Big Data and Accounting: A Bibliometric Study

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Abstract. Over the years, the importance and role of Big Data have grown considerably. Accountants' work requires sound judgement and decision making, which makes their activities less conducive to automation. Nonetheless, it is useful for accountants to be at ease with the use of data analysis, especially when data are unstructured and relevant to decision making. This study aimed to visualize the research panorama on the theme "Big Data and accounting" to appreciate the current state of knowledge in this field. Bibliometric analysis was used to study literature on the topic of Big Data and accounting. The data were collected using the Scopus database to ascertain the authors, countries, keywords and journals that have contributed the most to this body of knowledge. VOSviewer software was used for data visualization. Through a visual analysis, the results reveal the current state of knowledge on the theme of Big Data and accounting, with significant implications for future works in this field. The findings also highlight the potential opportunities for future studies on this topic and on peripheral themes.

Keywords: Big data, accounting, bibliometric analysis, digital accounting, research agenda.

1. INTRODUCTION

Generally, Big Data refers to a large set of data (structured, unstructured and semi-structured) captured mainly through automated sensing (Vasarhelyi et al., 2015)

and obtained from different sources and contexts (Malaka & Brown, 2015; Schüll & Maslan, 2018). According to Gartner Information Technology Glossary (2020), Big Data is characterised by a high volume, velocity and variety of information.

The relevance of Big Data in accounting has grown very rapidly and significantly. Many researchers have contributed to the collective understanding of Big Data and its relevance. For instance, Richins et al. (2017) opined that while Big Data will redefine the role of accountants, its impact will be limited since the nature of accountants' work makes their tasks less conducive to automation. However, the authors added that it is useful for accountants to be at ease with the use of data analytics, especially when unstructured data are relevant to the decision-making process. Warren et al. (2015) highlighted the unstructured component of Big Data information sourced from social media, videos and so on, concluding that an illustrative video of an asset may provide a more correct assessment of the worth of the asset than the accounting numbers per se. Gubbi et al. (2013) linked the transformational role of Big Data to the Internet of Things. Lindqvist and Neumann (2017) highlighted the role of self-sensing and self-acting devices used in small and medium businesses, smart factories and so on, which generate a lot of data.

Big Data is considered an integral part of modern business ecosystems and its relevance is felt in different parts of the value chain. According to Akter et al. (2016), Big Data is presumed to be beneficial for the efficiency of a firm's operations and also for the development of competitive advantage. However, it is incorrect to assume that companies automatically benefit from the availability of Big Data. In fact, to generate a competitive advantage and contribute to a firm's value creation, Big Data must support decision-making activities (Gandomi & Haider, 2015) and be integrated into accounting information systems to enable a continuous process of monitoring and control (Arnaboldi et al., 2017a) and to develop new predictive techniques (Vasarhelyi et al., 2015). Therefore, considering the relevant role that the accounting environment plays in enabling Big Data effectiveness, the present study explores the current state of knowledge of Big Data in the accounting domain. More concretely, we aim to answer the following questions: Which journals are pioneering this domain? Which countries are the leaders in Big Data and accounting research? What are the key peripheral themes of Big Data and accounting? Who are the prominent scholars researching this field? Which are the most cited papers that have contributed greatly to the development

of the field of Big Data and accounting? What are the Big Data and accounting topics that have not been covered and should be included in the research agenda?

Bibliometric techniques are used to address these key questions. Some scholars adopt this methodology to study the published knowledge in a particular field, such as finance (Alexander & Mabry, 1994), or to study a subfield or a subtopic, such as environmental management accounting (Schaltegger et al., 2013). Bibliometric techniques have also been used to study business and management disciplines in relation to information and communication technologies or emerging technologies such as artificial intelligence (Bonsón et al., 2021). However, to the best of our knowledge, bibliometric techniques have not been applied to the topic of Big Data and accounting.

