



Review

The Impacts of Emerging Technologies on Accountants' Role and Skills: Connecting to Open Innovation—A Systematic Literature Review

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Abstract: Purpose: This paper reviews the recent accounting literature focusing on emerging technologies' impacts on accountants' role and skills. Specifically, it determines what emerging technologies are most studied concerning their impacts on accountants' role and skills, which research strategies are used in the studies that focus on this theme, and the impacts of the identified emerging technologies on accountants' skills. It also investigates whether open innovation is an influencing factor in this connection. Methodology: Through a systematic literature review following the five-step approach described by Denyer and Tranfield, the Web of Science and Scopus databases are used as a source of article collection. Thus, our analysis starts with a total of 157 articles. Findings: The main analytical results of the study identify the skills that today's accountants must have and what role is assigned to them. Practical implications: Professional bodies and regulators may take the results into account in informing the revision of standards, rules, and laws for the new environment. Educational institutions can use the results to adjust their programs to prepare students with the skills employers expect them to have. Contribution: This study provides an integrated understanding of the implications of recent technological developments on the accountant's role and skills that have been hitherto discussed in the existing literature in a fragmented way. Future research suggestions are also provided, based on identified gaps in the literature, assisting other researchers in finding a way to augment knowledge in this area.

Keywords: accountant; accounting; artificial intelligence; big data; blockchain; emerging technologies; skills; open innovation



Citation: Kroon, N.; Alves, M.d.C.; Martins, I. The Impacts of Emerging Technologies on Accountants' Role and Skills: Connecting to Open Innovation—A Systematic Literature Review. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 163. <https://doi.org/10.3390/joitmc7030163>

Received: 2 April 2021

Accepted: 15 June 2021

Published: 23 June 2021

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1. Introduction

Emerging technologies are transforming the everyday work of accountants, impacting the professional life of millions of people worldwide. This phenomenon is more and more evident with the increasing speed of technological innovations. Changes have been caused by several factors, including rapid technological developments, more globalized and easily facilitated communication via the internet, and legislative and regulatory changes.

Until 2010, information and communication technologies were clearly the most critical factor, continuously improving, and reducing time and distances [1]. These improvements have made it widely possible to share knowledge and ideas in an expanding universe, giving rise to the concept of open innovation [2]. In his seminal work on open innovation, Chesbrough [3] argues that managers must rethink how they seek to create and profit from technological innovation. He contends that “open” innovation is the key to success. It is important to note that emerging technologies bring their own set of challenges that can best be overcome through the notion of open innovation [4]. In reality, current events

place a high value on open innovation since the integration of external knowledge is more important than ever to boost innovation within the organization [5].

Technological changes related to accounting have been widely studied recently [6–9], presenting accounting challenges for which future technological responses are still expected. In the same vein, studies have emerged approaching the new role and skills of accountants, many of them in the blockchain area. Blockchain technology will require a new generation of accounting professionals with skills to operate in the new blockchain environment [10,11]. Auditors' role will change after blockchain implementation, as internal control will be maintained, although its focus may be different or performed differently [12].

Accountants have always been very open to adopting new technologies [13], yet accounting technologies' radical potential can only be fully realized with a similarly profound accounting revolution in thought. Emerging technologies may have the potential to dramatically change and disrupt the work of accountants and accounting researchers [14], but it is not enough to evolve new technologies if there is no parallel development of new paradigms that allow the understanding of new data or ways of working [15].

Professional accounting bodies have responded to these challenges by developing competency frameworks [16,17] and reports on future careers in accountancy [18] to cope with these changes, to face predictable difficulties, and to seize presumable opportunities. Accounting work as we know it must be prepared to face an abundance of changes in the coming years due to these emerging technologies, and these changes can be disruptive, but at the same time open up many potential opportunities in the profession [19]. Overall, the main concern is how careers in the profession will adapt and how skills will transform.

The AACSB 2018 accounting accreditation standard A5 expects the development of knowledge and skills related to the integration of information technologies in accounting graduate programs. It specifically mentions "the ability of both faculty and students to adapt to emerging technologies as well as the mastery of current technology" [20] (p. 27). Thus, it becomes clear that technology and emerging technologies are relevant both for (the future of) students and for the accounting profession [21].

Although some recent studies link some sort of (emergent) technology to the accounting profession, there is still a call for further research regarding the impacts of digitalization [10,12,22]. Some related literature reviews have been published, linking digital transformation or specific technologies (blockchain) to the accounting profession [10,22–24], or investigating changes in the management accountants' role, related or not to technology [25,26]. However, to our knowledge, the link between emerging technologies and accountants' role and skills has not yet been made.

Therefore, to ascertain the current research situation, the main objective of this paper is to assess the accounting and information systems literature, focused on four aspects: (1) understanding how emerging technologies are transforming the everyday work of accountants; (2) what this means for today's accountants' role; (3) what skills are they expected to have; and (4) what is the connection between open innovation and the transformation mentioned above. Thus, the literature analysis is guided by the broader research question: What are the impacts of emerging technologies on accountants' role and skills?

In particular, four research sub-questions are addressed:

1. Which emerging technology is most often studied concerning its impacts on accountants' role and skills?
2. What research strategies are being used to identify emerging technologies' impacts on accountants' role or skills?
3. Is open innovation an influencing factor connecting emerging technologies and accountants' role and skills?
4. What are the most commonly identified impacts of emerging technologies on accountants' role and skills?

This work will answer these sub-questions by systematically reviewing the recent literature, following the five-step approach of a systematic literature review, as described by

Denyer and Tranfield [27]: (1) formulate the research questions; (2) locate studies; (3) select and assess these studies; (4) analyze and synthesize; and (5) report and use the results.

As for delimiting concepts in accounting and emerging technologies, we identified convenient categories as follows, developed largely based on the topical area classifications in Coyne et al. [28]—auditing, financial, managerial, accounting information systems (AIS), tax, and ‘others’. As the categories of AIS and tax did not return a relevant number of articles, these were included in ‘others’.

When approaching emerging technologies, we focus on research that connects the concept of emerging technology with impacts on the accounting profession, which helps us limit our search. Nevertheless, we found a study by Abad-Segura and González-Zamar [29], who analyzed the research on emerging technologies in corporate accounting from 1961–2019. They identified the main terms recently associated with new technology and digitalization related to accounting as big data, blockchain, social media, and artificial intelligence.

According to these categories, each analysis makes a first categorization according to the accounting area and a second according to the various emerging technologies, providing necessary depth to this review.

The rest of this paper is organized as follows. Section 2 sets out the methodology and fundamental principles of the systematic literature review. Section 3 presents and discusses the results obtained in the general analysis of the included articles (providing a global view of the topic) along with the results found in the more specific content analysis related to the three research sub-questions. Based on the results, Section 4 presents opportunities, challenges, and risks induced by emerging technologies in the accounting profession, offering a table of suggestions for future research found in the analyzed articles. Section 5 concludes this paper, pointing out its limitations and some research paths still to be followed.

2. Methodology

According to Snyder [30], a systematic review aims “to identify all empirical evidence that fits the pre-specified inclusion criteria to answer a particular research question or hypothesis” (p. 334). Bias can be minimized by using clear and systematic methods when reviewing articles, obtaining reliable results, from which conclusions can be taken, and decisions can be made [31]. All research, but especially for systematic reviews, should be reported in a comprehensive and transparent manner to allow readers to assess the investigation’s strengths and weaknesses [32].

To achieve this transparent systematization, this paper follows the method outlined in the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) Statement [31], updated in 2020 by Page et al. [33]. The PRISMA flowchart that illustrates the various steps in this systematic literature review is shown in Figure 1, and the inclusion/exclusion criteria in Table 1.

2.1. Article Collection

The collection of articles relevant to the topic under analysis was carried out on the Web of Science (WoS) and SciVerse Scopus (Scopus) databases, given their scope, quality, and prestige, which ensures the quality of the articles collected [34]. Although the research was carried out in only two databases, they cover the majority of the high-quality publications in the social sciences [34].

The keywords were defined to associate accountants or the accounting profession with emerging technologies. To broaden the emerging technologies research scope, we included terms identified by Abad-Segura and González-Zamar [29], as well as two terms to check for other types of emerging technologies. Regarding accounting, we searched for words representing accounting as a profession, or professional or scientific area.

