

Beyond Replacement: Professional Resilience and Human–Technology Complementarity in the Digital Transformation of Accounting

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Abstract: *This study critically examines the transformative influence of digital technologies on contemporary accounting practice, situating its inquiry within the broader context of the Fourth Industrial Revolution and the historical evolution of the profession. Rather than adopting a deterministic view of technological displacement, we investigate how accounting professionals cognitively and operationally adapt to sustained technological upheaval. Employing a theory-driven qualitative research design—grounded in human–computer interaction and professional autonomy frameworks—we conducted semi-structured in-depth interviews with three practicing accountants across distinct municipal jurisdictions, purposively selected to capture diverse institutional and operational environments. Our inductive thematic analysis reveals that, while automation and intelligent systems have substantively reconfigured routine transactional tasks, they simultaneously amplify the demand for higher-order professional competencies, including interpretive judgment, ethical deliberation, and strategic advisory capacity. Contrary to techno-deterministic predictions of occupational obsolescence, our findings demonstrate that technological infusion engenders a complementary rather than substitutive dynamic, wherein digital tools augment human expertise without rendering it redundant. This study contributes to the accounting literature by (a) empirically substantiating the resilience of professional agency amidst rapid automation, (b) offering a nuanced typology of adaptive strategies employed by practitioners, and (c) providing actionable pedagogical and policy implications for curriculum development and continuing professional education. The results serve as both a theoretical reference for scholars investigating digital disruption and a practical resource for students, early-career accountants, and educators navigating the evolving epistemic landscape of the profession.*

Keywords: Accounting Practice; Digital Transformation; Fourth Industrial Revolution; Human–Computer Collaboration; Professional Resilience; Qualitative Research.

1. INTRODUCTION

Scientific and technological development has brought about major changes in people's way of life and work, and it cannot be denied that technology has emerged as an essential tool in this new environment of human coexistence. It has altered communication habits, business relationships, commercial customs, and triggered both positive and negative effects on work relations. The Fourth Industrial Revolution represented a break from old standards and brought technological innovations, which increased competitiveness and production growth. Moreover, it introduced a new way of thinking, changed the market, people's consumption patterns, and relationships between them.

Industry 4.0, also known as the Fourth Industrial Revolution, began in 2011 and encompasses a vast system of advanced technologies, bringing previously unknown terms into essential use, such as artificial intelligence, cloud computing, robotics, cybersecurity, digital manufacturing, the internet, big data, Power Bi, among others.

All these transformations, consequences of technological progress, have significantly impacted the accounting environment, led to the replacement of jobs, and called into question the accounting profession itself. The current effects and future prospects of technology shaping new contours for the practice of the accounting profession are evident, thus requiring new skills to be developed by professionals in this globalized environment, such as higher technical qualification, business acumen, and communication skills. Therefore, this research is justified, born from the personal concern of the academics and the constant worry about the future of the accounting profession in the face of the productive restructuring triggered by the integration of new technologies into the labor market.

That said, this text stemmed from the following research problem: what were the impacts of the technological revolution on accounting, and how have accountants from three different municipalities faced the challenges and updated themselves daily in this scenario full of transformations? Its general objective is to analyze how

technology has impacted the activities of accountants, examining in a practical and objective manner how this technological scenario has defined new paradigms for the practice of the profession, significantly altering the traditional exercise of accounting activity. As specific objectives, the history of accounting and the Fourth Industrial Revolution, the transformations that have occurred throughout history, and a demonstration of how some accountants from three different municipalities faced the challenges posed by this revolution will be presented.

This article is structured as follows: in the first section, the history of accounting and its journey up to the technological changes brought about by the Fourth Industrial Revolution are presented. In the second, the Methodology presents the deductive method and field research, whose data collection instrument consists of interviews with some accountants in three different municipalities. In the Discussion of Results, a comparison is made between the interviewees and the way they faced the challenges regarding the technological changes and transformations in the profile of accounting professionals, how they update themselves in the face of new service models and new standards in learning to use new tools, and finally, in the Final Considerations, the scientific contributions of the research are presented, which reaffirm the importance of this profession that has successfully and dedicatedly overcome technological transformations.