This study contributes to accounting scholarship by visualising the research landscape on the theme "Big Data and accounting". The first objective is to assist accounting researchers in appreciating the contemporary state of knowledge in this field. Thereafter, this study aims to help scholars frame more interesting questions and themes in this domain by identifying leading authorities, key journals and the most cited papers that have had a significant impact on the development of the field. Thus, it serves as a guide to scholars and contributes an interpretation of the Big Data phenomenon from an accounting point of view. Since this study is specific in its theme, "Big Data and accounting", it purposely excludes peripheral themes such as the cloud, blockchain, artificial intelligence and machine learning. Moll and Yigitbasioglu (2019) clearly distinguished between the four technologies which are likely to impact the accounting profession: Big Data, the cloud, blockchain and artificial intelligence. All these technologies are equally impactful but not necessarily central to the study of Big Data and accounting. This is because they are independent technologies with their own unique interface with the accounting profession. Therefore, this study focused on acting as a guide to researchers on the progress made to date in the "Big Data and accounting" field only.

Big Data technology is also widely discussed in other disciplines, such as information science, computer science and information systems. However, since this study aims to develop accounting scholarship, only the top cited papers, key authors, co-citations and bibliometric coupling relevant to "Big Data and accounting" are explored. The objective is to give keen accounting scholars a head start on finding the key papers and identifying the top cited authors in this field.

The study attempts to demystify the intellectual structure of the research and explore the trends in the underlying research field. Data interpretation is made simpler and more convenient through graphical representation in the form of maps. This is especially helpful for scholars who do not have English as their first language. Overall, the paper is an attempt to celebrate the pioneering scholarly work in Big Data and accounting and to properly guide fresh works in this evolving domain.

The remainder of this article is organised as follows. Section 2 provides a literature analysis of the topic of Big Data in the accounting domain. Section 3 describes the research methodology, while section 4 displays the results of the bibliometric analysis. The discussion is presented in section 5. Section 6 concludes the paper and suggests future research directions.

2. BIG DATA IN THE ACCOUNTING DOMAIN

The adoption of Big Data in the accounting domain has opened many research questions since the pioneering study of Vasarhelyi et al. (2015). While some studies have been published to address these, the debate is still at an embryonic stage. Arnaboldi et al. (2017b) suggested themes for research on the interplay between Big Data and accounting, such as the role of accountants inside a firm in the usage of Big Data as well as the skills required to benefit from Big Data. Arnaboldi et al. (2017b) highlighted the reluctance of accountants to consider social media as a source of information for business development. Al-Htaybat and von Alberti-Alhtaybat (2017) studied the extent to which accountants engage in data analytics and contribute to the collective understanding of the results.

Big Data has generated research interest and scholars have probed its specific business applications from multiple research perspectives. The role of Big Data in supporting the auditing function has been studied by scholars such as Vasarhelyi et al. (2015), Yoon et al. (2015) and Zhang et al. (2015). Alles (2015) and Brown-Liburd et al. (2015) studied the challenges that firms and individuals face in using Big Data in auditing. Bhimani and Willcocks (2014) opined that a true understanding of Big Data comes from the seamless integration of managers' tacit knowledge with the management information system in place. They added that especially for management accountants, Big Data has a deep impact on the analysis and decision-making process. Moreover, the adoption of Big Data has been

investigated in the fields of risk management (Presti & Mancini, 2020) and intellectual capital (De Santis & Presti, 2018).

As highlighted above, research in the field of Big Data in accounting is scarce and fragmented. Extant studies investigate some issues and opportunities related to the implementation and usage of Big Data technologies from the accounting or accountants' perspective. However, they do not provide a comprehensive view of how different firms or industries and their accounting functions and specialists can capture value from Big Data.

3. RESEARCH METHOD

The study uses a bibliometric method to identify current research trends and interesting topics for future research. Since Pritchard (1969) used this method, it has become very popular with scholars. Bibliometrics involves analyzing published data (McCain, 1986). Using mathematical and statistical methods in order to ascertain the publication pattern. Thus, bibliometrics involves citation analysis and bibliometric coupling. Bibliometric methods use bibliographic data to create a structural model of a theme (Zupic & Čater, 2015).

The authors followed a three-step research procedure that consisted of identifying the relevant keywords and database, collecting data, and analyzing it to obtain results, the details of which are described in the following subsections.

