	Journal entry processing	…

Source: (C. (Abigail) Zhang et al., 2022)

Pilot Implementation:

Based on Moffitt et al. (2018) research there are several RPA implementation stages that should be considered. Adapting to accounting procedures, companies should consider the following questions:

1. What accounting processes are prime candidates for automation?
2. How can accounting tasks be broken down into manageable steps conducive to automation?
3. Which accounting processes have the potential for automation?
4. Is the data available in a machine-readable format?
5. Building on prior assessments, which accounting procedures should be prioritized for automation?
6. Does RPA perform according to expectations during the prototyping phase?
7. Can we identify areas for enhancement through evaluation and feedback?

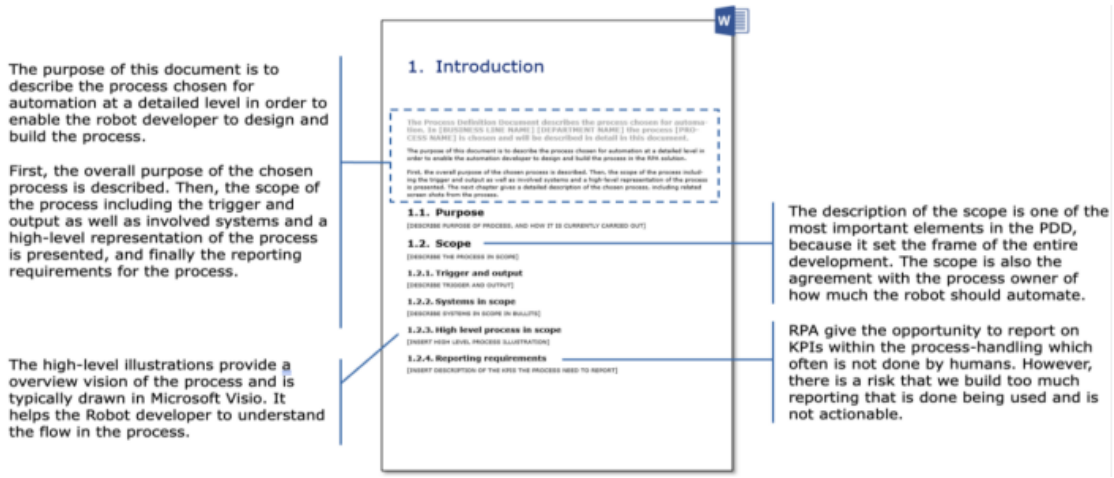
Table 16 and figure 11 below can help to populate and document the characteristics of the process.

Table 16 - An Example of Process Maturity Assessment Sheet

Process characteristics					
Is all input data in a digital format?	**How structured is the input data?**	**Are there any calculation during the process?**	**How many different routes can the process take?**	**Output Type**	**Is the process documented?**

Source: (C. (Abigail) Zhang et al., 2022)

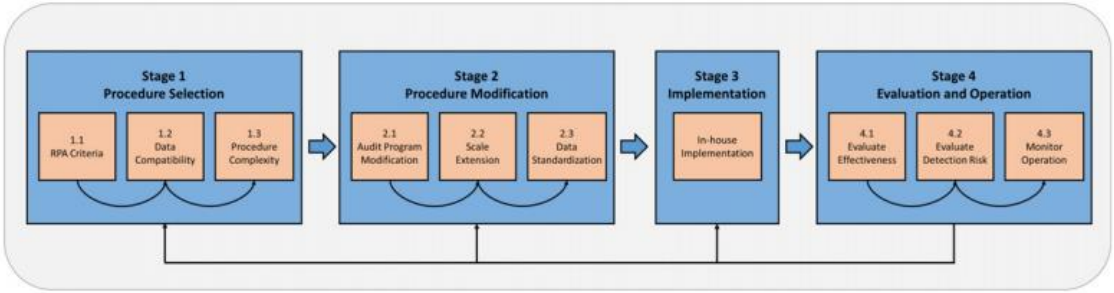
Figure 11 - An Example of the Process Definition Document (PDD)



Source: (C. (Abigail) Zhang et al., 2022)

A 4-stage framework is proposed by Huang & Vasarhelyi (2019) for applying RPA in audit practice (Figure 12). The results of a pilot project automating the confirmation process that can be applied to accounting practice are reported.

Figure 12 - 4-stage framework for RPA application



Source: (Huang & Vasarhelyi, 2019)

Huang & Vasarhelyi (2019) references an in-house pilot project conducted with the utilization of UiPath, a widely used RPA software package that offers free licenses for individual developers, small professional teams, and educational institutions. The research team acquired proficiency in using the software within a week by consulting online tutorials offered by the software provider.

To begin the steps to create a bot in UiPath software can be performed using the App/Web Recorder (Figure 13). Instead of selecting various activities like click, create file, folder, extract table data, etc., just click on the App/Web Recorder button that works like a VBA macro in Excel, thus creating robots that require only some user intervention. To add some complexity, rules and properties can be adjusted in the robot. For example, after or during the month close it is need extract the Trial Balance, Balance Sheets and other financial reports from the ERP of several companies or subsidiaries. It is a simple task but it does not add value and can take time, like extract, save and configure. In these cases, it can record the robot through the App/We Recorder and assign code to the robot to replicate this activity according to a list that we can add in the Notebook (figure 14).

Figure 13 - App/Web Recorder Uipath

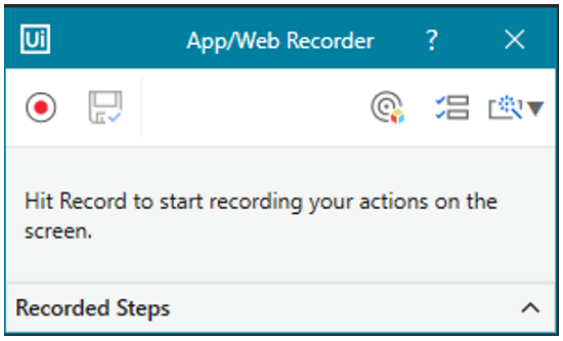
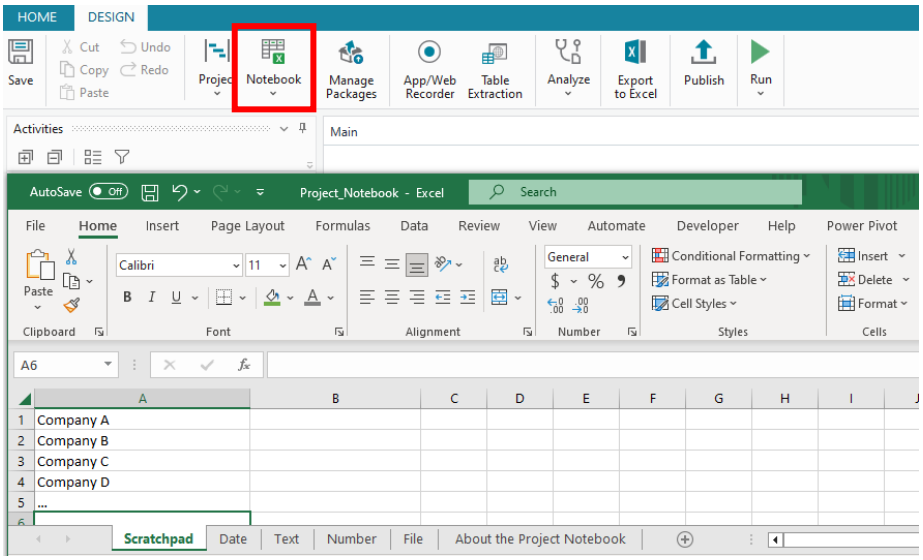


Figure 14 - Notebook function UiPath



It is important to explore the benefits of using RPA in accounting, and these valuable resources can help. Annex 1, authored by Kokina & Blanchette (2019), serves as an excellent starting point and provides practical examples of accounting processes that can be automated using RPA tasks. Annex 2, by Kokina & Blanchette (2019) presents an extensive list of accounting tasks that can be automated to enhance your workflow efficiency. To achieve a complete RPA implementation process, Annex 3 by Kokina et al. (2021) is a go-to guide. These resources will inspire the accountant to take their accounting processes to new heights.

Continuous Monitoring and Evaluation:

When it comes to evaluating the performance of RPA implementation, there are several metrics to consider. Table 17 provides some useful suggestions for measuring the effectiveness of RPA system (Kokina et al., 2021). By tracking metrics such as throughput time, error rate, and cost savings, it can gain valuable insights into the impact of RPA implementation on accounting processes.

Table 17 - Bot Key Performance Indicators

KPI Name	KPI Calculation
RPA Success Rate	Total number of invoices processed (including fallouts) / Total number of invoices loaded
RPA First Pass Rate	Total number of invoices processed without any intervention (no touch) / Total number of invoices processed
RPA Accuracy	Total number of invoices processed without errors / Total number of invoices processed
RPA Turn Around Time	Total number of invoices processed with-in agreed TAT / Total number of invoices processed

Source: (Kokina et al., 2021)

However, in Kokina & Blanchette (2019) research is suggesting that at the beginning instead of focusing on metrics, it should first determine what works and then evaluate metrics related to uptime and downtime the following year. They propose assessing outcomes at the end of each month to determine if processes were stable and if they were able to provide the expected output. If there were issues, they would inform the process owner and request that they complete the necessary work.