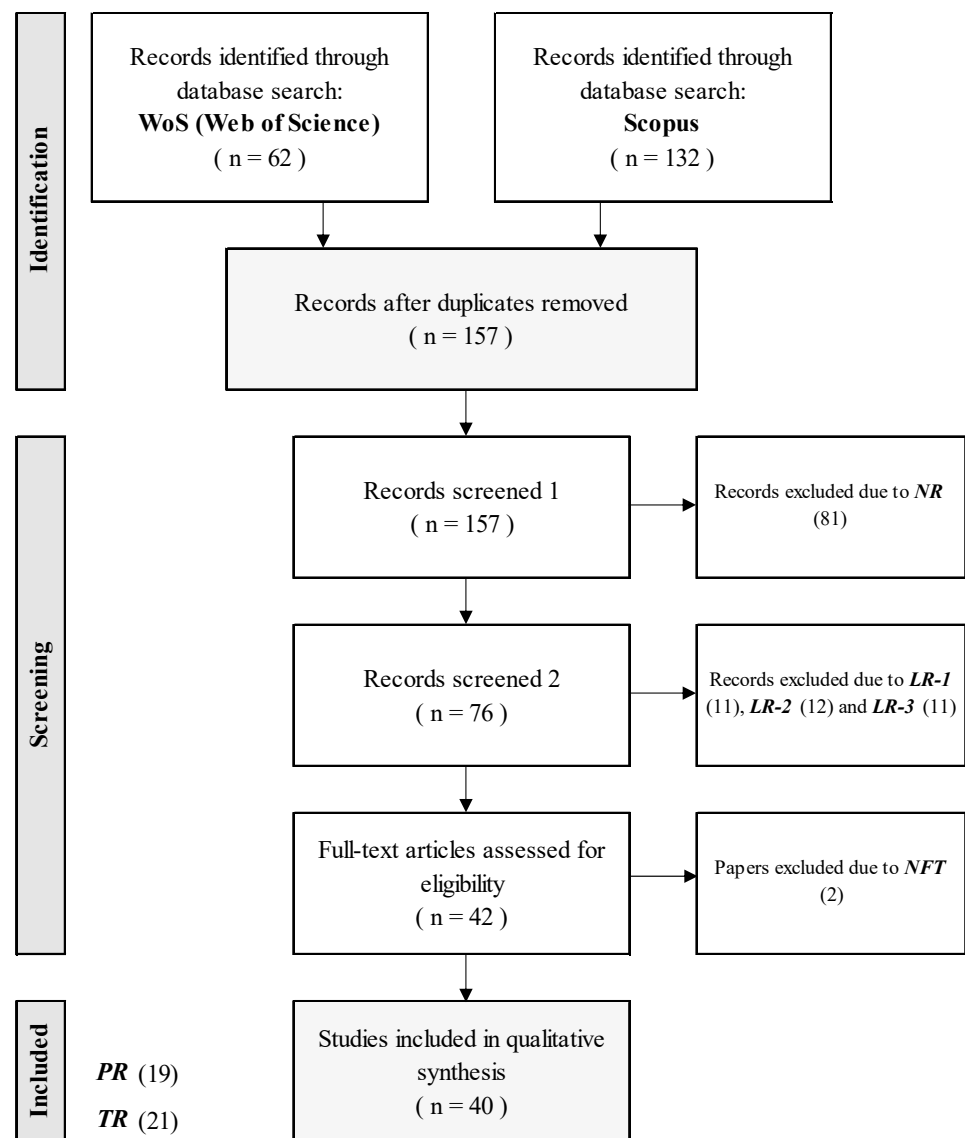


Figure 1. Search protocol (adapted from Page et al. McKenzie [33]).

Thus, on 13 June 2020, a basic search for title, abstract, author keywords, and keywords plus was conducted at the WoS Core Collection (indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED, IC), as follows:

TOPIC: (accountant OR accounting&profession OR accounting&industr*) AND (artificial&intelligence OR blockchain OR big&data OR emerging&technolog* OR digital*)

Using the Boolean operators AND OR, we guarantee that at least one of the concepts from the first part and one from the second part is included.

This search returned 112 results. The document types and language filters were then applied, restricting the results obtained to articles written in English. These restrictions led to a reduction in the sample, from 112 initial results to 67 articles that meet the defined conditions. We used time-period limitation as a final filter. As it is intended to identify the most recent impacts of emerging technologies in accounting, we decided to include only articles from 2015 onwards (inclusive). This option allows us to go deeper into all the impacts, firstly in accounting and then in accountants’ role and skills. On the other hand, the exclusion of articles prior to 2015 may affect the generalizability of our results. However, given the rapid rise of the subject, studying more recent literature was considered to be of special interest.

Table 1. Inclusion and exclusion criteria.

I/E Criteria		Reason for Inclusion/Exclusion
Exclusion criteria:		
No full text	NFT	No full text.
Not related	NR	The article does not deal with the accounting profession, accountants’ role or skills, and emerging technologies.
Loosely related	LR-1	The article addresses the accountants’ role or skills from a student’s or educator’s perspective.
	LR-2	The article addresses the accountant’s role or skills or the accounting profession without making a connection with emerging technologies.
	LR-3	The article addresses emerging technologies without making a connection with the accountants’ role or skills or with the accounting profession.
Inclusion criteria:		
Partially related	PR	The article focuses on the impacts of emerging technologies on accounting.
Totally related	TR	The article focuses on the impacts of emerging technologies on accountants’ role and skills.

At the same date, a combined search was conducted at Scopus database, with similar content:

TITLE-ABS-KEY ((accountant OR accounting&profession OR accounting&industr*) AND (artificial&intelligence OR blockchain OR big&data OR emerging&technolog* OR digital*)).

This search returned 1170 results. The document types and language filters were then applied, restricting the results obtained to articles written in English. These restrictions led to a reduction in the sample of 617 works, leaving 553 articles that meet the defined conditions. To reduce the number of articles, focusing on what was intended, a delimitation of the study area was applied to ‘business, management, and accounting’. This reduced the eligible articles to 246. Finally, we used time-period limitation, as explained above, limiting the results to ‘> 2014’, which gave us a final sample of 132 articles.

The 194 articles (62 WoS and 132 Scopus) returned using the combined search sequences were exported to reference management software (EndNote). The first step was to eliminate duplicates, which left 157 articles to be fully assessed. Explicit inclusion and exclusion criteria were defined (Table 1) to ensure that all articles were evaluated consistently and objectively. These criteria derived from the study’s objectives and were guided by the research question and four research sub-questions already presented.

After removing duplicates, the 157 pre-selected papers were reviewed by reading their titles and abstracts. One of the researchers carried out a first screening process to identify papers that do not deal with the accounting profession, accountants’ role or skills, or emerging technologies (NR), which led to the exclusion of 81 of the articles. All three investigators independently screened the remaining 76 papers to identify articles that do not focus on the connection between the accounting profession, accountants’ role or skills, or emerging technologies (LR-1, LR-2, and LR-3). Data from all researchers were compared, and disagreements were resolved by consensus, whereby the eligible articles were reduced to 42. Then the full-text articles were obtained, two of these being impossible to obtain, and for this reason were excluded from the analysis. Finally, all eligible papers were introduced in NVIVO (a qualitative data analysis (QDA) computer software produced by QSR International) to be subject to content analysis, which made it possible to highlight the answers to the previously identified research questions.

2.2. Data Collection

Two kinds of information were collected for each included paper, and these were introduced into the database. The first kind is fundamental data on the papers, which include: (1) author (s), (2) publication year, (3) paper title, (4) journal title, and (5) number of citations. This information is presented in Appendix A.

Each paper was also classified into one of the following three categories, according to the type of research used:

- Archival, which presents a review related to impacts of emerging technologies on accountants' role and skills as its main content (includes Literature Review);
- Behavioral, which uses experimental or observational methods to identify and analyze specific issues related to the impacts of emerging technologies on accountants' role and skills (includes Case Study, Survey, Interviews, and Experimental);
- Conceptual, which offers a discussion of challenges, issues, or trends related to impacts of emerging technologies on accountants' role and skills as its main content, adding something "new" to the research area.

Moreover, as all papers make a connection between an emerging technology and the accountants' role and/or skills, identifying the underlying accounting area, every article was classified into the following categories:

1. Big data analytics; Blockchain technology; Artificial intelligence; Several (includes several or all the before mentioned technologies); Other;
2. Accounting (general); Financial accounting; Management accounting; Auditing; Auditing and accounting; Management and financial accounting; Other.

One of the researchers extracted all previous data. As these are objective classifications, this will not raise any problems. The second type of information, specific data related to the four research sub-questions, including the data identifying significant impacts of emerging technologies on accountants' role and skills, was extracted using NVivo, where all researchers worked together on the same database.

3. Results

This section first presents the data that allows a general overview of the articles and then answers each of the research sub-questions.

3.1. Descriptive Results

Based on the electronic databases in which papers were collected, it was discovered that, among the 40 included articles, 67.5% (27 articles) could be found in both WoS and Scopus reference databases. Included papers that can only be found in the Scopus reference database were 32.5% of the total (13 articles).

According to the research type categories, 23 of the included papers (57.5%) are classified as Conceptual papers, ten papers (25.0%) fall into the Behavioral category, and seven papers (17.5%) are classified as Archival. Within the Behavioral category, there were four Case Studies, three papers applying Surveys, two papers using Interviews, and one paper applying an Experimental research.

Finally, a more detailed investigation was carried out to analyze (1) publication year, (2) citations, (3) included journals, and (4) geographical focus.

Figure 2 illustrates the annual evolution of the total number of publications and citations for the 40 articles included in the analysis. From 2015 on, there was a systematic increase in publication, noting that 2019 was the most productive year with 15 publications. This reveals the topic's topicality and relevance, remarking that 2020 (when the search covers only 5 months) already has eight publications. The citations show an irregular pattern, observing that the articles from 2015 and 2017 have a very relevant number of citations.