3.1. Key terms, data search and refinement

Given the aim and objectives of this study, the choice of keywords was purposely restricted to "Big Data and accounting". This was essential because the "Big Data and accounting" field is dynamic and evolving and a bibliometric analysis is needed to guide accounting scholars. By restricting their search in this way, the authors sought to avoid any overlaps with related technological subthemes, such as accounting and analytics, accounting and artificial intelligence or accounting and blockchain. Scholars such as Moll and Yigitbasioglu (2019) established the differences between technologies such as the cloud, Big Data, artificial intelligence and blockchain and how they are related to accounting. Therefore, the search was limited to Big Data and accounting; not partially related or unrelated papers were included in the dataset. The choice of these two keywords was an integral part of the authors' decision to limit the probe to studies relevant to the aims of this research. The authors believe that analyzing the studies inside the boundaries of

accounting and Big Data could help researchers find meaningful research questions. It could help researchers develop more mature and complete concepts in the accounting field by focusing the analysis on ideas borrowed from other disciplines already interpreted and expressed using the "lens" and "language" of accounting. The authors are aware that extending the data search to the other terms mentioned above (the cloud, artificial intelligence and blockchain) could be useful to identify novel ideas for new streams of research in the field of Big Data in accounting. Extra effort was made to ascertain how the studies were classified and related to the context.

The research was conducted in April 2019 and no time limits were imposed. Scopus was chosen as the database to be searched as it gives complete results (Rey-Martí et al., 2016). Furthermore, Big Data and accounting is a relatively new domain, and since Scopus covers more indexed publications (Ferreira, 2018) than other databases, such as Web of Science, it was the preferred choice. The search for "Big Data and accounting" uncovered journal papers, book chapters, notes and letters. Only journal papers were considered for the purpose of the analysis. This was in line with the process suggested by Zhang et al. (2019), who advocated for using only indexed, peer reviewed journal publications.

3.2. Data collection

In order to achieve the research objectives and enable data visualization and specific content analysis, a bibliometric analysis was conducted. Therefore, an analysis of citations, co-citations, bibliometric coupling, co-authors and keywords was conducted. The aim was to ascertain key papers, keywords, key journals, the evolution of the field over time and the impact of collaboration among the authors. VOSviewer version 1.6.13.0 (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands) software was used to aid in the creation and visualization of bibliometric maps (Van Eck et al., 2010). VOSviewer was chosen over other equally useful software, such as Gephi, BibExcel and Bibliometrica, as it offers better visualization of data and handles sources from multidisciplinary fields quite well (Börner et al., 2003). VOSviewer is also user friendly for analyzing co-citations and keywords and ascertaining co-author networks.

While analyzing the data, the authors made some significant choices. First, the Scopus database compiles information using the "full counting system". However, VOSviewer uses "fractional counting". As per Perianes-Rodriguez et al. (2016), in

the case of fractional counting, each publication is given the same weightage. Second, in the Scopus database, the search for titles, abstracts and keywords was restricted to journal articles written in English. There was no limitation on the year of publication; therefore, articles published at any point in time could be considered. The subject area was business, management and accounting. The search yielded 54 journal articles. This meant that, in the field of Big Data and accounting, any quality literature which was not in an English language peer reviewed journal was not part of the dataset. This study, based on a bibliometric analysis, uses quantitative techniques to examine all the bibliographical sub-elements. As indicated by prior research, such as that by Danvila-del-Valle et al. (2019), only certified knowledge found in journals is relevant to such an analysis. This is because journal publications undergo a strict evaluation process (Ramos-Rodríguez & Ruíz-Navarro, 2004). Hence, proceedings, news and other documents were not considered (Danvila-del-Valle et al., 2019). Other contemporary and significant bibliometric studies, such as that by Zhang et al. (2019) on the "green finance" theme, have recommended using only journal articles which are indexed in prominent citation indices. Therefore, this study considers only journal articles in the dataset. The final dataset is also subjected to individual item-wise scrutiny to filter out any unrelated terms, clean up the keywords and standardize the authors' names.

4. RESULTS

In this section, the authors describe the results of the bibliometric analysis, which was conducted to highlight the pioneering journals, influential countries, key topics and relevant papers addressing Big Data matters related to the accounting domain. VOSviewer enables the graphical construction and visualization of the relationships in undertaking the relevant analysis (van Eck & Waltman, 2010). The top 10 results of different categories are presented in the following subsections with the help of tables and graphs to show relevant data. To perform the analysis, the authors use some powerful tools of VOSviewer, such as two standard weight attributes: the links attribute and the total link strength attribute. 'Links' refers to the number of links a particular variable has with other variables. The total link strength connotes the collective strength of the links. In terms of visualization, the size of a particular item is mostly based on its total link strength. However, the thickness of the line of each connection is based on link strength.