The use of bots in companies poses risks that senior management must be aware of and take proactive measures to mitigate. It is imperative that internal auditors possess a high level of technological proficiency to establish and enforce effective internal controls for managing the digital workforce. One example of a control measure referred in Kokina et al. (2021) is changing bot passwords every six hours is a strategy employed to mitigate the risk of cyber-attacks.

The adoption of modern tech requires accounting and finance teams to rethink control frameworks. Cyber risks can be managed with formal policies and procedures (Kokina et al., 2021).

The implementation of RPA involves several consistent steps across organizations. Establishing Centers of Excellence helps standardize bot protocols and replicate bot activities in different areas. Demonstrating quick wins through proof of concept is crucial in gaining traction for wider adoption of RPA. Standardizing and improving processes before developing the bot can enhance its performance and minimize exceptions (Kokina & Blanchette, 2019).

Training and Change Management:

According to C. (Abigail) Zhang et al. (2022), steps proposed to increase effective RPA adoption: train employees, improve communication, and IT governance.

The article presented by C. (Abigail) Zhang et al. (2022) describes a learning strategy for teaching RPA in a graduate-level accounting course. It leverages existing materials, teaches students RPA concepts and skills, can be integrated into existing courses, and offers resource sharing. It provides an alternative reference for accounting faculty teaching RPA.

Continuous learning is necessary to keep up with the changing and advancing fields of accounting, with many free ways to acquire the needed skills for the future. (Kruskopf et al. (2020) research give ways to expand one´s skills, such as Online Courses (for example, Coursera and, Udemy), training courses offered by own company, YouTube channels, LinkedIn trainings and Podcasts.

In Portugal, the OCC offers training, tutorials, and other materials such as practical guides for Chartered accountants (*https://ccclix.occ.pt/category/guias-praticos/).*

To thrive in the digital era, accountants must embrace a fresh mindset and a novel perspective when evaluating their roles. Consider the evolving technological landscape and strategize ways to enhance the quality of your accounting services and overall performance in your practice (The Pros of Accounting Services Digitalization for Accountants, n.d.). Accountants will demonstrate resilience and importance, adapting to trends to guide businesses forward (NetSuite, 2023).

In summary, preparing appropriate guidelines for adopting ET in accounting systems is essential for organizations seeking breakthrough synergies. Analyzing real-world examples and cases provides valuable insights and ideas for formulating these guidelines. By learning from the experiences of others and considering the specific needs of their own organizations, companies can effectively integrate ET and unlock the transformative potential of their accounting systems.

5 CONCLUSIONS

ET are reshaping the daily responsibilities of accountants, influencing the professional lives of countless individuals around the globe (Kroon et al., 2021).

Big data and advanced analytics tools, as well as cloud and AI, present fresh prospects and solutions for improving and adjusting accountants' capabilities within the intricate and fast-paced landscape of the digital era. ML and RPA are actively redefining the accounting approach, while continuous accounting leverages automation and other technological advancements to integrate tasks typically reserved for period-end procedures into the routine day-to-day activities.

Robotics and AI are at the center of change (Kruskopf et al., 2020) and humans will need to adapt to these changes. The fear that these changes will make humans obsolete is decreasing as we enter an age of human-machine cooperation.

The integration of technology into accounting practices has revolutionized the way financial information is processed, analyzed, and communicated. The accountant's job is often routine and stressful. The month close requires time and task management with very short deadlines. With the use of technology, automating tasks and processes, it is possible to reduce the manual entry of accounting entries, allowing them to allocate more time and resources to high-value activities such as analysis, forecasting, and strategic decision-making. The same is happening in Portugal, with the high level of reporting to various entities that Chartered Accountant must do, feeling like Government workers. Technology fit-for-purpose in accounting is undoubtedly a paradigm shift.

Furthermore, technological advancements have facilitated real-time data processing and improved accuracy in financial reporting. With cloud computing, accountants can access and update financial data from anywhere and at any time, ensuring timeliness and accuracy in their work. This enables accountants to provide more up-to-date information to stakeholders, enhancing the decision-making process and enabling businesses to respond swiftly to market changes.

However, it is important to note that technological advancements also bring challenges and risks that accountants must navigate (Abad-Segura & González-Zamar, 2020). The rapid pace of change necessitates ongoing professional development to ensure

accountants remain up to date with the latest tools and practices. Additionally, increased reliance on technology introduces cybersecurity concerns, requiring accountants to possess knowledge and skills to safeguard sensitive financial data and protect against cyber threats.

As technology continues to advance at an unprecedented pace, it becomes crucial for accountants to adapt to these changes to remain effective and relevant in their profession. To adapt to the changing landscape of accounting work, it is crucial to understand emerging roles and engage in digital upskilling efforts (Kokina et al., 2021).

To successfully embrace technological changes and be part of the system, accountants must demonstrate a willingness to learn and adapt. Continuous professional development and staying abreast of technological advancements are essential. Accountants need to develop skills in data analytics, AI, and cybersecurity to effectively utilize ET in their work. Moreover, they should actively seek opportunities to collaborate with technology experts and participate in interdisciplinary projects to enhance their understanding and integration of technology.

It is crucial to acknowledge that entry-level positions have been changing rapidly for the past decade. Therefore, it is essential to update the accounting programs to prevent them from becoming obsolete. It is needed to make these changes before accounting graduates face the challenge of not being able to find entry-level positions or struggling to meet their employer's expectations after being hired (Sangster, 2022).

Incorporating technology into accounting procedures brings forth a multitude of advantages, encompassing enhanced efficiency, precision, collaboration, and communication. However, it also poses challenges that accountants need to navigate skillfully. By continuously learning, adapting, and staying updated with the latest technological advancements, accountants can position themselves as valuable assets in the digital era of accounting.

5.1 Main Contributions

The digital age brings with it new challenges and opportunities for the accountant, transforming the way accountants think from looking backward to looking forward and calculating and forecasting the future.

The insights presented in this study are highly valuable for those involved in the accounting profession, including professional bodies, regulators, and educational institutions. The findings emphasize the importance of adapting standards to the current digital landscape, as failure to do so may lead to underutilization of existing tools by professionals. Educational institutions should take note of this and update their accounting programs accordingly to equip students with the necessary skills to thrive in the evolving industry (Y. Zhang et al., 2020). Accounting programs need to listen to employers and adapt to changing demands, teaching critical thinking skills through principles of double entry. Collaboration and partnership between accounting educators and industry are prerequisites for the successful accounting career of graduates.

It also contributes to shaping the roles and skills required for future accountants. The expectations for accountants now encompass more value-added responsibilities like financial management and data-driven decision-making. Therefore, higher education institutions should maintain their focus on providing a well-rounded liberal education rather than solely emphasizing professional training.

This work encourages experts to embrace new technologies and provide opportunities to reflect on the risks involved and threats.

It's crucial to not only work hard but also work smart by using technology that is fit-for-purpose. Technology allows the tasks of the accountant that are referred to as boring, devaluing or without added value to be automated, thus making a hybrid job between man and machine. This work is intended to give a boost to accountants who have not yet embraced technology to their advantage.

This research provides a comprehensive set of guidelines that can be used to effectively apply technology in the field of accounting.

This work was conducted after submitting and accepting articles for conferences such as:

- Journal *"Contabilidade & Empresas"*, of the *Vida Económica* group, November and December 2022 edition, participation as co-author of the article Emerging technologies in accounting and the future of the profession, being the first page of the paper in Appendix 5.

- 56th World Continuous Auditing and Reporting Symposium, which took place in Madrid, Spain between April 27 and 28, 2023, whose presentation was the subject of discussion and suggestions from experts, senior researchers in the field of technologies applied to accounting, as per certificate of participation in Appendix 6.
- 18th Iberian Conference on Information Systems and Technologies (CISTI) which took place in Aveiro, Portugal, between June 20 and 23, 2023, being the first page of the paper in Appendix 7.

5.2 Limitations

This section aims to provide an overview of the primary limitations encountered during the work and the corresponding measures taken to address them.

Although this study has made valuable contributions, it is important to acknowledge its limitations. The current coverage of accounting technologies is limited in scope as it only caters to a few types, while other types remain unaddressed. As a result, it could not provide detailed descriptions for each one of them. This suggests that further research is required to develop a more thorough comprehension of accounting technologies.

Despite the diverse range of interviewees, it is important to note that this study has a limitation in that the sample selected by the researcher is a convenience sample as opposed to a random sample. Although the sample includes a diverse range of participants, the non-random selection process could affect the study's findings' generalizability.

This work had some limitations in the collection and processing of interview data, since it was not possible to transcribe it into text along with the audio recording, but these were mitigated by transcribing it into text and acquiring a license for the MAXQDA program. The limitations in data processing impacted the exploratory work resulting from the interviews.

5.3 Future Work

The rapidly evolving landscape of robotics and AI demands that humans adapt to this new reality. Though some may fear that such advancements will make humans irrelevant,

research indicates that we are entering an era of symbiotic cooperation between man and machine, one that is expected to persist well into the future. Nonetheless, many institutions continue to grapple with the implications of Industry 4.0 and struggle to secure the talent they need to adapt to these transformative changes (Kruskopf et al., 2020).

RPA integration into accounting tasks has yielded significant benefits. A comprehensive case study is the best way to showcase its potential advantages. This case study should offer detailed information on the implementation process, challenges, opportunities, best practices, and impact on accounting functions.