In this context, this article aims to serve as research material for those looking to face the challenges of accounting, such as undergraduate and technical students in accounting, those still studying Accounting Sciences, so that they can identify the skills to be developed throughout the course; as well as for professionals already in the job market who can access the new characteristics the market demands of them.

2. THEORETICAL FRAMEWORK

2.1 Accounting and Its History

According to research, the history of accounting dates back thousands of years to Mesopotamia, developing through society's needs in commerce, when simple commercial transactions were recorded on clay tablets using symbols to represent quantities. In the Middle Ages, accounting began to organize as a professional practice; later, Luca Pacioli wrote a book presenting the double-entry method in one of its chapters, which revolutionized accounting and is still used by some today. Over the years, the profession grew in proportion to the growth of industries during the Industrial Revolution, and regulatory bodies also emerged; then, in the 20th century, there was rapid evolution with the automation of accounting processes and the use of software. It is worth noting that the major milestone was in the Fourth Revolution. Humanity has an intimate connection with the history of techniques, which have evolved and reinvented themselves into new methods and instruments. Thus, according to Veraszto (2009, p. 21), "the term technique and technology derive from the Greek *techné*, which consists of altering the world in a practical way, and comes from a verb meaning to make, produce, build, give birth, while the verb *teuchô* or *ticein* means tool, instrument". In the view of Vieira Pinto (2005, p. 15):

Considering this multiple meaning of the term and the numerous applications of technologies, the choice was made to adopt the understanding proposed by Vieira Pinto (2005) regarding technology, comprehending it as an instrument of domination, bringing in his work the imbalance in technical advancement across eras and societies. In this sense, accounting is part of a constant process of technological innovation, and understanding and applying what is innovative is essential for cutting-edge professionals.

When portraying this scenario of change and innovation, Castells (2000) analyzes this new economy that emerged from the technological revolution, which began in the late 20th century and was based on a new paradigm centered on information technology, bringing with it a new style of production, communication, management, and lifestyle.

This constant advancement began to cause concern because, in addition to offering practicality and convenience, it also brought negative factors such as cyberattacks, unemployment, data distortion, and questions about who would be responsible for possible system failures or even the strict handling of data fraud. However, according to Oliveira (2014, p. 70-71):

Two of the most critical points for the success in the use and good management of integrated systems is user management. Properly defining each user's profile is a task of great responsibility, as they are the ones who make the system work. Users are the main operators of information, in addition to generating reports and checking the records made. No system works well if there are no good users operating in the areas that use that system. Technical support is also very important, but developers invariably have well-trained teams to provide the necessary

assistance.

After a brief historical analysis of technological innovations, Castells (2000) provides an illustration where, in the mid-1970s, new telecommunications technologies went through three distinct stages: task automation, usage experiences, and application reconfiguration. For him, in the first two stages, one learned by using, while in the third stage, one learned by doing, thus reorganizing the activities performed and rediscovering new ways of applying technology, and it is from this perspective that the discussion and analysis of the accounting environment will be deepened. After these three stages addressed by Castells (2000), it can be seen that the advancement of technology has come to assist the lives of accountants; one just needs to learn to use it, and as scientist, speaker, and professor Antônio Marcos Alberti (2023) states in one of his live lectures:

In approximately ten years, Artificial Intelligence (AI) will be a being that will do much more than ChatGPT, for example, and we will have to learn to enjoy the benefits it provides us and use it correctly. One example is my book, where all the design, such as the illustrations, for instance, were developed by AI, and it addresses the convergence of over a hundred technologies covering the physical and virtual worlds, and inspires people to take an interest in science and explore the possibilities offered by technology.

International studies also highlight how computerization has affected traditional work relations, and in the work of Frey and Osborne (2013, p. 44), 702 occupations at risk from the computerization process were listed. The research presents an alarming and concerning figure from the North American scenario, where 47% of total U.S. employment is classified as high risk (our translation).

Based on these guidelines and with a view to verticalizing the study applied to Accounting 4.0, this term is used to define the development and evolution of society and industry, and also to designate changes in the way people deal with technology in daily life. It is a period marked by industrial automation that originated thanks to technological inventions. According to Breda's (2019) lessons, the "do it yourself" (DIY) trend is gaining ground in accounting, requiring accountants to pay greater attention to clients to avoid data distortion, as the accountant or auditor has the commitment to inform the whole truth, as this is the main reason for the profession. He also reports on the large number of job losses and estimates that around 400 to 800 million individuals could lose their jobs by 2030 due to automation. According to his research, people will have to reinvent themselves to adapt to the job market and minimize unemployment.