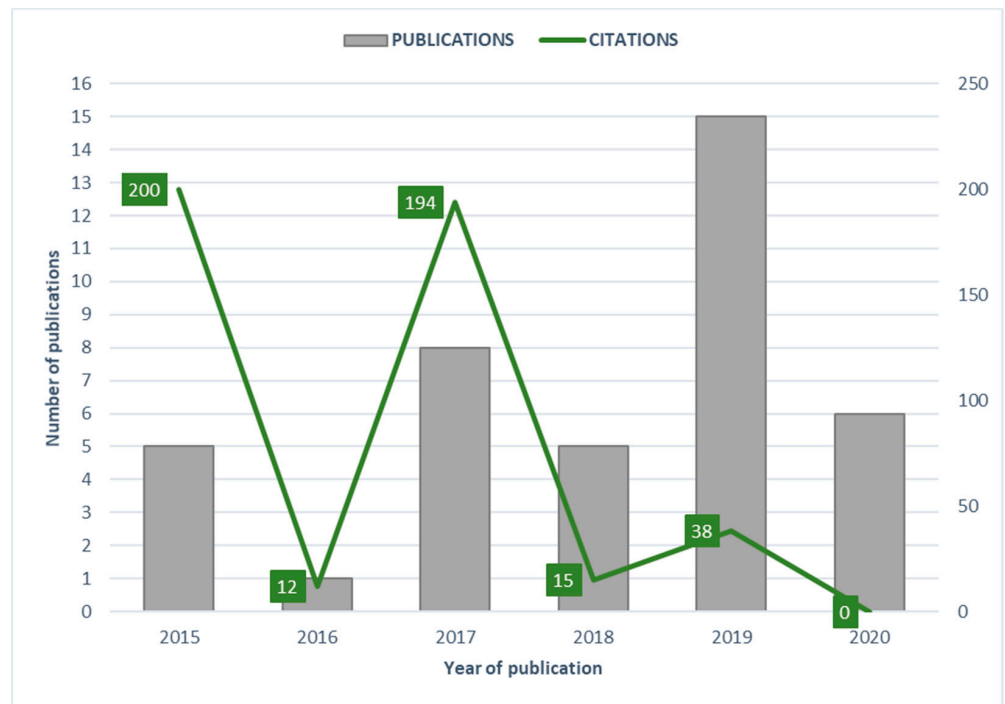


Figure 2. Evolution of total publications and citations per year.

Figure 3 depicts the most productive magazines in the topic under analysis. In a brief examination, one journal (Journal of Emerging Technologies in Accounting) stands out as having the most significant number of articles published on this topic, responsible for 15% of the sample articles. Given the focus of that journal, this shows consistency. Two journals (Journal of Information Systems and Australian Accounting Review) represent 10% each of the publications, the remaining 65% distributed by 16 journals.

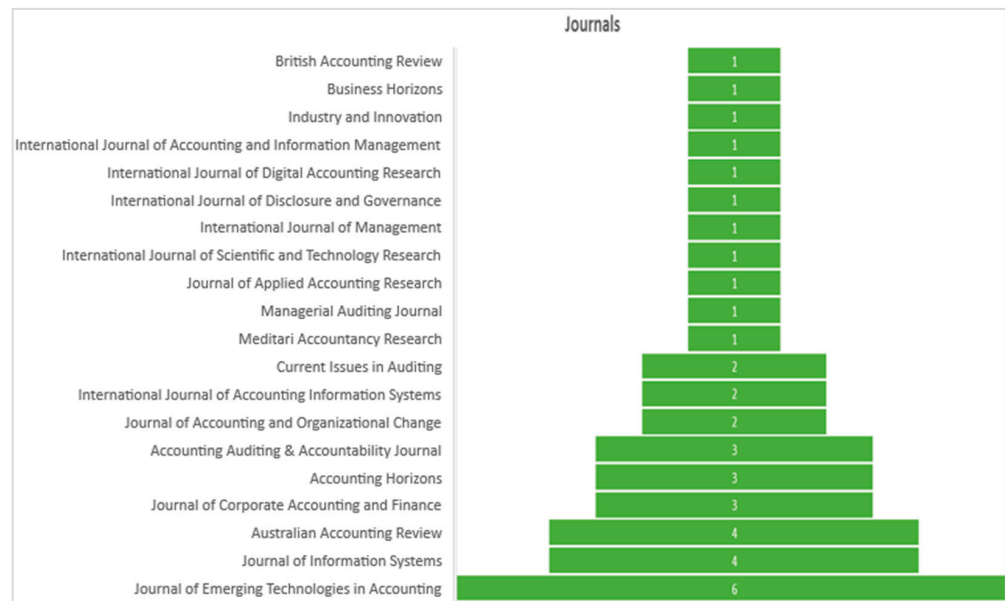


Figure 3. Represented journals in the sample.

The articles’ geographical focus was approached to close this descriptive analysis. Figure 4 shows the results by continent and country.

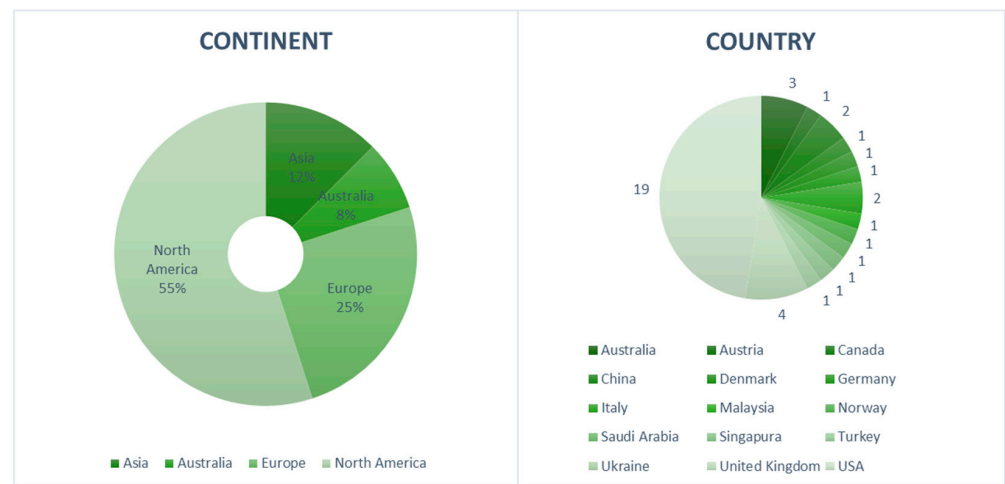


Figure 4. Geographic distribution of the sample.

Given that most of the articles apply a conceptual research strategy, the geographical focus may not be evident. Figure 4 represents the geographic area where the institutions in which the authors of these articles belong are located. It was found that 55% of the studies originate from North America, mainly the USA. The second continent with the highest number of publications is Europe, with 25% of publications.

Although geographical data was crossed with the accounting area covered and the investigation type, no underlying logical pattern was found.

3.2. Content Analysis Results

This section analyses and synthesizes the most significant contributions and conclusions of the included papers, which will provide answers to the research questions.

3.2.1. Which Emerging Technologies Are Most Studied Concerning Their Impacts on Accountants’ Role and Skills?

Although we performed quite a comprehensive search, including terms such as emerging technologies and digitalization, the obtained articles focus essentially on three emerging technologies: big data analytics, blockchain technology, and artificial intelligence. There are only two exceptions that have been classified as ‘other’: one article deals with social networks and the other with robotic process automation. Articles that deal with several technologies at the same time were classified as ‘several’.

As shown in Figure 5, the most commonly addressed technology in the sample is big data analytics, with 17 articles. The term big data is used when dealing with big and complex data sets from various sources, which need advanced techniques for their storage, management, analysis, and visualization [35]. These advanced techniques and technologies are referred to as big data analytics, which is included in a broader area encompassing several similar concepts, often used interchangeably, such as data analytics, business analytics, real-time analytics, predictive analytics, or business intelligence [35].

Gartner [36] defines big data as “high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation”. According to Earley [37], these three characteristics that make big data unique are often referred to as the Three V’s of big data (volume, speed, and variety) [37].

The second most commonly discussed technology is blockchain (nine papers), which is also the most recent. Blockchain was conceptualized in 2009, and its initial and most well-known application was Bitcoin [38]. Bonyuet [39] defines blockchain as a “digital ledger that allows to capture transactions conducted among several parties in real-time and serves as a decentralized database where each participant keeps an identical copy of

the ledger” (p. 31). The advantage of blockchain is that it can be used without the need for a trusted third-party intermediary, being a technology that “self-controls” through its sequential network infrastructure, with cryptographic resources [39].