Conducting a survey would be a valuable approach to gain insights into the readiness of accounting students for the digital age. The survey's purpose would be to evaluate the present level of digital skills and familiarity with ET among accounting students. This data can be employed to pinpoint areas requiring improvement and to create specific interventions aimed at equipping accounting students with the necessary skills and knowledge to excel in their future careers.

This gap opens avenues for future research, including questions such as: Can large corporations and governments facilitate the adoption of new technologies? In what ways can they support SMEs in adopting these technologies?

The research explores the increasing interest in ET, including AI, Big Data, Blockchain, and RPA, and proposes that these technologies be studied through collaborative research involving both academia and industry practitioners. Collaborative research endeavors have the potential to advance the evolution of professional accountants' roles and set the foundation for the next generation of professional engagement standards. Additionally, the insights gained from the integration of ET in accounting could lead to potential revisions in university curricula and teaching methods for accounting educators in the future.

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APPENDICES

APPENDIX 1. Informed Consent (EN)

Title of Research Study: The future of Accountants - Emerging Technologies in Accounting

Researcher: Ana Ferreira

Researcher's Contact Information: Ana Ferreira, Phone #: 966859517, Email: ana.ma.ferreira21@gmail.com

Organization of Researcher: Higher Institute of Accounting and Administration of Coimbra

INFORMED CONSENT

This document serves as an informed consent form, providing you with the necessary information to make an informed decision about whether to participate in this study. Please read this document carefully and thoroughly to ensure you understand the study's purpose, procedures, risks, and benefits.

STUDY DETAILS

• Purpose: This study aims to investigate the implications of emerging technologies in the field of accounting. The purpose of the study is to provide valuable insight into the potential impacts of these technologies on the accounting profession, and to better understand how accounting professionals can prepare for these changes.

• Duration: approximately one hour (for interview session).

• Summary of Procedures: If you decide to participate in this study, you will be invited to take part in an interview. During the interview, we will ask a series of questions to gain insight into your thoughts, hopes, and concerns related to the current technologies being implemented in the accounting profession.

Upon receiving your contact information, I will directly reach out to you via email or message to confirm your participation in the study. Once confirmed, we will schedule an interview at a time that works best for your schedule.

• Benefits: While there are no direct benefits to you, your participation in this study will greatly benefit the accounting profession as a whole. By providing us with valuable

insight about the potential changes that may arise from the implementation of emerging technologies, you will help to inform and prepare accounting students and professionals for the future.

• Risks: Rest assured that your privacy is our top priority. We will take all necessary precautions to ensure that all personally identifiable information is kept out of the thesis report and deleted upon conclusion of the study.

• Data privacy: Please be assured that we will take every measure to ensure that your study records remain confidential. Please know that the Ana Ferreira will have access to the study records. However, we will abide by all current legal requirements and keep your records absolutely confidential unless required by law or as outlined in this document. Your personal information, including your name, will not be disclosed or published in any manner. It is important to note that the results of this study may be shared through publication and/or presentations. However, you will remain anonymous and will not be identified as a participant.

• Contact for questions: Should you have any questions or concerns regarding your confidentiality or privacy, please don't hesitate to contact Ana Ferreira, iscac5137@alumni.iscac.pt.

Thank you for considering participating in this study.

_____ _____

Signature of Participant Date

_____ _____

Signature of Researcher Date

APPENDIX 2. Informed Consent (PT)

Título do Estudo de Pesquisa: O futuro dos Contabilistas - Tecnologias Emergentes em Contabilidade

Investigadora responsável: Ana Ferreira

Dados de contacto do investigador responsável: Ana Ferreira, Telefone: 966859517, Email: ana.ma.ferreira21@gmail.com

Organização de Investigador Principal: Instituto Superior de Contabilidade e Administração de Coimbra

CONSENTIMENTO INFORMADO

Este documento serve como um termo de consentimento livre e esclarecido, fornecendo as informações necessárias para tomar uma decisão informada sobre a participação ou não neste estudo. Por favor, leia este documento com atenção e cuidado para garantir que você entenda o propósito, procedimentos, riscos e benefícios do estudo.

DETALHES DO ESTUDO

• Objetivo: Este estudo tem como objetivo investigar as implicações das tecnologias emergentes no campo da contabilidade. O objetivo do estudo é fornecer informações valiosas sobre os potenciais impactos dessas tecnologias na profissão contábil e entender melhor como os profissionais da contabilidade podem se preparar para essas mudanças.

• Duração: aproximadamente uma hora (para sessão de entrevista).

• Resumo dos Procedimentos: Se decidir participar neste estudo, será convidado a participar numa entrevista. Durante a entrevista, faremos uma série de perguntas para obter informações sobre seus pensamentos, esperanças e preocupações relacionadas às tecnologias atuais que estão sendo implementadas na profissão contábil. Ao receber suas informações de contato, entrarei em contato diretamente com você por e-mail ou mensagem para confirmar sua participação no estudo. Uma vez confirmada, agendaremos uma entrevista no horário que melhor se adequar à sua agenda.

• Benefícios: Embora não haja benefícios diretos para você, sua participação neste estudo beneficiará muito a profissão contábil como um todo. Ao nos fornecer informações valiosas sobre as mudanças potenciais que podem surgir da implementação de tecnologias

emergentes, você ajudará a informar e preparar estudantes e profissionais de contabilidade para o futuro.

• Riscos: Tenha a certeza de que a sua privacidade é a nossa principal prioridade. Tomaremos todas as precauções necessárias para garantir que todas as informações pessoalmente identificáveis sejam mantidas fora do relatório de tese e excluídas após a conclusão do estudo.

• Privacidade de dados: Tenha certeza de que tomaremos todas as medidas para garantir que seus registros de estudo permaneçam confidenciais. Saiba que a Ana Ferreira terá acesso aos registos do estudo. No entanto, cumpriremos todos os requisitos legais atuais e manteremos seus registros absolutamente confidenciais, a menos que exigido por lei ou conforme descrito neste documento. As suas informações pessoais, incluindo o seu nome, não serão divulgadas ou publicadas de qualquer forma. É importante notar que os resultados deste estudo podem ser partilhados através de publicações e/ou apresentações. No entanto, permanecerá anónimo e não será identificado como participante.

• Contacto em caso de dúvidas: Caso tenha alguma questão ou preocupação relativamente à sua confidencialidade ou privacidade, não hesite em contactar Ana Ferreira, iscac5137@alumni.iscac.pt.

Obrigado por considerar participar neste estudo.

Assinatura do Participante Data

_____ _____

Assinatura do Investigador Data

_____ _____

APPENDIX 3. Interview Guiding Script (EN)

– Prior information

The interviewee should be reminded that this interview is conducted in an academic context, and the information collected is used solely for this purpose, ensuring the confidentiality of the data provided by the interviewee, and these are not disclosed to any entity in an individualized way that allows identifying the person who made them available.

– Framework and objectives of the interview

Frame the research as to the triggering and university:

Research of master's thesis in Management Information Systems, on the theme The future of Accountants - Emerging Technologies in Accounting

ISCAC – Coimbra Business School under the guidance of Prof. Isabel Pedrosa

– Characterization

Identification of the interviewee (name, age, gender, area of residence, professional activity)

Questions per section:

Familiarity with emerging technologies

1- How will the role of accountants change as new technologies emerge?

2- Do you think some technologies may be more impactful than others? If so, what would they be?

3- How do you intend, within your work team, to adopt emerging technologies, considering people, processes and structure?

Training and Skills

4- What skills should you have to be a good accountant?

5- Is the stereotype that accounting is boring and monotonous true?

6- What do you like most about being an accountant?

7- After becoming an accountant, do you think there is space for growth and diversity? That is, does the accountant have room to diversify his work, in terms of optimizing his work?

8- Is there a lack of digital skills of accounting professionals in this digital age?

9- Would it make sense for curricular plans to incorporate technology-related themes?

Impact and expectations in the profession

10- What are your expectations for integrating automation into your Portuguese accounting department?

11- What concerns do you have about this automation integration?

12- Do you think people are concerned about accountants being overly reliant on technology?

13- In your opinion, how can accounting professionals prepare for the next technological changes?

14- Will accounting SMEs be affected differently or more severely than larger companies?

APPENDIX 4. Interview Guiding Script (PT)

Guião Orientador da Entrevista (PT)

– Informação prévia

O entrevistado deverá ser relembrado de que a presente entrevista é conduzida num contexto académico, sendo a informação recolhida utilizada unicamente para esse fim, garantindo a confidencialidade dos dados disponibilizados pelo entrevistado, não sendo estes divulgados junto de qualquer entidade de forma individualizada que permita identificar a pessoa que os disponibilizou.

– Enquadramento e objetivos da entrevista

Enquadrar a investigação quanto ao desencadeamento e universidade:

Investigação de tese de mestrado em Sistemas de Informação de Gestão, sobre o tema Tecnologias Emergentes na Contabilidade, e o futuro do contabilista

ISCAC – Coimbra Business School sobre a orientação da Prof. Isabel Pedrosa

– Caracterização

Identificação do entrevistado (nome, idade, género, área de residência, atividade profissional)

Questões por secção:

Familiaridade com as tecnologias emergentes

1- Como mudará o papel do contabilista com o surgimento de tecnologias emergentes?