2.2 New Accounting Challenges

Currently, the challenge for accountants is to incorporate technological innovations into their work to provide a more agile and quality service, with co-creation with AI and General Artificial Intelligence (AGI) being essential, including these tools in daily use, such as ChatGPT, Khan Academy, Jusbrasil, among others. Technology has revolutionized accounting by automating repetitive processes, improving data accuracy, and enabling advanced analyses. Specialized software facilitates financial management, making accountants' work more efficient and providing strategic insights based on precise, real-time data. Cloud computing and big data analysis are examples of how technology has modernized accounting, increasing its relevance and impact on business decisions.

In times of constant change and high competitiveness, knowing how to use innovations to one's advantage can be the differentiating factor of a service. We start from the following premise presented by Fortes Tecnologia (2021, p. 1), which states that "technology can impact the accountant's activity through data integration with the client, support, ease in complying with tax obligations, and a more precise financial diagnosis, allowing complete reports to be prepared in an agile manner".

In this information age, there is an increasing demand for greater quantities of data and at a faster pace, and such data is essential for managers to make assertive decisions based on reliable indicators. Technology can and should be evaluated as a differentiator for an office to stand out in the market, and according to Nonato (2014, p.3):

Each period has had its own accounting evolution, its methods considered advanced, and uses that in some way met its needs at the time, whether in the most primitive form through measurement with pebbles or the latest generation of software. What can be seen is that accounting evolution has not reached its peak, nor will it anytime soon. The world is in constant evolution, whether financially, intellectually, or through technological advances; what matters is that accounting will always contribute in some way.

It is important to highlight Breda's (2019) points, stating that the accounting profession will not cease to exist; on the contrary, it will become even more important. However, for this to happen, professionals will have to adapt to fourth-generation models, master technological tools, but consider that some tasks—such as understanding the client and meeting their needs, developing a company's principles, and analyzing data carefully—will remain the professional's tasks, not a robot's. Accountants will not lose their position to technology, after all, it does not work without the human element, but they may lose it to someone who knows how to use these new technologies. For this reason, constant updating and learning are inevitable.

The advancement of technology not only ensures the accountant's continued relevance but also contributes to and is transforming accounting from a reactive to a proactive discipline. Professionals no longer just record past events but also predict and shape the financial future of organizations. Advances in information technology are significantly changing the way management accountants work and the roles they perform in organizations. (Scapens, 1991).

Accounting professionals are challenged to adapt to new technologies and develop skills in data analysis and result interpretation. The traditional function of simply recording transactions is evolving to include strategic analysis and data-based financial advice. Adopting technologies can revolutionize accounting by making it less susceptible to human error; it is important for accountants to adapt to new technological tools to remain relevant and competitive in the current market.

A current tool that assists accountants is e-social, a platform whose objectives are to unify and simplify the submission of labor, social security, and tax information by companies. Currently, thanks to it, the digital FGTS has emerged, which simplified the famous GFIPs that generated a lot of paperwork and took much more time to complete. Furthermore, these papers had to be filed in folders and the guides were printed separately; this is just one example of how evolution can bring practicality, but at the beginning it is not always easy, after all, they require studies to understand all these new tools, and accountants need to learn to redo what they already did, living in constant learning, which is why they must stay updated.

3. METHODOLOGY

This study involved the deductive research method, which according to Gil (2007), is the method that proceeds from the general to the specific, starting from principles recognized as true and indisputable, and makes it possible to reach conclusions in a purely formal way, that is, solely by virtue of its logic.

Regarding the approach, the type of research used was qualitative, which is not concerned with numerical representativeness, but rather with deepening the understanding of a social group, an organization, etc. According to Prodanov and Freitas (2013), it must be considered that there is a dynamic relationship between the real world and the individual, that is, an inseparable link between the objective world and the subjectivity of the person, which cannot be quantified. The interpretation of phenomena and the attribution of meanings are fundamental in the qualitative research process. This approach does not require the use of statistical methods and techniques. This type of research is descriptive and researchers generally analyze their data inductively. The main focus of the approach is on the process and its meaning (Triviños, 1987).