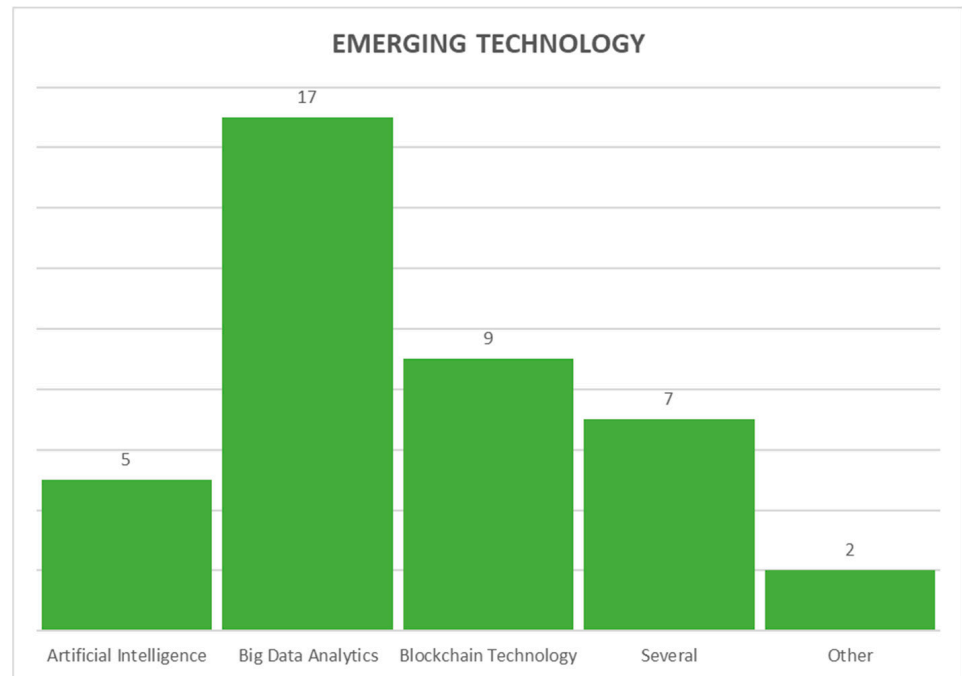


Figure 5. Emerging technologies studied in the sample.

As technology has evolved, two types of blockchain have emerged: permissionless and permissioned blockchain [40]. A permissionless blockchain can be described as one that enables records to be “shared by all network users, updated by miners, monitored by everyone, and owned and controlled by no one” [41] (p. 1). A permissioned blockchain is a “type of blockchain with restrictions in its membership and control procedures. In such a blockchain, such as Ripple, an intrinsic configuration defines the participants’ roles in which certain members can access, write information on the blockchain, or approve new members’ admission” [42] (p. A22).

Finally, artificial intelligence is an emerging technology approached in five papers, linked to accounting, especially auditing. Artificial intelligence is a comprehensive technology, and not all of its applications are relevant to accounting. Performing physical tasks is the traditional domain of robots, but it may have relevance to specific auditing tasks like counting inventory. In fact, the analysis of numbers is the dominant task in accounting and auditing. This was traditionally understood as algebraic analysis, but accountants and auditors increasingly use business intelligence and visual analysis to communicate results [43]. It is already possible to make predictions based on hypotheses to foresee the likelihood of future financial events and their contingent non-compliance [44]. According to Kokina and Davenport [45], when this type of analysis is performed in an operational and repetitive way, it may be eligible for repetitive task automation. “Some accounting firms have begun to do this type of ongoing production work in the context of their auditing platforms, although it is only in the early stages of application” [45] (p. 117).

3.2.2. What Research Strategy Did the Papers Use to Identify the Impacts on Accountants’ Role or Skills?

To answer the second research question, we classified the papers into several categories related to the technology and accounting area they address and the research strategy they use. The results of this classification are reflected in Table 2.

It can be observed that most studies approach the accounting profession as one, not distinguishing between financial accounting, management accounting, auditing, or others. This seems to be possible because many tasks accountants fulfill require the same skills and competencies. Nevertheless, there are several peculiarities in each specific accounting area, mainly studied in the audit area.

Studies that approach the accounting profession in general mainly focus on big data analytics. Richins et al. [46] indicate how accountants can occupy a strategic place in the world of big data, exploring the opportunities and threats that this technology can pose for the accountancy profession. Al-Htaybat and von Alberti-Alhtaybat [47] investigated the specific link between big data and corporate reporting, identifying the current condition and the impact of big data on corporate reporting.

Artificial intelligence seems to be in its early stages when related to accounting practice; nevertheless, Kokina and Davenport [45] provide a synopsis of the emergence of artificial intelligence in accounting and auditing. In a more targeted way, Marshall and Lambert [48] present a tool based on artificial intelligence technologies that may help task automation in the accounting profession.

One of the most recent emerging technologies, blockchain technologies, in its connection to accounting, is the most commonly studied technology in 2019 and 2020, representing 33.3% of the included papers from those years. Several researchers analyzed the (possible) impacts of blockchain on accounting and auditing services [38,42,49,50], its opportunities and limitations [51], and its main implications for accountants and auditors [11]. Yu et al. [49] argue that the public blockchain could be used as a platform for firms to voluntarily disclose information in the short run. "In the long run, the application could effectively reduce errors in disclosure and earnings management, increase the quality of accounting information and mitigate information asymmetry" (p. 37). Karajovic et al. [52] present a more conceptual and philosophical dialogue to blockchain's long-term implications.

In a more generic study, Gardner and Bryson [53] propose to explore the impacts of technological and regulatory changes on accounting firms and their professionals. "Some of these impacts highlight that there is perhaps always a darker side to innovation; innovation simultaneously destroys and creates tasks/jobs" [53] (p. 2).

Big data analytics is still the most commonly studied emerging technology when it comes specifically to the auditing area. Feung and Thiruchelvam [66] connect continuous auditing and big data analytics for a more coherent approach to this technology and its link to accounting reality. They propose a continuous auditing framework model, using big data analytics as its main component in the context of financial statement auditing. Earley [37] also focused on data analytics to explain how this technology can be applied to audits of financial statements and why it may cause a change in the way audits are executed. More generically, Alles [65] considers the evolution of big data usage in the audit profession and the extent to which it will actually be adopted.

In artificial intelligence, two specific subjects arise related to auditing: the intelligent virtual assistant (I.V.A.) and intelligent process automation (IPA). Burns and Igou [63] discuss the advantages and disadvantages of the intelligent virtual assistant. They idealize the type of use that accountants can make of these devices in the near future and identify the challenges related to their implementation. Zhang [64] addresses IPA, which is seen as a combination of a certain level of intelligent automation by incorporating artificial intelligence and other emerging technologies in traditional robotic processes. The focus is on the usefulness that the audit profession may obtain through IPA using the concept of audit workflow. In this vein, Huang and Vasarhelyi [69] propose a "robotic process automation framework that frees auditors from doing repetitive and low-judgment audit tasks and enables them to focus on tasks that require professional judgment" (p. 1).

The link between blockchain and auditing is made by Sheldon [68]. He considers the implementation of private and allowed blockchains from the perspective of general controls of information technologies incorporated in internal control audits, establishing the risks as well as the advantages of both.

Finally, referring to emerging technologies in general, Dzuranin and Mălăescu [70] identify the audit profession’s key topics; Kend and Nguyen [62] approach how artificial intelligence, robotics, big data analytics, and blockchain technologies may affect audit and assurance client services in Australia.

Table 2. Paper classification concerning profession, emerging technology, and research strategy.

Profession	Emerging Technology	Studies	Research Strategy
Accounting (general)	Artificial intelligence	[48]	Conceptual
		[54]	Conceptual
	Big data analytics	[47]	Case study
		[55]	Conceptual
		[46]	Conceptual
		[56]	Conceptual
		[57]	Conceptual
		[58]	Review
		[59]	Survey
	Blockchain technology	[60]	Conceptual
		[38]	Conceptual
		[51]	Conceptual
		[50]	Conceptual
	Several	[52]	Conceptual
		[61]	Conceptual
[62]		Interviews	
[53]		Interviews	
[16]		Review	
[15]	Review		
Auditing	Artificial intelligence	[63]	Conceptual
		[64]	Conceptual
	Big data analytics	[37]	Conceptual
		[65]	Conceptual
		[66]	Review
		[67]	Survey
	Blockchain technology	[68]	Conceptual
		[42]	Conceptual
		[39]	Review
	Other	[69]	Case study
Several	[70]	Conceptual	
Auditing and Accounting	Artificial intelligence	[71]	Conceptual
	Big data analytics	[72]	Conceptual
	Blockchain technology	[49]	Conceptual
		[11]	Review
Financial Accounting	Several	[73]	Case study
Management Accounting	Big data analytics	[74]	Conceptual
		[75]	Experimental
	[76]	Review	
Other	[77]	Case study	
Other	Big data analytics	[78]	Survey
Accounting (general)—(47.5%)			
Financial accounting (2.5%)	Big data analytics (42.5%)		Conceptual (57.5%)
Management accounting (10%)	Blockchain technology (22.5%)		Review (17.5%)
Auditing (27.5%)	Artificial intelligence (12.5%)		Case study (10%)
Auditing and accounting (10%)	Several (17.5%)		Experimental (2.5%)
Other (2.5%)	Other (5%)		Survey (7.5%)
			Interviews (5%)

3.2.3. Is Open Innovation an Influencing Factor in Connecting Emerging Technologies and Accountants’ Role and Skills?

Technological innovation comes in several forms: dramatic breaks with the past (radical technological change) or incremental improvements in current products and processes. It is not just high-tech industries that rely heavily on technological innovations. Nowadays, companies from all activity sectors and all dimensions feel this need, keeping up with this new context and with competitors.