Figure 1 shows the distribution of articles by years. As per the graph, the first contribution on Big Data and accounting was published in 2014 by Bhimani and Willcocks in the journal Accounting and Business Research. Most of the articles on this topic were published in 2017 (18 articles) and 2018 (19 articles). In 2019, only three articles were published. However, this result could be attributed to the fact that the research was conducted in April 2019.
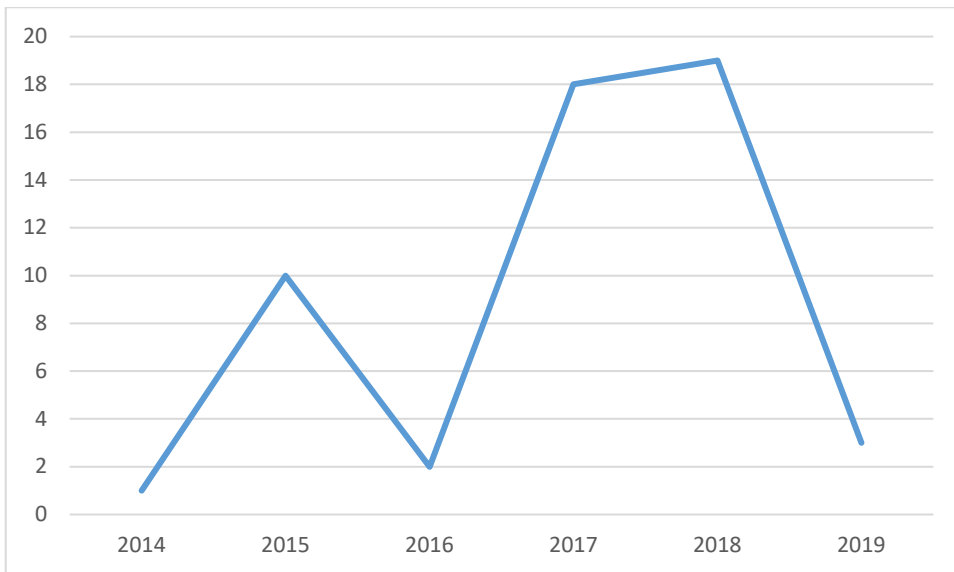

Figure 1. Distribution of papers (per year)

4.1. Most cited journal

As shown in Table 1, the most productive journal is Journal of Information Systems, with nine articles published. This is followed by Accounting Horizons, with eight articles, and International Journal of Accounting Information Systems, Journal of Emerging Technologies in Accounting and Journal of Accounting Education, with four articles each. Accounting Horizons is the most influential journal, with the highest number of total citations (327). This is followed by Accounting and Business Research, with 41 citations, and Journal of Accounting Education, with 28 citations. Furthermore, if we consider the average number of citations (total citations per journal/total number of articles published on the topic), we find that the best performing journals are Accounting and Business Research, which generated 41 citations with only one article, and Accounting Horizons, with an average of 40.88 citations per article. These are followed by Business Horizons, with an average of 11 citations per article.

Source	Documents	Citations	Average article citations	Total link strength
Accounting Horizons	8	327	40.88	100
Journal of Information Systems	9	24	2.67	44
International Journal of Accounting and Information Management	2	0	0.00	12
International Journal of Accounting Information Systems	4	19	4.75	11
Journal of Emerging Technologies in Accounting	4	5	1.25	11
Journal of Accounting Literature	2	8	4.00	10
Meditari Accountancy Research	3	5	1.67	10
Journal of Accounting Education	4	28	7.00	9
Accounting, Auditing and Accountability Journal	3	18	6.00	5
Business Horizons	1	11	11.00	3
Accounting and Business Research	1	41	41.00	2
Journal of Accounting and Organizational Change	1	0	0.00	1
Academy of Accounting and Financial Studies Journal	1	0	0.00	0
Accounting, Organizations and Society	1	0	0.00	0

Construction Management and Economics	1	0	0.00	0
Eastern-European Journal of Enterprise Technologies	1	0	0.00	0
Human Resource Management	1	1	1.00	0
International Journal of Economics and Business Research	2	0	0.00	0
International Journal of Supply Chain Management	1	0	0.00	0
Journal of Applied Accounting Research	1	0	0.00	0
Journal of Cleaner Production	2	12	6.00	0
Knowledge Management and E-Learning	1	2	2.00	0