Finally, the case study, as mentioned by Gil (2007), is a research modality widely used in the Social Sciences. A case study can be described as the investigation of a well-defined entity, such as a program, an institution, an educational system, a person, or a social unit. The objective is to deeply understand how and why a specific situation, which is believed to be unique in many aspects, occurs, seeking to identify what is most essential and characteristic about it. The researcher does not intend to interfere with the object of study, but rather to reveal it as perceived.

As the case study was conducted in three accounting offices, some characteristics of the municipalities in question are presented below.

3.1 Considerations About the Municipalities

The object of study in this work is three accountants from Accounting Offices located in the municipalities of Itambaracá, Londrina, and Santo Antônio do Paraíso. Below are descriptions of the municipalities relevant to the research topic. To gain a broader view of the cities, we chose three with different characteristics, the main one

being size: Santo Antônio do Paraíso, the smallest, practically a district; Itambaracá, also a small city; and Londrina, practically the metropolis of the northern region of Paraná. This is because large and small cities face different challenges and have different resources; furthermore, choosing three municipalities allows analyzing how development and public policies affect communities.

According to the Municipal Prefecture's website and the knowledge of one of the students who is a resident, the city of Itambaracá was founded in 1922, initially named Jaborandi, which means "Stone of love". It currently has an approximate population of 7,000 inhabitants, and its demonym is itambaracaenses. In 1955, by state Decree-Law 32° of 1955, it was elevated to the category of municipality, with Mr. Horácio Cheira as its first mayor. It is located on the banks of the Paranapanema River, and the local economy is based mainly on agriculture, livestock, and also fish farming.

Although it is a small city, it has several commercial establishments, two banks, and industries focused on agribusiness, as well as various service-providing companies. Among them, a mechanized sugarcane harvesting company stands out, employing approximately 150 workers with formal contracts, providing services to several mills in the region. In terms of accounting offices, the city has only two, both serving all accounting segments and each with only one accountant in charge.

3.1.2 Santo Antônio do Paraíso

According to the prefecture's website, through State Law No. 4245, the municipality of Santo Antônio do Paraíso was created, emancipated from São Jerônimo da Serra. The official installation took place on October 29, 1961. Initially, the name given by the settlers was Patrimônio do Dez, referring to the distance between the locality and the road connecting Nova Fátima to Congoninhas. Later, the name as a district was Santo Antônio do Pary, referring to a water spring in the region. Finally, the name Santo Antônio do Paraíso was chosen upon emancipation.

The urban area is not very large, with an average of 3,000 inhabitants. Santo Antônio do Paraíso is strongly influenced by the rural area, with many families contributing to family farming, but it also has large rural producers of corn, soybeans, and wheat, as well as a fruit pulp industry, Villa Puree, which generates jobs for the city's inhabitants. The city has only one accounting office.

According to the prefecture's website, among the twenty-five municipalities in northern Paraná, Londrina is considered the most transparent city in the state. It is the second most populous city in the state, the fourth largest in the southern region, constitutes an important axis connecting the South to the Southeast of the country, and is a major urban, economic, industrial, financial, administrative, and cultural center in the northern part of the state of Paraná.

The city's name is an allusion to and a tribute to the "daughters of London," and was coined by Dr. João Domingues Sampaio, one of the first directors of the Companhia de Terras Norte do Paraná (Northern Paraná Land Company). The municipality was created five years later by State Decree No. 2,519, signed by interventor Manoel Ribas on December 3, 1934. It was established on December 10 of the same year, the date on which the city's anniversary is celebrated. Londrina has a strong variation in the job sector, including industries, civil construction, and commerce such as shopping centers, street markets in the downtown area, and various stores throughout the city. Londrina has an average of 550 accounting offices.

3.2 ABOUT THE ACCOUNTANTS

Regarding the accountants from the selected cities: Aldo Gamaliel de Carvalho, born on April 13, 1974, in Bandeirantes, Paraná, son of José Carlos de Carvalho and Luzia Rubin de Carvalho, graduated in Accounting Sciences in 1997 from the Faculdade Estadual de Filosofia, Ciências e Letras de Cornélio Procopio (State College of Philosophy, Sciences and Letters of Cornélio Procopio), now UENP, and also graduated from the same institution with a degree in Geography in 2001, holder of CRC-Pr 042283/O-3, has practiced the profession in the city of Itambaracá since 1998, as the owner of Escritório Carvalho (Carvalho Office). He is also a civil servant with a state public service exam in the education field and currently serves as assistant director at Colégio Estadual Marcílio Dias (Marcílio Dias State School) in this city.