2- Existem certas tecnologias que considera como potencialmente mais impactantes do que outras? Se sim, quais seriam?

3- Como tenciona, no âmbito da sua equipa de trabalho, adotar as tecnologias emergentes, considerando pessoas, processos e estrutura?

Formação e Competências

4- Que competências deve ter para ser um bom contabilista?
5- O estereótipo de que a contabilidade é aborrecida e monótona é verdade?
6- O que você mais gosta em ser contabilista?
7- Depois de se tornar um contabilista, acha há espaço para crescimento e diversidade? Ou seja o contabilista tem espaço para diversificar o seu trabalho, no que se refere a optimizar o seu trabalho?
8- Falta competências digitais dos profissionais de contabilidade nesta era digital?
9- Faria sentido os planos curriculares incorporarem temas relacionados com a tecnologia?

Impacto e expectativas na profissão

10- Quais são as suas expectativas para a integração de automação em departamentos de contabilidade em Portugal?
11- Quais são as suas preocupações em relação à referida integração de automação?
12- Acredita que haverá alguma preocupação em relação aos contabilistas se tornarem excessivamente dependente da tecnologia?
13- Na sua opinião, como podem os profissionais de contabilidade preparar-se para as próximas mudanças tecnológicas?
14- As PMEs de contabilidade serão afetadas de forma diferente ou mais significativa do que empresas de maior dimensão?

APPENDIX 5. Article published in Magazine "*Contabilidade & Empresas*"

Tecnologias emergentes em contabilidade e o futuro da profissão


ANA FERREIRA
ISCAC
Coimbra Business School


ISABEL PEDROSA
ISCAC
Coimbra Business School


MIGUEL GONÇALVES
ISCAC
Coimbra Business School


LARA MENDES
ISCAC
Coimbra Business School

1. Introdução

Nos últimos 25 anos, as tecnologias de informação e comunicação (TIC) contribuíram para uma mudança profunda e irreversível na vida quotidiana da sociedade, em geral, ena contabilidade, em particular.

Com efeito, nesta área científica do saber – a contabilidade –, o desempenho obtido pelas TIC é incomparavelmente superior ao conseguido pelos modelos e procedimentos tradicionais existentes antes do advento da informática. Eis um exemplo, para fixar ideias: a tecnologia genérica comummente denominada inteligência artificial, permitindo a automatização do cumprimento de obrigações fiscais, trouxe consigo um alívio das tarefas mais repetitivas e rotineiras do contabilista certificado, proporcionando condições para que este profissional pudesse dedicar mais tempo de qualidade à atividade de consultoria, em especial àquela conferente de valor acrescentado às organizações.

A disrupção tecnológica a que presentemente se assiste na contabilidade (e em áreas conexas) concorre, inevitavelmente, para que o seu futuro seja substancialmente diferente do seu tempo presente, designadamente no quadro de três dimensões principais: (1) a profissão, (2) o ensino e (3) os modelos de negócio das empresas de contabilidade, sejam elas individuais ou coletivas (Ferreira e Marracho, 2022). De forma mais circunstanciada, tecnologias como a *big data*, a computação em nuvem (*cloud*), a inteligência artificial ou a realidade virtual, por exemplo, irão impactar (1) a profissão, em termos de um novo portefólio de competências a adquirir (e.g., técnicas, tecnológicas, analíticas, sociais e emocionais), (2) o ensino da contabilidade, em função de novas unidades curriculares a criar (e.g., *Programação, Computação em Nuvem, Dados e Segurança, Inteligência Artificial*) e (3) os modelos de negócio das empresas de contabilidade, mais virados no futuro para um elevado uso de tecnologia, o que se traduzirá numa contabilidade totalmente automatizada e digitalizada e num posicionamento do contabilista, que de *confiança* junto das organizações evoluirá para um posicionamento que se deseja de *indispensabilidade* junto dessas mesmas entidades (Ferreira e Marracho, 2022).

Sob este pano de fundo, o objetivo deste artigo é promover uma breve reflexão sobre o uso de tecnologias emergentes em contabilidade e o futuro da profissão. Com isto em mente, o texto prossegue com a segunda secção, a qual concretiza de um ponto de vista mais abrangente e compreensivo a noção de tecnologias emergentes em contabilidade. A finalizar, a terceira secção apresenta a conclusão do estudo.

2. Tecnologias emergentes em contabilidade

Há muito que se diz que a tecnologia é ubíqua, ou seja, está em todo o lado (Leung, 2011). Esta omnipresença vem tendo impacto, em especial nas últimas décadas, em muitas profissões e funções. Muitas já desapareceram e outras tendem a desaparecer ou passarão por um processo obrigatório de reinvenção; daí, não raramente, estas tecnologias serem também referidas como *tecnologias disruptivas*, precisamente pelo impacto que têm na vida pessoal e profissional de quem as utiliza e até mesmo de quem as não utiliza (sendo, neste caso, pelo efeito de exclusão).

Tecnologias emergentes ou disruptivas incluem *robotic processautomation* (RPA) (automatização robótica de processos), inteligência artificial, *blockchain*[1], contratos

1 - Blockchainé uma tecnologia de registos distribuídos que armazena a informação em blocos (ou lotes), guardados de forma sequencial e em cadeia (chain), sendo que cada bloco recebe um código único (hash) que não deve ser mudado, já que uma modificação gera novo hashe novo bloco e não uma atualização do anterior. Cada transação é verificada por várias máquinas em simultâneo, o que a torna mais segura. Blockchain está associada ao conceito de internet do valor (ou seja, da veracidade dos dados e da confiança que podemos depositar nas transações) e tem sido apresentada como a maior novidade depois do aparecimento da internet. A blockchain pode estar presente, por exemplo, em transações de criptomoedas, ou em transações financeiras em geral, identidades digitais e contratos.

APPENDIX 6. Certificate of Participation 56th WCARS

CERTIFICATE OF PARTICIPATION

The paper entitled

«Emerging technologies, the opportunity for accountants to shine».

by

Ana Ferreira and Isabel Pedrosa,

has been presented in the 56th World Continuous Auditing and Reporting Symposium. Banco de España, Madrid, Spain.
27th – 28th April 2023.

BONSON PONTE ENRIQUE - 29737349M

Enrique Bonsón
Conference Co-chair

aeca Asociación Española de Contabilidad y Administración de Empresas

BANCO DE ESPAÑA Eurosistema

BiDA

RUTGERS Rutgers Business School Newark and New Brunswick

APPENDIX 7. Paper published in CISTI 2023

Emerging Technologies, the opportunity for accountants to shine – An literature review

Ana Ferreira
Polytechnic Institute of Coimbra,
Coimbra Business School, 3045-601
Coimbra, Portugal
iscac5137@alumni.iscac.pt

Isabel Pedrosa
Polytechnic Institute of Coimbra, Coimbra Business School,
3045-601 Coimbra
ISTAR - Instituto Universitário de Lisboa
Portugal
ipedrosa@iscac.pt

Abstract — Emerging technologies are changing the accounting paradigm. "It has always been done this way" will certainly be an old expression that will become outdated. More than ever, accountants need to acquire technological skills to be successful. This article reviews the literature to understand the associated concepts of emerging technologies in accounting with a particular emphasis on Portugal. An initial selection of keywords was made to be the core of this article. Subsequently, the selection of information sources that contained information within the scope of these concepts was carried out. This article intends to determine which emerging technologies are most studied considering their impact on the role and skills of the accountant. The aim of this work is to contribute to the evolution and resilience of current and future accountants in the face of emerging technologies.

Keywords – accountant; accounting; artificial intelligence, emerging technologies; Big Data; Blockchain; Automation; Robotic Process Automation; Skills

I. INTRODUCTION

The accounting of the past, surrounded by big and heavy books, papers, and even more papers, was a picture of passive and "analogic" accounting. Accounting, written in the present and anticipated in the future, is done by active, business-oriented accountants using digital tools. Various studies predict that some professions will become obsolete or "die" in the next few years. In fact, in 2020, the COVID-19 pandemic accelerated the adoption of technology across industries, and accounting was no exception. While some experts predict an uncertain future for accountants in a digital world, technologies such as cloud-based data management, robotic process automation, and advanced analytics present opportunities for accountants. The incorporation of automation and innovative technologies enables accountants to perform tasks more efficiently, and in less time, allowing them to perform more complex and higher value-added tasks.

In fact, it's not the first time technology has impacted accounting, digitization is happening, which means engagement is needed. Technology adoption is inevitable, the definition of an accountant needs to be rethought, with regard to the skills needed to be a successful accountant.

The profession of accountant is of great responsibility, it is perhaps one of the most demanding professions from the point of view of knowledge and updating, however in Portugal it is not highly valued. Due to the workload of meeting legal and tax deadlines, the accountant is often unable to stop to optimize repetitive tasks that prevent him from having time to analyse data and extract insights.

Paula Franco, the chairwoman of the Portuguese Institute of Chartered Accountants stated in a webinar on technology in 2022 that the multiplicity of tasks, very administrative and not very challenging, make the accountant's career not very interesting. In order to be a successful Chartered Accountant, it is necessary to minimize tasks that do not add value. Technology is extremely important in helping the business to offload paper-based and routine tasks, use and dematerialize IT mechanisms. Until 2022, the technological aspect of specific training for accountants in Portugal was in fact very scarce. Small steps have begun to be seen in offering online training on digital tools.