Table 1. List of journals ranked on the basis of citation total link strength

As per Figure 2 and Table 1, according to total link strength, the most prominent journal that discusses the theme of "Big Data and accounting" is Accounting Horizons, with a total of 327 citations from 8 papers and a link strength of 100. This is followed by the Journal of Information Systems, with 24 citations from 9 documents and a link strength of 44, and The International Journal of Accounting and Information Management, with a link strength of 12. In Figure 2, the size of a rectangle connotes the relative status of an entity vis-à-vis its peers. The total link strength of a given journal indicates the total strength of the connections that can be made between it and the other journals in our dataset. In Figure 1, this parameter is represented by the lines that connect the rectangles; the greater the thickness of a journal's lines, the greater its total link strength. As we can see, Accounting Horizons has a central role in developing the Big Data research. It is the most influential and pioneering journal on the topic of Big Data and accounting, even if it is not the most prolific journal. It is essentially focused on the connection between auditing and Big Data. Furthermore, we can notice that the Journal of Information

Systems is a reference journal in the Big Data and accounting domain, with a major focus on accounting information systems and Big Data.
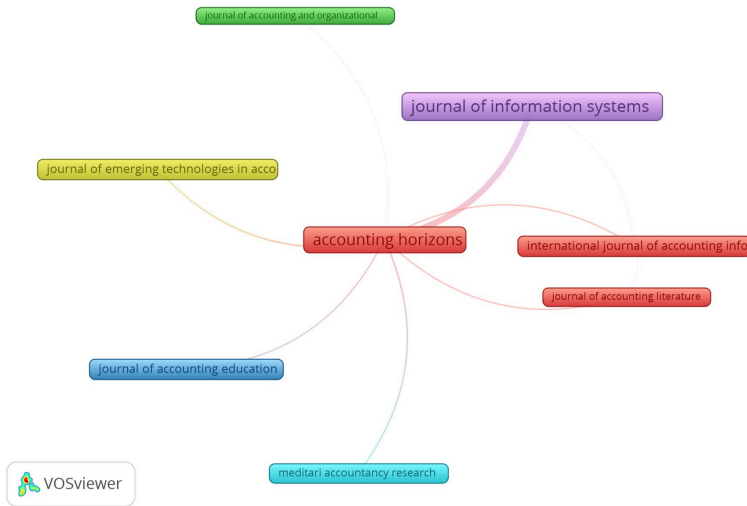

Figure 2. Top journals and their relations in terms of citations

4.2. Publication trend by country

Table 2 highlights countries' contributions to the development of research in Big Data and accounting, considering the top 10 countries in terms of the number of publications and citations. The results are influenced by the fact that our dataset was limited to publications in the English language. The United States is the leader in this field of research, contributing the most documents (33) and generating the most citations (413). It is followed by the United Kingdom, with a total of 52 citations for 4 articles published. Next is China, with a total of 45 citations for 3 articles published. Australia follows, with a total of 23 citations for 7 articles published, and then Italy, with a total of 16 citations for 4 articles published. European countries are in second place in this field compared to the United States, China and Australia, while some big emerging economies, such as India and Brazil, are absent.

Country	Documents	Citations	Average article
United States	33	413	12.52
United Kingdom	4	52	13.00
China	3	45	15.00

Australia	7	23	3.29
Italy	4	16	4.00
Saudi Arabia	1	7	7.00
New Zealand	3	4	1.33
Canada	2	4	2.00
Iceland	1	1	1.00
South Africa	1	2	2.00

Table 2. Countries ranked in order of citations

If we consider the countries' average number of citations per article, the best performing country is China, with an average of 15 citations. This is followed by the United Kingdom, with an average of 13 citations, and then the United States, with an average of 12.52 citations.