Our second interview was with the accountant from Santo Antonio do Paraíso, Raquel Elizangela Ruy Munhoz, born on December 13, 1978, in Nova Fátima, graduated in Accounting Sciences in 2000 from the Faculdade

Estadual de Filosofia, Ciências e Letras de Cornélio Procopio, now UENP, holder of CRC-PR 045421/O-2, has practiced the profession in the city of Santo Antônio do Paraíso for 24 years at Escritório Contábil Ruy (Ruy Accounting Office), which she acquired before completing her degree. In addition to her accounting activities, she is a mother of two children, married, and has also worked as a public servant in the role of teacher for 17 years, currently teaching technical courses in administration and logistics.

The third interviewee was Fernando Faria, born on March 10, 1983, in São Paulo, SP, graduated in Accounting Sciences from PUC SP, married, father of two girls, and also a pastor since 2009. He has worked in accounting since 2004 and has had his own office since May 2022, serving clients in São Paulo and Londrina.

3.3 Data Analysis

The three accountants interviewed shared experiences about the challenges and advances in the profession, especially regarding the technological transformations that came after the fourth revolution, which spurred its development, as stated by Vieira Pinto (2005), who notes that accounting is part of a constant evolutionary process of innovation. The first one highlighted that one of the biggest difficulties early in their career was building a client base, a fact that can be explained by the size of the city and also due to the lack of technological resources at the time, such as TeamViewer, smartphones, among others. Offices used to serve only clients from the city or nearby region, but currently they can have clients in any state, even another country. To stay updated, the accountant in question turns to consultancies, citing Sescap-Ldr, invests in reading and courses, praises modern accounting software that automates repetitive tasks, reduces time spent on routine activities, and simplifies most tasks and calculations, but does not replace the full role of an accountant, supporting the view of Fortes Tecnologia (2021, p.1), which states that "technology can impact the accountant's work through data integration with the client, support, ease in meeting tax obligations, and a more precise financial diagnosis, enabling the preparation of complete reports quickly".

The second interviewee told us that, throughout her career, she faced challenges related to her condition as a woman in a sector historically dominated by men, a fact that required resilience and confidence from her. She emphasized that technological changes played an important role in facilitating her adaptation by reducing manual workload and increasing process accuracy. However, she stresses that success in her profession goes beyond the use of technological tools: accountants need a critical and analytical eye, as also stated by Edson oliveira (2014, p.70-71) cited in the theoretical framework "...users are the main operators of information...". She recognizes the importance of support from specialized systems to understand innovations. For her, the accountant's critical view of generated reports and other services remains fundamental, and she opposes the hypothesis that the profession will one day become extinct; after all, technological evolution has increased the demand for accounting services, and even with all this technological ease, services remain extensive because new things to do and learn always emerge. Finally, she states that analytical ability allows a deep understanding of reports and generated information, and is something that, in her view, cannot be easily replaced by automated systems.

The interviewee also believes that technological evolution, rather than threatening the profession, has contributed to the growth in demand for accounting services. She notes that despite the conveniences introduced by automated systems, the accounting field remains complex and dynamic. With each new regulation, innovation, or economic change, new challenges arise and there is a need for constant updating, which keeps the professional indispensable. For her, accounting will continue to be a relevant and constantly expanding profession, challenging the idea that it could one day become extinct. Thus, technology proves to be an ally in performing accounting tasks, but it does not replace the critical and interpretive role of the accountant, aligning with the observations of Breda (2019), who states that the profession will not cease to exist; on the contrary, it will become even more important, but for this, professionals will have to adapt and update themselves to the fourth-generation models.