To define the concept of open innovation, Chesbrough [4] considers some defining characteristics of this concept, distinguishing between “open” and “closed” innovation. Essentially, closed innovation arises entirely from the company’s internal innovation activity, mainly in the form of organized research and development. Open innovation arises from sources outside the company, combined with the company’s complementary internal innovation activity.

Based on the content analysis, it was possible to identify the articles which considered the concept of open innovation or somehow referred to a similar idea. The attempt to identify the specific concept of open innovation was unsuccessful, so we chose to identify related ideas. In this way, we identified two different approaches, which we called: (1) Innovation and (2) Partnerships, collaboration, and alliances. In Table 3, it can be observed that innovation is the most commonly identified approach and that blockchain technology and big data analytics are the technologies that make the most frequent link with one of the open innovation approaches.

Table 3. Approaches to open innovation.

Technology	Innovation	Partnerships, Collaboration, and Alliances	Total
Artificial intelligence	1	2	3
Big data analytics	3	3	6
Blockchain technology	2	4	6
Other	1		1
Several	4		4
	11	9	20

The innovation concept was the most commonly mentioned, which is not surprising as technology and innovation have a very direct connection: thinking of one seems to induce the other automatically. We found references to continuous innovation [53,70], disruptive innovation [11,48,53,65] and technological innovation [47,50,53], all dealing with the innovative potential that emerging technologies have. Whether they will prove to be a disruptive force is still considered an open question [16,65]. Two articles refer to innovation theories [16,62], but only Kend and Nguyen [62] used a theory (diffusion of innovation theory) to ascertain the state of adoption of big data analytics and other emerging technologies.

Gardner and Bryson [53], who focus on the dark side of the industrialization of accounting, wrote the article with the most references to innovation. They conclude that regulatory and technological innovation are resulting in three levels of innovation within organizations: process innovations, product innovations, and business model innovations. The first arises from the use of new technologies to improve existing routines in companies; the second from technological innovations being used to improve existing products; and the third by the expansion of accounting firms’ “professional” limits, investing in complementary services to diversify their portfolio of provided services.

The other relationship we found between open innovation and emerging technologies is how firms cooperate to get the best out of every technology. The “Big Four” accounting firms (PwC, Deloitte, EY, and KPMG) are a reference for various authors, linking accounting services and artificial intelligence [45,64], big data [46,66], and blockchain [39,51,52]. To

take advantage of the latest technological innovations, they have already realized that they should not work alone, so all of them have already established partnerships, collaborations, or alliances with large technology companies (e.g., Kira Systems, IBM, Accenture).

Revealing collaboration also are the DevOps [56], the Hyperledger project [50,51], and the Enterprise Ethereum Alliance [51,52]. The first integrates the efforts of development and IT operations teams—two groups that traditionally practiced separately from each other or in silos [79]. The second project, led by the Linux Foundation, was announced at the end of 2015 and was backed by 17 founding members. It now has over 190 members, including technology companies such as IBM and Consensus, consulting and professional services companies such as Accenture PLC, and financial services companies such as JPMorgan and the Depository Trust and Clearing Corporation (DTCC) [80]. The project aims to support open-source blockchain-based distributed ledgers and advance cross-industry blockchain technologies [51]. The third project, founded at the beginning of 2017, is a member-led industry organization whose goal is to drive the use of Enterprise Ethereum and Mainnet Ethereum blockchain technology as an open standard to empower all businesses [81].

All these alliances allow firms to collaborate, brainstorm ideas, and develop the best strategies for implementation [52]. Global organizations, incumbent firms, and start-up companies building the technology together will ensure consistency and compatibility across the industry, giving sense to the meaning of open innovation.

3.2.4. What Are the Most Identified Impacts of Emerging Technologies on Accountants’ Role and Skills?

The in-depth analysis of the articles in the sample provided the data presented in Tables 4 and 5. As referred earlier, all articles were subjected to content analysis using NVivo, whose categorization can be found in Appendix B.

Table 4. Impacts on accountants’ role.

Role	Studies
Emphasis on judgment	4 [37,38,49,62]
Advisory functions	3 [11,16,42]
Use data analytics	3 [37,39,76]
Blockchain implementation	2 [11,42]
Modify audit procedures	1 [39]
Information governance	1 [56]
Policy setter/validator	1 [38]

Table 5. Impacts on accountants’ skills.

Role	Studies
Analytical skills	7 [37,46,47,55,57,75,76]
Basic knowledge of ET	4 [11,46,53,75]
Creativity and openness	3 [47,55,76]
Communication skills	3 [47,55,76]
Teamwork skills	2 [56,76]
Systemic thinking	1 [39]

The impacts caused by emerging technologies on the role of accountants are shown in Table 4.

In turn, Table 5 presents skills that accountants should acquire or reinforce considering the evolution of technologies in the accounting area. The analyzed studies specifically identified these impacts and respective changes. Other (implicit) effects may exist, all of them evidenced in the subsequent analysis.

Impacts on General Accountants' Role

The accounting profession has undergone several changes over the years due to its environment's natural evolution. Accounting practice is still adapting to emerging technologies in recent years, and academia monitors these impacts even though empirical studies are still lacking.

As indicated by Coyne [56], "accountants have particular expertise as business specialists. As a result, accountants are valuable collaborators with information technology (IT) specialists in information systems design and maintenance, not only as end-users of business information but also as advocates for other internal and external decision-makers" (p. 21). In addition, accountants are very familiar with data management and regulatory compliance control issues, which are vital aspects of information management. Thus, a collaboration between these professionals, business specialists, and IT specialists is essential if the control objectives are to be achieved and the information needs of decision-makers are to be satisfied [56].

In fact, Richins et al. [46] assert that accountants are privileged to take a leading role in analyzing problem-oriented structured and unstructured data and help data scientists create value through exploratory data analysis. They justify these claims on the premise that accountants have a deep understanding of the business and are already used to data analysis and working with structured data sets [46]. In the same sense, Pickard and Cokins [57] state that the accounting skills of handling financial data, understanding where they come from, and knowing which models are best suited to apply qualify accountants to build data mining & analytics models accurately, interpret their results and make decisions based on them.

In conclusion, Huerta and Jensen [55] see data analytics as an "opportunity for accountants to move from the role of watchdog within an organization to being a business partner" (p. 105), filling a strategic role by facilitating their organizations to become more data-driven.

Blockchain technology will also change how accounting is performed and hence shift the accountant's role. Tan and Low [38] (p. 317) "speculate that digitizing current validation processes and hosting accounting transactions on a private blockchain will improve the accounting data's reliability for financial statements preparation". Although in the blockchain context, accountants may no longer be the 'owner' of the accounting database, they will continue to define the digitized process's policies and validate the entire procedure. In addition, the exercise of analyzing and judging subjective values and balances indicated in the financial statements remains necessary, as these cannot be simply taken from a blockchain-based accounting database. [38].

As indicated by Marrone and Hazelton [16], for accountants, "it is only a small step from automatic contract execution and payment to transactions being automatically recorded in the corporate ledger, which may relegate the bookkeeping role of the accountant to a historical footnote" (p. 684). It may be concluded that blockchain technology causes a change in the tasks to be performed by the accountant, going from the more traditional and laborious recording and preparing of financial statements to the evaluation and authentication of the original documents and of the rationality of smart contracts [11,49].

Related to artificial intelligence technologies, Kokina and Davenport [45] report that, in the short term, job losses associated with the implementation of AI technologies will be relatively slow and marginal, as these technologies replace specific tasks and not entire jobs. They indicate some activities that are likely to be part of the remaining jobs in accounting:

- Work along with intelligent accounting machines, monitoring their performance and results and (eventually) improving their performance;
- Monitor the use of intelligent machines in audit processes and find out the need to adjust the automation tools (more, less, or different);
- Develop new tools or technologies based on AI in conjunction with accounting firms and software houses and support the existing ones.

- Perform tasks that AI-based computers cannot do, such as cultivating internal and external customers, interpreting results for top managers and boards of directors, and so forth;
- Perform accounting tasks that are infrequent and out of the ordinary, for which it is not economically viable to build automated solutions.

Impacts on Auditors' Role

Analyzing, in particular, the role of auditors Liu et al. [42] state that audit firms should “shift their focus to assess the effectiveness of risk management and advise on solutions and assurance for internal control” (p. A27). This shift will be possible if auditors actively participate in blockchain development, emphasizing risk control and considering stepping forward to influence and lead blockchain implementation [42].

Bonyuet [39], analyzing the impact of blockchain on auditing, concludes that blockchain allows all data to be available in real-time, so statistical sampling techniques may no longer be necessary. In that case, auditors need to be able to rely on data analysis to test the entire database. Liu et al. [42] also indicate that applying appropriate data analytics in blockchain opens a way to conduct continuous auditing due to real-time access to transaction records. As the traditional and more time-consuming way of collecting and testing evidence is no longer needed, the release of resources allows audit firms to expand their consulting services, such as control design, change management, and blockchain governance [42].