The purpose of this paper, based on a literature review, is to reflect on challenges and responses from emerging technologies to support accounting. It seeks to unveil the accounting discipline's new challenges that need technology so much. The main goal of this study is to research the impact of emerging technologies on the work of the accountant and assess the necessary digital skills that Accountants need to develop, given the new paradigm in Accounting, a result of the 4th Industrial Revolution.

This article is organized as follows: the second section presents the methodology, the third is the literature review and the fourth is the discussion. The paper concludes by briefly expanding on suggestions for future research-

https://ieeexplore.ieee.org/document/10211334

ANNEXES

ANNEX 1. Automated accounting and finance tasks (Kokina & Blanchette, 2019)

Appendix A

Accounting task automation by area.

Panel A: Order-to-cash

Example area/task	Description of procedures	Task category
Customer Masterfile		
Customer creation	Using predefined parameters, the robot creates a new customer in the accounting system. If errors or exceptions are encountered in customer set up, the robot will inform necessary parties of the follow up required. Once the exception is resolved, the robot will complete customer creation.	1, 2, 4, 5, 6, 7, 11
Customer data maintenance	The robot prepares authorization request to make changes to the customer master data file. Once approved, the robot updates the data in the customer master file.	1, 2, 5, 6 , 9, 11
Customer credit limits	The robot can provide new credit or adjust credit limits for an account based upon predefined parameters.	2, 6, 7
Loan and bank account applications	The robot checks email to obtain new customer applications for loans and/or bank accounts. The robot gathers selected information from web applications and transfers information into system.	1, 2, 4, 6, 12
VAT validation	The robot verifies customer provided VAT registration number with the appropriate authority (i.e., European Commission). If an exception is identified, the robot will forward the information via email to the necessary parties.	1, 6, 11, 12
Order entry		
Order entry	The robot can scan customer order form using optical character recognition and input order information into the accounting system.	2, 5, 6, 9
Invoicing		
Invoice preparation	The robot prepares invoice based upon obtaining information from internal reports for revenue activity. In addition, the robot adds details to invoice based upon predefined parameters.	2, 4, 5, 6, 7, 9
Time and material invoicing	For time and material invoicing, the robot accesses a job report within the accounting system to obtain necessary information to create an invoice based upon time and materials.	2, 4, 5, 6, 7, 9
Service invoicing	The robot prepares and issues invoices for service related activity based upon verifying service has been provided. If an exception is identified, the robot will forward the information via email to the necessary parties to resolve the matter.	1, 2, 4, 5, 6, 9, 11
Invoice exceptions	The robot uses predefined parameters to identify exceptions in invoicing. If an exception is identified, the robot will forward the information via email to the necessary parties. For those without exceptions, invoices are sent to the customer electronically by the robot.	1, 2, 7, 11
Re-invoicing	The robot updates invoice information based upon data provided and can resend invoice to customer electronically.	1, 2, 4, 5, 6
Cash receipts		
Identification of duplicate payments	The robot looks for duplicate checks in the accounting system using algorithms.	1, 2, 6, 8, 9, 11
Cash application	The robot can apply cash based upon predetermined algorithms. The robot can use optical character recognition or interpret payment remittance information.	2, 6, 7
Resolution process		
Customer follow up	Based upon predefined parameters, the robot can send a late payment email to the customer.	1, 2, 6, 7, 11
Issue identification and support	Based upon predetermined parameters, the robot finds supporting documentation for identified customer disputes and/or customer orders. Based upon predetermined parameters, the robot will provide the supporting information for the particular issue to the necessary parties via email.	1, 2, 6, 7, 11
Client communication	The robot determines if "selected" invoices have been paid through searches of various financial systems and updates this information in Excel. For those invoices remaining unpaid, the robot will update Excel to provide customer reasons why invoice has not been paid. Based upon predetermined parameters the robot will send the customer an email communication about the next steps.	1, 2, 4, 5, 7, 9, 11

Panel B: Procure-to-pay

Example area/task	Description of procedures	Task category

21

Vendor master file information		
Vendor creation	Using predefined parameters, the robot creates a new vendor in the accounting system. If errors or exceptions are encountered in vendor set up, the robot will inform necessary parties of the follow up required. Once exception is resolved, the robot completes the vendor creation.	1, 2, 4, 5, 6, 7, 11
Purchase order activity		
Purchase order creation	Based upon data collected from MRP system and predefined parameters, the robot creates the purchase order. Once created the robot sends the purchase order to the necessary parties for approval.	1, 2, 6, 7, 9, 11
Purchase order modification	The robot updates purchase order based upon data provided.	2, 4, 5, 6
Open purchase orders	The robot obtains a report from system of all open purchase orders. This information is downloaded into an Excel template and the robot sends the report to the necessary parties for follow up.	1, 2, 6, 9, 11
Invoice processing		
Incomplete invoice information	Based upon predefined parameters, the robot identifies invoices with incomplete information and updates this to an Excel exception report. The robot sends an email to the vendor with the invoice and supporting details required. After information has been provided by the customer, the robot will update the system information and Excel exception file and inform the necessary parties.	1, 2, 4, 5, 6, 7, 9, 11
Audit and review of travel invoices	The robot obtains travel invoices and compares this information to Excel data to validate, upload and email the information to the appropriate party for review and authorization.	1, 2, 3, 7, 9, 11
Preparation of procure-to-pay reports	The robot downloads files based upon predetermined parameters files from the accounting system. The robot uses the information in these files to populate a template. The robot uploads template to client system.	2, 3, 4, 5, 7
Unpaid invoice related issues	The robot determines if "selected" invoices were paid through searches of various financial systems and updates this information in Excel. For those invoices remaining unpaid, the robot will update Excel to provide the reasons why the invoice remains unpaid. Based upon predetermined parameters the robot will send the vendor an email communication about required information or payment status.	1, 2, 4, 5, 7, 9, 11
Cash disbursements		
Payment processing	The robot accesses and compares purchase order with invoice. If exceptions are encountered, the robot will inform necessary parties of the exception. For those without exceptions, the robot completes invoice for payment processing.	1, 2, 6, 7, 11
Request payment date for invoices	The robot compares invoice payment date to data in supporting Excel files and updates for any conflicting information.	2, 4, 5, 6

Panel C: Record-to-report

Example area/task	Description of procedures	Task category
Journal entries		
Data entry	Utilizing email correspondence and predefined parameters, the robot enters account entry information into the accounting system. The robot will send a confirmation email to initiator.	1, 2, 4, 5, 6, 7, 11
Data entry	The robot accesses Excel files that contains information need to record journal entries. The robot enters the journal entries into the accounting system.	2, 4, 6, 9
Data entry and account classification	Utilizing bank statements, credit card activity and previous transaction posting history, the robot records journal entries in the accounting system. If the robot identifies transactions for which there is no recorded past history, an exception report is generated and the robot sends an email to the necessary parties.	1, 2, 4, 5, 6, 9, 11, 12
Standard journal entries	The robot prepares standard journal entries based upon completing or accessing predefined templates. The robot enters the journal entries into the accounting system.	2, 4, 5, 6, 7, 10
Reconciliation preparation and analysis		
Extract account movements from	Based upon predefined parameters, the robot accesses online banking information to download selected activity for reporting. This information can be uploaded to a shared folder and used as part of the reconciliation process.	2, 3, 7, 12

bank website		
Upload and validation of bank statement activity	The robot obtains bank statements and downloads information daily. The robot compares information from bank statements to the accounting system to compare to prior periods and validate balances. The robot will export an Excel file, upload the information to a shared folder and send emails to appropriate individuals for follow up.	1, 2, 3, 4, 5, 7, 11
Account analysis		
Accruals creation	Based upon pre-established templates, the robot updates the inputs to revise the calculations of selected accruals. The robot will perform a comparison analysis of the current calculations to past calculations based upon predefined parameters/thresholds. If an exception is identified, the robot will forward the information to the necessary parties to resolve the matter.	1, 2, 4, 5, 7, 10, 11
Warranty calculation	Based upon predefined parameters, the robot updates Excel file for warranty claim information based upon individual claim data. The robot saves and uploads the excel file that can be further analyzed as part of the reconciliation process. Intercompany payment requests related to warranty are also initiated by the robot.	2, 3, 4, 5, 6, 7, 9, 10
Commissions calculation	The robot calculates and processes payments for commissions based upon sales data and predetermined commission plans.	2, 6, 7, 9, 10
Rebate calculation	The robot calculates and processes payments for rebates based upon predefined parameter.	2, 6, 7, 9, 10
Closing/reconciliation process		
Export and data consolidation	The robot exports and downloads information from accounting system and then uploads the information to a shared site that can be used as part of the reconciliation process.	2, 3
Reconciliation process	The robot downloads predefined files from the accounting system and uses the information in these files to update an Excel file that can be used for further analysis or processing.	2, 3, 4, 5
Foreign exchange rates	The robot updates accounting system for foreign exchange rates based upon published information.	2, 6, 12

Panel D: Task summary by frequency

No	RPA task type (Deloitte 2018a)	Frequency of occurrence in Table 2, Panels A, B, and C
1	Open, read, and create emails	22
2	Log in to enterprise apps	38
3	Move files and folders	7
4	Copy/paste	21
5	Fill in forms	21
6	Read/write to database	30
7	Follow decision rules	24
8	Collect statistics	1
9	Extract data from documents	18
10	Make calculations	5
11	Obtain human input via emails/workflow	20
12	Pull data from the internet	5