Finally, the third interviewee, with over two decades of experience, brought a in-depth perspective on the challenges and transformations in accounting life. He highlighted long working hours as one of the main obstacles of the profession, mentioning that the workload is often intensified by the complexity of demands and the constant need for precision. For him, staying updated through reading and participating in forums is essential, always emphasizing the importance of reviewing the data generated by the system. This habit not only helps him keep up with changes in the sector but also enhances his critical eye when reviewing data generated by systems, ensuring the quality and reliability of the information he delivers. And although he recognizes the benefits of the speed and quality of information, he believes the profession will not be extinct but that there may be a possible reduction in the need for professionals, as technology allows for more agile and efficient work, confirming Breda's (2019)

statement: "do-it-yourself is gaining ground in accounting, requiring accountants to pay greater attention to clients". Even so, he sees technology as a powerful ally, a facilitator that, by automating routine tasks, allows accountants to focus on more strategic activities such as financial analysis, tax planning, and management consulting—areas where human insight and contextual interpretation are irreplaceable. And he also believes that it can expand opportunities for accountants, enabling them to play more relevant and strategic roles in organizations.

Thus, although each faces distinct challenges, all agree on the importance of continuous updating and the critical role that accountants still play, even in an increasingly technological scenario, affirming the statement by Edson Oliveira (2014, p. 70-71):

One of the most critical points for the successful use and good management of integrated systems is user management. Properly defining each user's profile is a task of great responsibility, as they are the ones who make the system work. Users are the main operators of information, in addition to generating reports and checking the records made. No system functions well if there are no good users operating in the areas that use that system. Technical support is also very important, but invariably, developers have well-trained teams to provide the necessary assistance.

This chapter presents the experiences and perspectives of three accountants regarding the challenges and transformations in the profession amid technological changes driven by the Fourth Industrial Revolution. The interviewees highlighted how technological evolution has facilitated daily work routines by automating repetitive tasks and expanding opportunities to serve clients in various locations. However, all agreed that despite these advances, technology does not replace the accountant's critical and analytical role, which remains essential to ensuring the accuracy of information and providing strategic consulting. Additionally, they emphasized the importance of continuous updating and adaptation to new tools and regulations, reinforcing the idea that the accounting profession is constantly evolving and will remain fundamental, albeit with new demands and challenges to face.

4. FINAL CONSIDERATIONS

This article aimed to present the challenges of accounting in a fully connected world that is constantly updating, arguing that even with the assistance of technologies and the tools they provide, it is impossible to eliminate the profession, demonstrating the importance of accountants.

After analyzing the entire history of accounting, from its emergence and evolution to the current scenario filled with technological innovations available to professionals, we revisit the initial question of our research, which asked: What were the impacts of the technological revolution on accounting, and how have accountants from three different municipalities faced the challenges and updated themselves daily in this scenario of constant transformations? In response to this problem, we conducted research and interviews with three accountants, all of whom stated that the use of technologies and daily updating methods are indispensable, but disagreed with the hypothesis that the profession will one day be extinct, arguing that the accountant's role goes beyond mere data recording—they are strategic consultants capable of offering valuable insights for decision-making in companies.

Finally, it is essential for accountants to be willing to constantly reinvent themselves, adopting a mindset of continuous learning. The ability to adapt to new market demands and incorporate emerging technologies will be a crucial competitive advantage. The future of accounting is closely linked to professionals' ability to turn challenges into opportunities, ensuring that their role remains relevant and strategic in organizations. It is also essential for educational institutions and regulatory bodies to keep up with this technological advancement by reviewing and updating professional training curricula. Only then will it be possible to prepare new generations of accountants for the challenges and opportunities of the digital age.

The future of accounting is closely linked to professionals' ability to adapt and innovate, who must be prepared to navigate the transformations yet to come, ensuring that accounting remains a relevant and strategic function in organizations. These professionals must keep up with technological advancement by reviewing and updating professional training curricula according to current market demands. This means incorporating subjects focused on the use of technological tools, data analysis, and a broader understanding of data science and automation. Only with solid and up-to-date training will it be possible to prepare new generations of accountants for the challenges and opportunities of the digital age, enabling these future professionals to possess the necessary skills to work in an increasingly digital and dynamic environment.

They need to ensure that accounting remains a relevant and strategic function in organizations, playing a crucial role in the financial health and sustainable growth of companies. The combination of technical knowledge, adaptability, and a proactive stance towards technological innovations will ensure that the accounting profession continues to thrive and contribute significantly to the success of organizations and the economic development of society as a whole.

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