According to Bonyuet [39], some potential new roles for accountants (auditors) when blockchain systems are standardized across industries can be: (1) auditor of smart contracts and oracles; (2) service auditor of consortium blockchains; (3) administrator function; (4) arbitration function.

Impacts on Management Accountant's Role

Finally, regarding the management accountant's role, Oesterreich and Teuteberg [75] predict this will shift from the “traditional role of the information provider towards a data scientist with strong systematic and mathematical-statistical competencies” (p. 335). When adopting data analytics, companies must decide whether they can reskill their controlling professionals or whether it will be better to hire specialists, such as data scientists, to perform the new tasks [75].

As accountants and auditors face changes in their business and consequently in their role, they must broaden their skillset and knowledge to anticipate and meet their clients' demands [11].

Table 5 shows the main skills that accountants must acquire or reinforce, according to the analyzed articles.

Impacts on General Accountants' Skills

Senior accountants in large firms uniformly argue that the need for human accountants will not go away anytime soon [45]. However, many say that the skills for successful accounting and auditing are likely to be different in the future, and some admit that they will need substantially fewer entry-level accountants in coming years [45] (p. 120).

Accountants are used to dealing with large amounts of numbers, but big data incorporates other data such as free text, images, and videos, which can be analyzed and manipulated. The analytical skills and technical knowledge requested for this type of analysis are different, so accountants will need to enhance these analytical skills. Huerta and Jensen [55] emphasize that “extracting meaningful knowledge from big data requires not only a deep understanding of the data but also a creative way of thinking about data. The challenge with big data is identifying the right questions to ask” (p. 102).

Al-Htaybat and von Alberti-Alhtaybat [47] point out similar skills to develop in the accountants of the near future: analytical skills, creative and open mind (creativity), and telling a story (communication skills).

As one of the major challenges for the future of accountancy may be the general automation process, Richins et al. [46] state some focus areas to help accountants acquire skills in order to be resilient to automation:

- Seek additional training in business strategy and business models to complement existing accounting knowledge.
- Develop business analytic capabilities.
- Learn to work with the (new) tools developed for big data/scaled for big data contexts, working with extensive structured and unstructured data.
- Understand the basics of programming so that accountants can more easily interact with data and computer scientists and at the same time develop the ability to learn about new technologies emerging in the future.

Impacts on Auditors' Skills

As is true for any profession, the changing role of audit brings a need for new skills. According to Gardner and Bryson [53], "the increased deployment of technology in the audit process has resulted in a shift in the types of technical skills required by accountancy firms" (p. 8). With the introduction of the latest technologies, accounting is increasingly becoming a technical process of applying algorithms instead of traditional accounting information and financial reporting delivery.

An example of this is pointed out by Liu et al. [42] when they state that auditors should "acquire competency in blockchain technology and governance of blockchain" (p. A26). In this way, auditors would assess the advantages and disadvantages of adopting a particular type of blockchain and advise their customers on this same implementation.

Another reality is focused on by Nielsen [76] regarding the increasing demand for data scientists and finance executives with data expertise. "Closer integration between data specialists and other functions can help unlock new sources of information, delivering fresh insights about past outcomes as well as helping to predict the future environment" (p. 9).

However, soft skills, such as intuition, creativity, and communication, remain relevant in today's technological environment, if not even more critical. As some portions of financial statements are subject to estimates, auditors cannot be exempted from carrying out audit procedures on such estimates, given their subjective nature. Even if the auditor's role is reduced in terms of verification, judgment, supervision, and insight will be more critical. Thus, audits in the new technology's context will focus on systemic evaluation, risk assessment, predictive auditing, and fraud detection. "A solution to address this issue, either in private or public blockchains, would be to engage auditors in the transaction validation process" [39] (p. 37).

In summary, tasks with a more routine nature have become more automated, leaving auditors to focus their minds and skills on more critical aspects of the audit, those that require key judgments [62].

Impacts on Management Accountants' Skills

Management accountants should also shape their professional identity and develop the necessary skills to keep up with the latest technologies. According to Oesterreich and Teuteberg [75], "business analytics and IT skills are expected to gain importance as one of the new major skills areas of the controller's and MA's skills profile, being a 'must have' capability for both professions to gain benefits from business analytics" (p. 334).

Nielsen [76] reports that there is a need to go deeper in IT, business intelligence, data mining, programming, and data management. He states the the most popular techniques in statistics and economics are correlation and multiple regression. Still, if management accountants want to reach a high analytical level, they must understand and apply more advanced statistical techniques.

Highlighting the management accountant profession's evolution, the Institute of Management Accountants (IMA) has recently updated its competency framework [18]. The revised competency framework considers six domains of core skills essential for

management accounting professionals to maintain their position. Beyond the common core skills such as reporting and control, strategic management, or leadership, one primary skill area includes technology and analytics skills, described as “the competencies required to manage technology and analyze data to enhance organizational success” [18] (p. 4).

4. Discussion of Results and Implications

It arises from the analysis of the results that emerging technologies’ impact on the accountants’ role and skills is not direct. Figure 6 represents the way emerging technologies impact the role and skills of accountants.

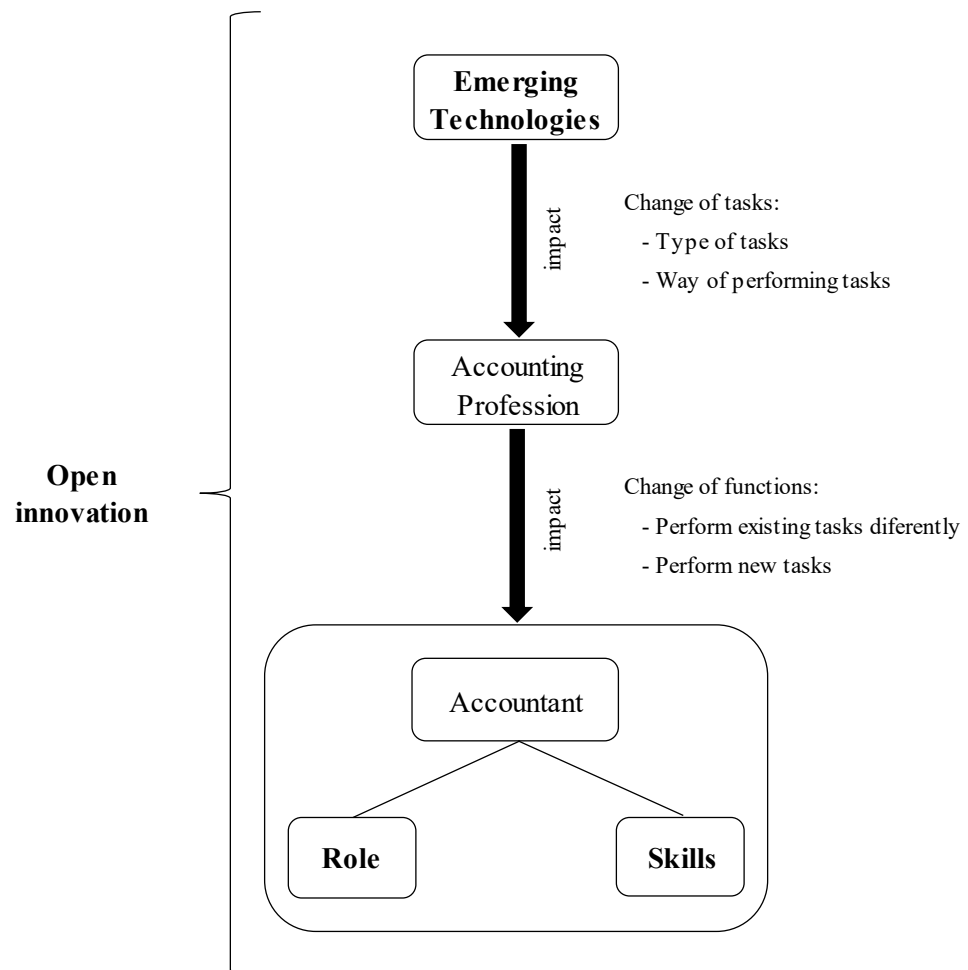


Figure 6. How do emerging technologies impact accountants’ role and skills?

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. Similarly, the skills needed by accountants to perform their profession may also be affected.

4.1. Opportunities, Challenges, and Risks

The opportunities created by emerging technologies are immense. As Marrone and Hazelton [16] conclude, “there is much more to be done in exploring both the potential benefits and limitations of new technologies for accounting” (p. 677). Activities commonly performed by accountants, such as conformity assessment, analysis, and presentation of information for decision making and the resolution of problems characteristic of the

accountant's role, can be supported by big data analytics, blockchain technology, and artificial intelligence. While professionals may feel these technologies as a threat, they also create many opportunities.

For example, Marshall and Lambert [48] found that "augmented intelligence provides greater opportunities for accountant-professionals to leverage their knowledge through federation, thereby freeing them to pursue activities that offer more value to the organization" (p. 208).