ANNEX 2. Automated accounting and finance tasks (Kaya, C. T., Türkyılmaz, M., & Birol, 2019)

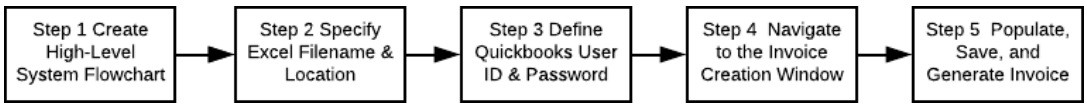
Kaya, C. T., Türkyılmaz, M., & Birol (2019) research identified several accounting tasks that could be automated, as listed below:

- Opening, reading and sending emails and attachments.
- Automated Internet application processing: Logging into web/enterprise
- applications or reading\entering\deleting or changing data in any web\enterprise.
- Automating data cleansing: Moving, changing or deleting files and folders.
- Automatically connecting to system APIs and uploading or downloading data
- Automatically running batches.
- Automatically following "if/then" decisions and rules.
- Automatically extracting and reformatting data into reports or dashboards.
- Automatically extracting structured data from documents, formatting any data.
- Automatically collecting and analyzing social media data.
- Automatically collecting and processing data from multiple data resources, working with different data types, from structured and unstructured data.
- Automatically making calculations and executing tasks or jobs due to the results of these calculations.
- Automatically filling in forms.
- Automatically connecting, reading and, writing to databases.
- Automatically generating\sending\sharing reports.
- Automatically generating early-warnings.
- Making auto-corrections, block or stop transactions above the limit or threshold.
- Automating fraudulent account closure process and fraud chargeback processing.
- Making automatic bookings in accounting.
- Making auto-monitoring and auto-corrections on accounts.
- Executing, changing or correcting standing order details

- Executing, changing or correcting direct debit details
- Executing, changing or correcting address details
- Auditing, blocking or correcting transaction duplications
- Automating branch risk monitoring process
- Automating personal loan application opening
- Payment protection insurance claims processing
- Automation of the administration of payment terms
- Automated support for sale of insurance products
- Automated marketing campaigns
- Customer complaints automation
- Compliance reporting automation
- Insurance product administration automation
- Automated risk analysis and automated execution due to this risk analysis
- Automated direct debit cancellations
- Automated personal account closures
- Automated payment processing
- Automated business account audit requests
- Automated business account onboarding
- Automatically excessing transaction approvals
- Automatically excessing check approvals
- Automatically excessing customer letters (Deloitte, 2017; IRPA, 2015)

ANNEX 3. RPA implementation example with UiPath (Kokina et al., 2021)

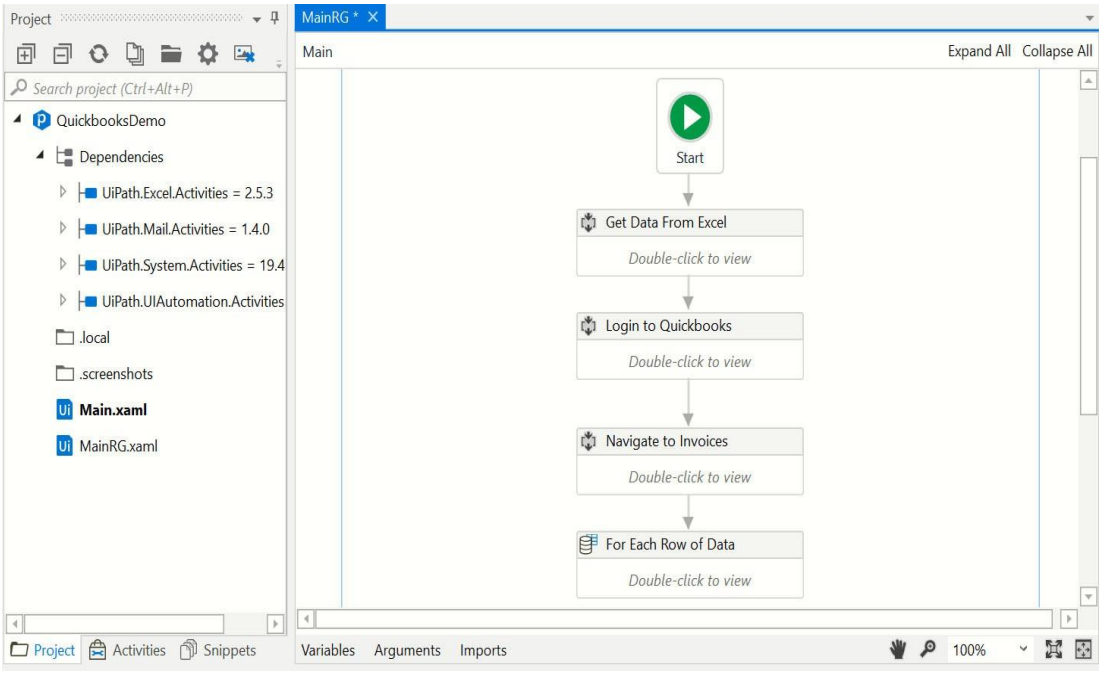
The use case presented by Kokina et al. (2021) for sample implementation is a business consulting firm. Each week, the firm's consultants log their hours and client information into an Excel worksheet. At month-end, the company's accountant downloads this data from Excel, logs into the firm's QuickBooks Online Accounting System, and generates client invoices. Because the consulting firm would rather its accountant concentrate on analytical work, a bot was constructed to perform the routine invoice creation task. To code the bot, the RPA developer logs into the RPA software and performs the following five steps:



Step 5 is the most involved as the developer defines the detailed steps a human takes when interfacing with the QuickBooks application. Below, we present each of the five steps along with the UiPath flowcharts and process code.

Step 1—Create System Overview Flowchart

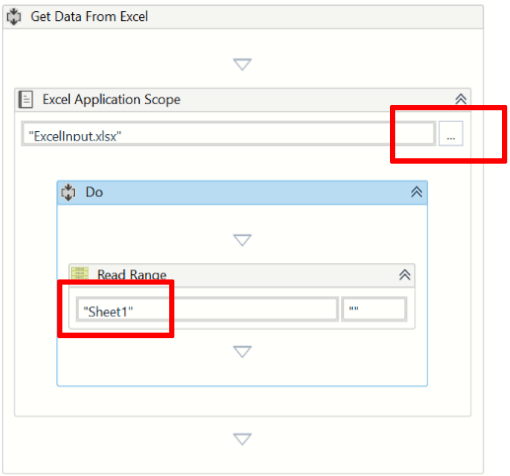
In the high-level system overview flowchart shown below, you see the four main activities the bot will perform. These include retrieving data from Excel, logging into QuickBooks, navigating to the invoice creation window, and then for each row of data in the Excel worksheet, populating the invoice window and generating a client invoice.



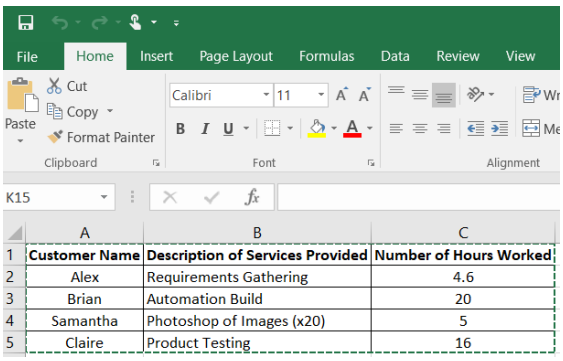
Step 2: Specify Excel Filename and Location

Once the high-level flowchart is created, the developer double-clicks on each process and enters the associated code. In the Get Data From Excel process, as shown in the screen below, the developer clicks on the ellipsis under the Excel Application Scope and specifies the Excel file name and its location.

Under Do and then Read Range, the developer specifies the name of the workbook sheet.



Below is a sample of the Excel file that is opened by the digital worker. This data is eventually used to populate the invoice form within QuickBooks. However, before invoice transactions can be processed, the company's master data, for example, customers, vendors, and products or services, must be entered into the system.

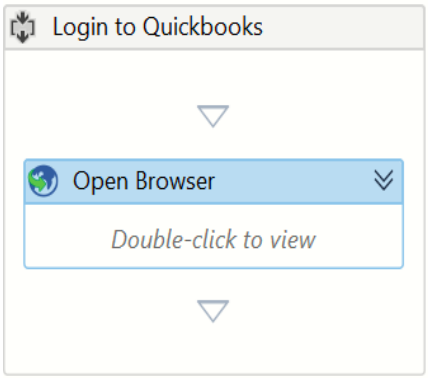


	A	B	C
1	**Customer Name**	**Description of Services Provided**	**Number of Hours Worked**
2	Alex	Requirements Gathering	4.6
3	Brian	Automation Build	20
4	Samantha	Photoshop of Images (x20)	5
5	Claire	Product Testing	16

Excel Worksheet Read by the Bot

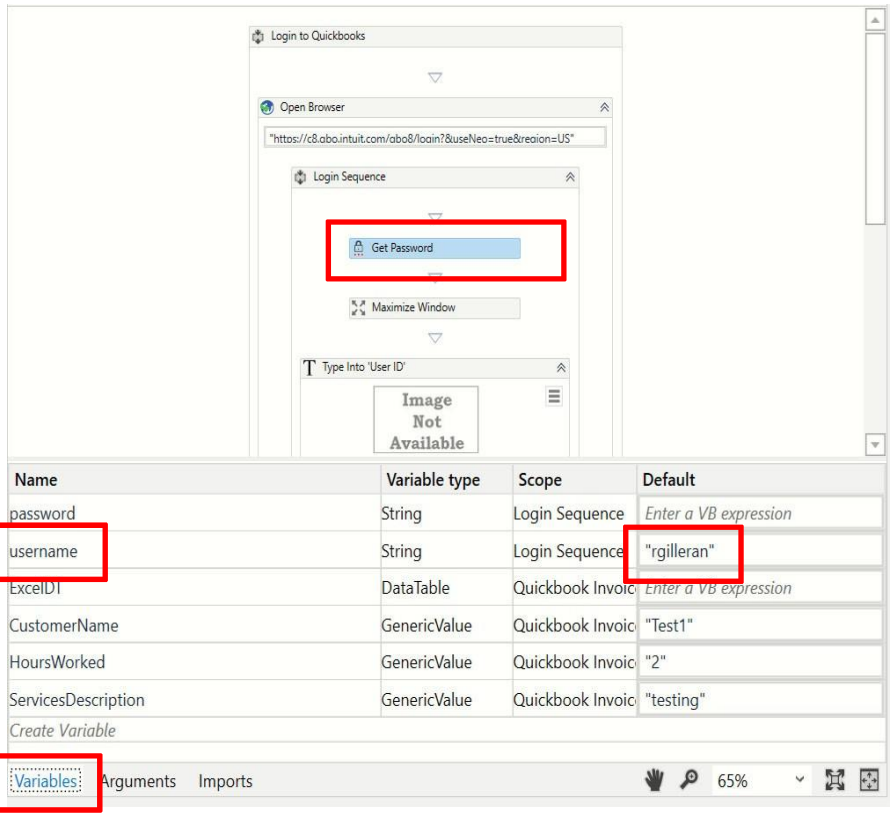
Step 3: Define QuickBooks Login

From the main flowchart the developer click on the Login to QuickBooks process and documents the bot's pre-defined QuickBooks login credentials. Like humans, bots must be given User IDs and passwords for the systems they access. This process shows the Open Browser activity since the consulting firm is running QuickBooks in the cloud.



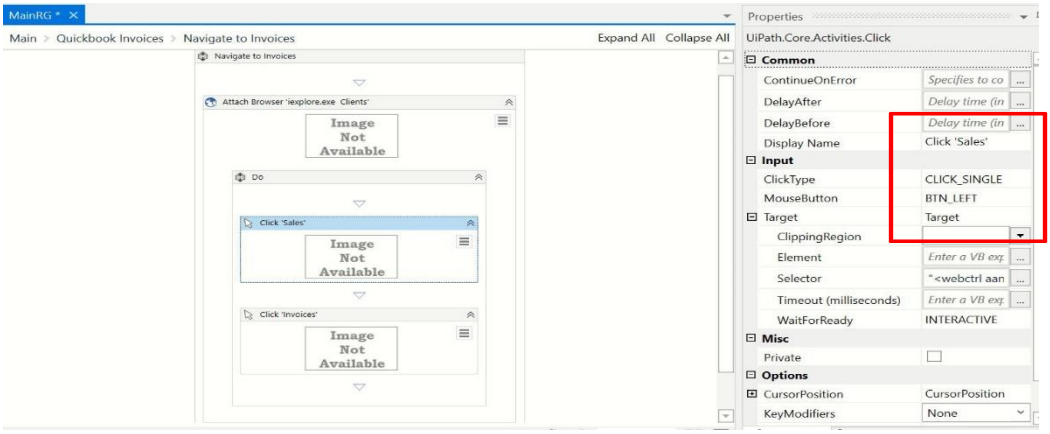
After double-clicking on the Open Browser process above, the developer creates the lower level flowchart shown below. The developer single-clicks on Get Password, and enters the digital worker's QuickBooks password. Next, the developer clicks on Variables at the bottom of the screen and enters the bot's QuickBooks User ID or username. A variable is a named storage location which contains some known or to-be-determined value. Variables are defined at the start of programs and then referenced and manipulated throughout. Prior to the step you are seeing below, the RPA developer

defined the variable username. The bot's QuickBooks username, rgilleran, is entered on the right side of the screen.



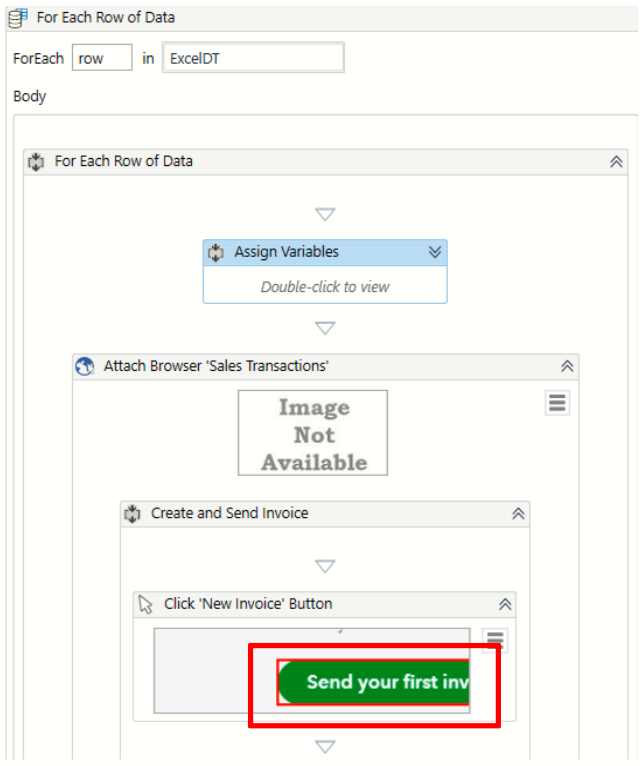
Step 4: Navigate to Invoice Creation Window

The developer clicks on the Navigate to Invoices process in the main flowchart and specifies how to navigate to the QuickBooks invoice creation window. The steps in this process consist of clicking on the Sales Menu and then selecting Invoices. When you drill into the Click Sales process, as you see in the Properties window on the right-hand side of the screen, the developer sets the Input to single-click with the left mouse button, just as a human would do. In other words, to navigate to the Create Invoice form in QuickBooks, an individual would first single-click on the Sales menu and then select the Invoice submenu.



Step 5: Populate and Generate Invoices

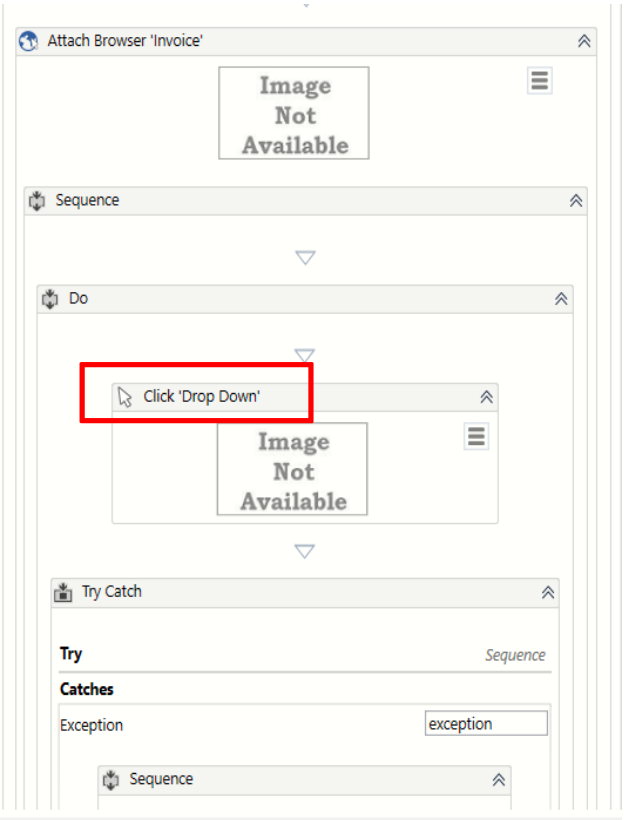
The developer clicks on the For Each Row of Data process in the main flowchart and defines the steps a human performs when populating the invoice creation window within QuickBooks. In Step 5a, Send an Invoice, the Send your first invoice button is pressed (assuming this is the first invoice, in a series of invoices, being processed).



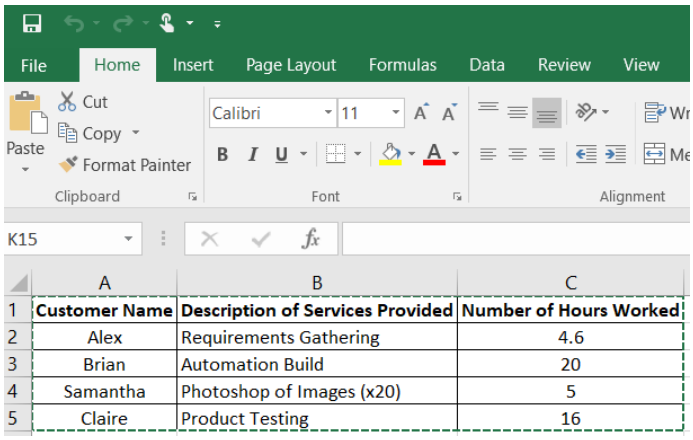
Step 5a – Send an Invoice

In Step 5b, Select a Customer, the Drop Down listbox is clicked and the customer name, from the first row in the Excel workbook shown below, is selected from the list of valid values.