Liu et al. [42] identify many opportunities related to blockchain technology, including accountants assuming the role of planner and coordinator of potential blockchain participants or even acting as its administrator. Other tasks they identify as opportunities are examining transaction records on the blockchain, developing novel audit processes on blockchain transactions, or verifying the consistency between items on blockchain and the physical world.

When it comes to big data, the auditor's judgment will assume a much more significant role in the data analysis environment than in the traditional (sample-based) audit due to the potential for evaluating large amounts of anomalies [37]. To take advantage of big data opportunities and, at the same time, avoid pitfalls, companies must bet on individuals who understand data analysis and the business. Accountants are already starting to work with data scientists and understand their business, so "accountants are poised to contribute meaningfully to their firms as part of the big data revolution" [46] (p. 74).

On the other hand, any novelty carries its risks, obstacles, and challenges. One of the risks identified by several authors is the willingness accountants will have to adapt in practice [63,66]. While the first analyzes the impacts of an intelligent virtual assistant, the second approaches big data analytics. Burns and Igou [63] report that "users will have to adapt to a more intimate, habit-forming interface when voice assistants are deployed in accounting workplaces" (p. 85). These interfaces can be felt as intrusive, a threat to privacy, even exceeding some social norms or boundaries, which can make users feel uncomfortable; however, at the same time, they can be addictive in nature. Feung and Thiruchelvam [66] conclude that practitioners must be willing to change and adopt big data analytics aside from the awareness of these upcoming areas. As the real-time business environment primarily propels the need for continuous auditing, practitioners cannot avoid this transition in the future.

An obstacle referred to for both financial accounting and auditing relates to the standards that should be generally applied. According to an interviewee from Al-Htaybat and von Alberti-Alhtaybat [47], "our standards currently do not allow for speculative financial information. Sure, I can include some non-financial predictions, but I could not publish a progressive financial statement in the annual report. For big data to really benefit users of corporate reporting information, we will have to look into this" (pp. 866–867).

Richins et al. [46] state that "auditors' role in the world of big data analytics will largely depend on the evolution of auditing standards" (p. 75). For big data to fit into the audit of the financial statements, standards must be adjusted or revised, replacing or complementing the traditional way of collecting evidence by these new techniques. Kend and Nguyen [62], in a similar way, obtained evidence that it is necessary to update auditing standards so that automation challenges for auditors and their companies are overcome.

Finally, there is a general concern with the skills and knowledge that accountants should have to keep up with the newest technologies. Earley [37] expresses the concern of regulators that "auditors will lack the requisite skills to apply data analytics techniques properly, and firms will begin expanding advisory services to attract and hire data scientists with data analytics skills" (p. 497). This raises concerns about audit quality, as data scientists have a different mindset than traditional auditors, focusing more on consulting services than on auditing itself.

On the other hand, Al-Htaybat and von Alberti-Alhtaybat [47] mentioned the risks of a lack of knowledge of big data, data analytics, and this field of study, showing that a little bit of knowledge is a dangerous thing. "However, accountants' tacit knowledge, their

approach to decision-making, and their inherent values, such as conservatism, reliability, and risk-adversity, must not be eliminated and replaced by statistical analyses and data scientists’ analytical approaches. Big data needs interpretation and story-telling, which is based on prior knowledge, experience, and theory” [47] (p. 868). Instead, they recommend that multidisciplinary teams of accountants and data scientists are created, which complement and enhance each other’s experience, thereby increasing the accuracy and reliability of corporate reports [47].

Lastly, related to management accounting, Oesterreich and Teuteberg [75] found out that “the supply of business analytics competencies and IT skills in management accountant professional’s profiles tends to decrease with company size. Thus, the assumption is near that in large organizations, management accountants do not need business analytics competencies and advanced IT skills as these skills constitute a significant part of a data scientist’s job profile rather than of a management accountant’s job profile” (p. 318).

4.2. Suggestions for Future Research

As in all study areas, accounting research should present conceptual works and empirical works that support established theories and concepts. As referred to by Feung and Thiruchelvam [66], there is not much use case research (analytical) being done in this area. They indicate that the analytical research type needs more attention from researchers, such as modeling, applications, and simulations, as this is what the practitioners could benefit from. Many other researchers have indicated the need for significant further empirical analyses of big data analytics [37,46,47,62], artificial intelligence [63], and blockchain technology [38] to gather a broader range of insights.

Considering the above, Table 6 presents several future research suggestions, withdrawn from the articles included in the content analysis, organized by accounting area and emerging technology.

Table 6. Future research suggestions.

Accounting Area	Future Research Suggestions
I—Accounting (General)	
Artificial Intelligence	<ul style="list-style-type: none"> ■ Investigate issues related to human intervention in the development and use of cognitive computing systems for augmented intelligence. ■ Identify ways of managing organizational changes for increased intelligence that enhance: (1) accounting knowledge and skills; (2) an increase in task performance; (3) assigning tasks with greater added value to accountants. ■ Relate assurance of accounting cognitive computing system compliance to normative standards.
Big Data Analytics	<ul style="list-style-type: none"> ■ Investigate how to use digital content analytics, such as data analytics, multimedia analytics, text analytics, web analytics, network analytics, and mobile analytics in corporate reporting. ■ Determine how accounting standards and their theoretical framework should be adjusted to better use the information provided by big data analytics. ■ Address the education agenda to see if accounting courses have adapted to new technologies, connecting theory and practice. ■ Explore whether accountants trust big data and provide guidance on the appropriate level of trust in different external data sources. ■ Provide guidance on the changes caused by the passage of the sampling technique to the use of all data, made possible by big data analytics.
Blockchain Technology	<ul style="list-style-type: none"> ■ Empirically assess whether the audit’s efficiency and effectiveness improve due to lower error rates in the database engine and lower incentives for accounting fraud.
Several	<ul style="list-style-type: none"> ■ Analyze stakeholders’ awareness of emerging technologies and conduct some sort of acceptance analysis.

Table 6. Cont.

Accounting Area	Future Research Suggestions
II—Auditing	
Artificial Intelligence	<ul style="list-style-type: none"> Address the concern of intelligent virtual assistants’ users regarding the company’s potential leakage of confidential or private information.
Big Data Analytics	<ul style="list-style-type: none"> Focus on both the processes and audit evidence gathering to expressly point out areas that the auditing standard-setting board could look at to update the existing standard (s) or issue new standard (s). Explore whether education institutions incorporate the skill sets to apply financial statement audit supported by continuous auditing into their accounting and finance curriculum and to what extent.
Blockchain Technology	<ul style="list-style-type: none"> Understand how ‘smart features’ can be used to provide the controls to satisfy values of integrity, valuation, and classification
III—Auditing and Accounting	
Artificial Intelligence	<ul style="list-style-type: none"> Explore the bias in artificial intelligence and assess whether humans using AI applications can/do make appropriate decisions. Examine the role of transparency, or the lack thereof, in AI-based decision-making in the field of accounting and auditing. Explore how bias and transparency are addressed by smart system manufacturers and users of accounting and auditing systems.
Blockchain Technology	<ul style="list-style-type: none"> Investigate which form of blockchain (private, public or hybrid) is most suitable for accounting and auditing, especially regarding information accessibility. Explore what knowledge and skills accountants and auditors need to provide accounting and auditing services to BT customers. Analyze how BT changes the nature of the accountants’ and auditors’ tasks and their impact.
Several	<ul style="list-style-type: none"> Investigate whether accounting degree programs are structured to satisfy the present job market, producing accounting graduates with the skills set and knowledge necessary for current audit practice, considering the implementation of BDA, AI, and robotics.
IV—Management Accounting	
Big Data Analytics	<ul style="list-style-type: none"> Investigate the existence of an association between contextual variables in providing business analytics competencies and IT skills. Explore how the management accountant and the data scientist’s competence profiles can be defined more precisely in different organizational contexts.

5. Final Considerations

Following the systematic literature review methodology, this article analyzed and systematized 40 articles published between 2015 and 2020. The approach was taken from the accountant’s perspective, making a connection with emerging technologies and open innovation. The main results reveal that several studies have discussed the changes caused by emerging technologies on accountants’ role and skills. Notwithstanding, a significant gap still exists in empirical studies (case studies, surveys, interviews, etc.) to verify the results.

One of the contributions of this study is identifying emerging technology types that impact the accounting profession. We identified this gap in our literature review. Even though it is not the scope of this study, we may conclude that big data, blockchain, and artificial intelligence are emerging technologies related to the accounting profession. However, it remains to be studied which other emerging technologies may also impact the accounting profession.

Concerning open innovation, some authors of the analyzed articles mention the link between emerging technologies, innovation, and the accounting profession, but no study

focuses on innovation. There is still little research on the impact of open innovation in accounting, and the existing research is limited to a few areas. Thus, it would be of great interest for future studies to address the link between open innovation and emerging technologies in accounting services, providing insights into how accounting firms can better use new technologies through open innovation.

Although we were unable to identify a starting theoretical framework, the second contribution of this study is the construction of a diagram that represents the impact of emerging technologies on the role and skills of accountants (Figure 6). With the help of this representation, new avenues for future research can be identified, connecting the three concepts under study.