NOTE: For the customer name to appear in the dropdown listbox, a customer record must have been created within QuickBooks.



Step 5b – Select a Customer



	A	B	C
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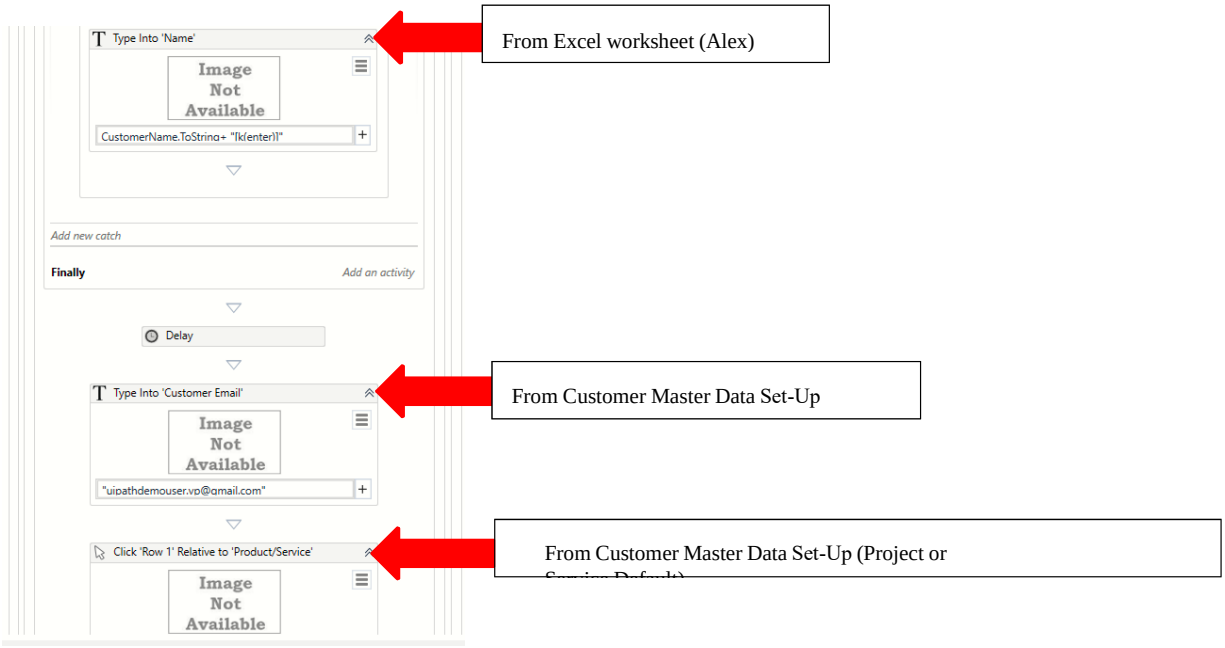
2	Alex	Requirements Gathering	4.6
3	Brian	Automation Build	20
4	Samantha	Photoshop of Images (x20)	5
5	Claire	Product Testing	16

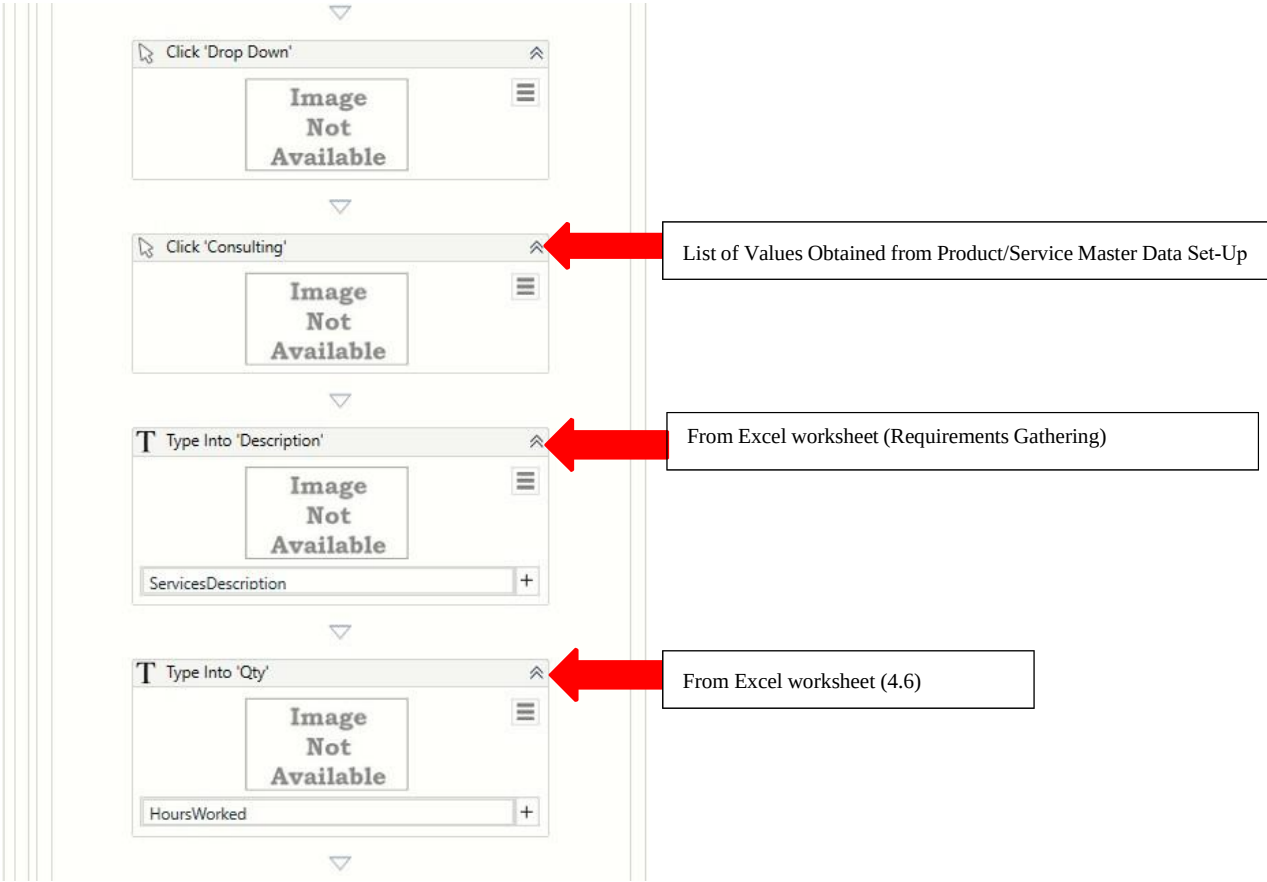
Excel Worksheet Read by the Bot

In Step 5c, Populate the Invoice Window, using the data from the first row in the Excel worksheet, the Name (customer), Customer Email, Product/Service Type (consulting), Description, and Qty (quantity) fields are populated. NOTE: The values

entered into the customer name and product/service fields must have been pre-defined in QuickBooks.

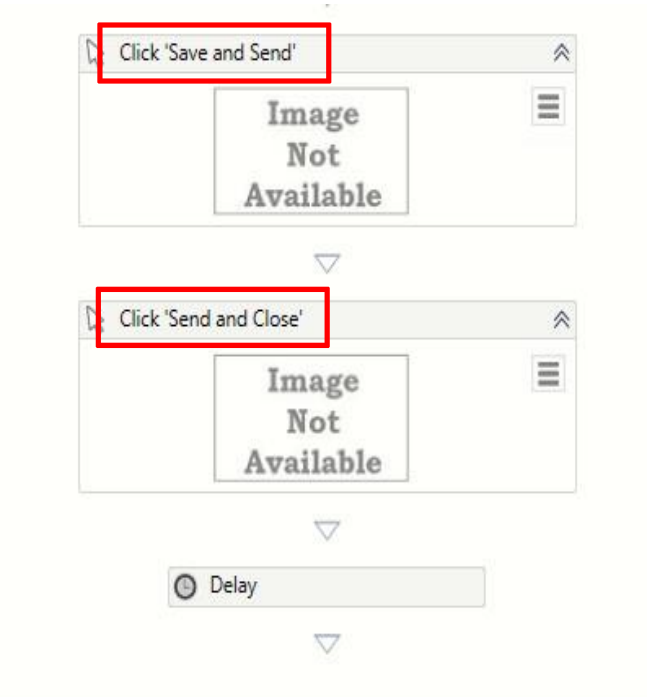
	A	B	C
1	**Customer Name**	**Description of Services Provided**	**Number of Hours Worked**
2	Alex	Requirements Gathering	4.6





Step 5c – Populate the Invoice Window

In Step 5d, Save and Send an Invoice, after populating the invoice fields, the bot moves to the Save and Send field and creates the first invoice. It then loops through the code, creating invoices for the remaining clients, until the program reaches the last row in the Excel worksheet. After processing the last invoice, the bot selects Send and Close.



Step 5d – Save and Send an Invoice