Furthermore, a very recent research line concerns the current pandemic situation caused by COVID-19, which introduced substantial changes both in the general societal context and in the professional accounting area. The difficulties and opportunities created by COVID-19 (e.g., telework, increased use of technologies), their impact on accountants' work, and their role and skills could be explored.

This study can be helpful for professional bodies, regulators, and educational institutions since they all deal with the accounting profession. As mentioned in the results, professional bodies and regulators must be attentive to adjusting their standards to the current digital state. Without this adjustment, many existing tools may not be implemented by professionals. As for educational institutions, the need to update accounting programs, preparing students for their new roles, has already been identified [51]. As such, the results indicated in Sections 3 and 4 can be used to adjust the programs to the needs of the profession, future employers, and clients.

Several limitations must be considered when analyzing the results of the present study. First, papers were collected from only two abstract and citation databases of peer-reviewed literature (WoS and Scopus). Second, since the search criteria restricted the language of the collected articles to English, existing articles published in other languages were excluded. Third, the defined keywords may have limited the scope of the study. This review could be broader from a completeness point of view if more databases, languages, and keywords were considered. However, a systematic literature review requires that restrictions and criteria be specified and reported so that the review is feasible.

Despite these limitations, the main conclusion withdrawn from this research is the lack of empirical research connecting emerging technologies to accountants' role or skills in an open innovation context over the analyzed years. For research in this area to benefit its stakeholders, conceptual models need to be constructed, tested, and validated, so this is the key suggestion for future research. It is necessary to develop new studies that allow the deepening and solidifying of knowledge in this area.

Author Contributions: N.K.; methodology, N.K.; validation, N.K., M.d.C.A. and I.M.; formal analysis, N.K.; investigation, N.K.; resources, N.K.; data curation, N.K., M.d.C.A. and I.M.; writing—original draft preparation, N.K.; writing—review and editing, N.K. and M.d.C.A.; visualization, N.K.; supervision, M.d.C.A.; project administration, N.K.; funding acquisition, I.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Funds through the FCT (Foundation for Science and Technology), I.P., within the scope of the project Ref. UIDB/05583/2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to thank the Research Centre in Digital Services (CISeD) and Research Center in Business Sciences (NECE-UBI) for their support.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Fundamental data about the papers.

Author (s)	Year	Title	Journal	Citation
Al-Htaybat and von Alberti-Alhtaybat [47]	2017	Big Data and corporate reporting: impacts and paradoxes	Accounting Auditing & Accountability Journal	21
Alles [65]	2015	Drivers of the use and facilitators and obstacles of the evolution of big data by the audit profession	Accounting Horizons	52
Appelbaum, Kogan [74]	2017	Impact of business analytics and enterprise systems on managerial accounting	International Journal of Accounting Information Systems	49
Arnaboldi, Azzone [77]	2017	Governing social media: the emergence of hybridized boundary objects	Accounting Auditing & Accountability Journal	6
Arnaboldi, Busco [58]	2017	Accounting, accountability, social media and big data: revolution or hype?	Accounting Auditing & Accountability Journal	35
Bonyuet [39]	2020	Overview and impact of blockchain on auditing	International Journal of Digital Accounting Research	0
Burns and Igou [63]	2019	“Alexa, Write an Audit Opinion”: Adopting Intelligent Virtual Assistants in Accounting Workplaces	Journal of Emerging Technologies in Accounting	1
Coyne, Coyne [56]	2018	Big Data information governance by accountants	International Journal of Accounting and Information Management	8
Dzurainin and Mălăescu [70]	2016	The current state and future direction of IT audit: Challenges and opportunities	Journal of Information Systems	12
Earley [37]	2015	Data analytics in auditing: Opportunities and challenges	Business Horizons	20
Feung and Thiruchelvam [66]	2020	A framework model for continuous auditing in financial statement audits using big data analytics	International Journal of Scientific and Technology Research	0
Fuller and Markelevich [50]	2020	Should accountants care about blockchain?	Journal of Corporate Accounting and Finance	0
Gardner and Bryson [53]	2020	The dark side of the industrialization of accountancy: innovation, commoditization, colonization and competitiveness	Industry and Innovation	0
Huang and Vasarhelyi [69]	2019	Applying robotic process automation (RPA) in auditing: A framework	International Journal of Accounting Information Systems	0
Huerta and Jensen [55]	2017	An accounting information systems perspective on data analytics and big data	Journal of Information Systems	13
Izmailov, Pilevych [61]	2020	Information systems and technologies in accounting and taxation as a means of integration into the digital economy	International Journal of Management	0
Karajovic, Kim [52]	2019	Thinking Outside the Block: Projected Phases of Blockchain Integration in the Accounting Industry	Australian Accounting Review	6
Kend and Nguyen [62]	2020	Big Data Analytics and Other Emerging Technologies: The Impact on the Australian Audit and Assurance Profession	Australian Accounting Review	0

Table A1. Cont.

Author (s)	Year	Title	Journal	Citation
Kokina and Davenport [45]	2017	The emergence of artificial intelligence: How automation is changing auditing	Journal of Emerging Technologies in Accounting	28
Kokina, Mancha [51]	2017	Blockchain: Emergent industry adoption and implications for accounting	Journal of Emerging Technologies in Accounting	26
Krahel and Titera [72]	2015	Consequences of Big Data and Formalization on Accounting and Auditing Standards	Accounting Horizons	53
Liu, Wu [42]	2019	How Will Blockchain Technology Impact Auditing and Accounting: Permissionless versus Permissioned Blockchain	Current Issues in Auditing	0
Marrone and Hazelton [16]	2019	The disruptive and transformative potential of new technologies for accounting, accountants and accountability A review of current literature and call for further research	Meditari Accountancy Research	0
Marshall and Lambert [48]	2018	Cloud-Based Intelligent Accounting Applications: Accounting Task Automation Using I.B.M. Watson Cognitive Computing	Journal of Emerging Technologies in Accounting	5
Michael and Dixon [67]	2019	Audit data analytics of unregulated voluntary disclosures and auditing expectations gap	International Journal of Disclosure and Governance	1
Moll and Yigitbasioglu [15]	2019	The role of internet-related technologies in shaping the work of accountants: New directions for accounting research	British Accounting Review	6
Nielsen [76]	2018	Reflections on the applicability of business analytics for management accounting—and future perspectives for the accountant	Journal of Accounting and Organizational Change	0
Oesterreich and Teuteberg [75]	2019	The role of business analytics in the controllers and management accountants' competence profiles. An exploratory study on individual-level data	Journal of Accounting and Organizational Change	1
Perkhofer, Hofer [59]	2019	Interactive visualization of big data in the field of accounting A survey of current practice and potential barriers for adoption	Journal of Applied Accounting Research	5
Pickard and Cokins [57]	2015	From bean counters to bean growers: Accountants as data analysts—a customer profitability example	Journal of Information Systems	3
Rezaee and Wang [78]	2019	Relevance of big data to forensic accounting practice and education	Managerial Auditing Journal	4
Richins, Stapleton [46]	2017	Big Data Analytics: Opportunity or Threat for the Accounting Profession?	Journal of Information Systems	16
Schmitz and Leoni [11]	2019	Accounting and Auditing at the Time of Blockchain Technology: A Research Agenda	Australian Accounting Review	9
Sheldon [68]	2019	A primer for information technology general control considerations on a private and permissioned blockchain audit	Current Issues in Auditing	0

Table A1. Cont.

Author (s)	Year	Title	Journal	Citation
Sutton, Arnold [54]	2018	How Much Automation Is Too Much? Keeping the Human Relevant in Knowledge Work	Journal of Emerging Technologies in Accounting	1
Tan and Low [38]	2019	Blockchain as the Database Engine in the Accounting System	Australian Accounting Review	4
Türegün [73]	2019	Impact of technology in financial reporting: The case of Amazon Go	Journal of Corporate Accounting and Finance	0
Warren, Moffitt [60]	2015	How Big Data Will Change Accounting	Accounting Horizons	72
Yu, Lin [49]	2018	Blockchain: The Introduction and Its Application in Financial Accounting	Journal of Corporate Accounting and Finance	1
Zhang [64]	2019	Intelligent process automation in audit	Journal of Emerging Technologies in Accounting	1

Appendix B

Name	Files	References	Created By
Old		0	NK
RQ1 - Most studied emerging technologies		19	NK
Continuous Auditing		1	NK
Artificial Intelligence		1	NK
Cognitive Computing		1	NK
Intelligent Virtual Assistant		1	NK
Generic or Several		3	NK
Robotic Process Automation (RPA)		1	NK
Big Data analytics		10	NK
Business analytics		1	NK
Blockchain technology		5	NK
RQ4 - Impacts accountants' role and skills		19	NK
New role		3	NK
Obstacles to achieve impacts		4	NK
New functions, tasks or services		9	NK
Develop skills and knowledge		13	NK
RQ3 - Impacts in accounting profession		19	NK

Figure A1. Content analysis categorization in NVivo.

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