Furthermore, Figure 3 highlights those American researchers are leading the scholarly probe of Big Data in accounting, holding a special collaborative relationship with authors from the other countries. The size of the rectangles highlights the relative proportion of articles, while the proximity of the rectangles depicts the relations between countries in terms of cited documents. The latter is considered a proxy of the research collaboration between authors from those countries.
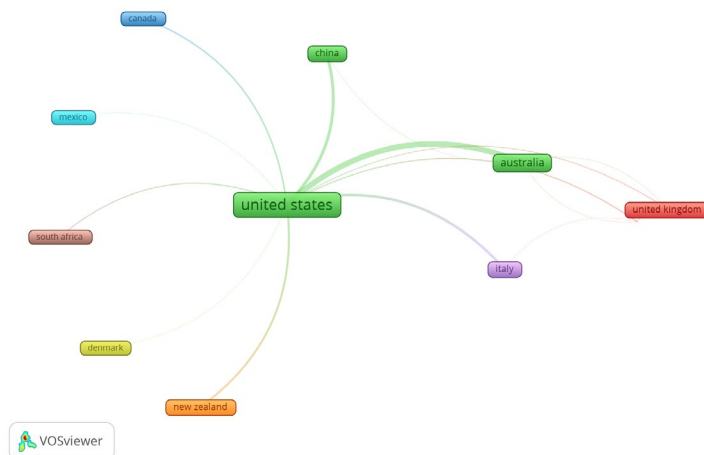

Figure 3. Visualisation of countries' collaborative relationships in terms of citations

4.3. Keyword co-occurrence network

A keyword analysis helps clarify the conceptual points of a domain (Zhang et al., 2019). In order to assess whether two terms are related, the distance between them is ascertained. The closer two terms are to each other, the more related they are and the more they co-occur.

Figure 4 and Table 3 collectively present the author keywords. According to Danvila-del-Valle et al. (2019), keywords highlight authors' views on how concepts and studies are classified and related. Table 3 shows that Big Data is the most frequent and most related keyword. Among the other 10 most common author keywords, we find a group of words related to accounting (auditing, management accounting, accounting and intellectual capital) and another group related to technologies and tools (data analytics, business analytics, analytics, data mining and business intelligence). It is interesting to note that terms such as cloud technology, blockchain and artificial intelligence do not have the highest occurrence.

Author keywords	Occurrences
Big Data	39
Data analytics	9
Auditing	7
Business analytics	4
Data mining	4
Management accounting	4
Accounting	3
Analytics	3
Business intelligence	3
Intellectual capital	3
Privacy	3

Table 3. Author keywords occurence

Figure 4 can offer fresh insights and immediate visualization to accounting scholars who are looking for themes to work on in the Big Data and accounting domain. Based on the authors' keywords, auditing is one of the main themes investigated in relation to Big Data in the field of accounting, while data analytics is the main theme investigated in relation to Big Data in the field of technology. So, among other possible topics, these two are peripheral themes connected to Big Data in the accounting domain in which we can find a number of research products.

Figure 4. Author keywords co-occurrence network visualisation

Furthermore, looking at Figure 4, we can find some clusters, which contain accounting and technology keywords related to Big Data. The yellow clusters symbolize articles on auditing and analytical methods; the red clusters pertain to papers on management accounting and business analytics; the green clusters represent articles related to intellectual capital, privacy and data security; and the violet clusters signify papers related to management control, social media and customer profitability. The blue clusters mainly contain information technology related keywords such as data mining, data analytics and business intelligence in the banking industry specifically.

We can also assert that, in our dataset, there are some under-investigated topics. In the right part of the figure, some circles are linked to the word Big Data but not to others. Those keywords are gaining attention and popularity as emerging peripheral

themes. Some of them are related to Big Data and the accounting studies tradition, such as accounting standards, accounting theories, accountants' role, accounting curriculum and continuous auditing. Other topics are related to technologies and tools, such as semantic data analysis, Big Data value and information governance.

4.4. Most cited authors

Citations are relevant as it is considered that cited works have an impact on the topic concerned (Culnan, 1987). As a paper is cited more often, its contribution to shaping the conversations in that area becomes meaningful. Citations are therefore used as a metric to ascertain the influence and significance of a paper.

Table 4 shows the top 10 authors with the highest number of citations. The most cited author is Kogan, A., with 73 citations, followed by Vasarhelyi, M. A., with 60 citations in the Big Data and accounting domain. They are followed by Tuttle, B. M., with 58 citations, and Appelbaum, D., with 53 citations. Kogan, A., obtained the highest number of citations from three papers. If we consider the average number of citations for each document, the most mentioned author is Tuttle, B. M., with 58 citations from a single article in our dataset.

Moreover, Table 4 shows that although Appelbaum, D., is only in fourth place in terms of the number of citations, he is the most productive author among the top cited authors, as he published four papers on the topic of Big Data in the accounting domain.

Author	Citations	Documents	Average article citations
Kogan, A.	73	3	24.33
Vasarhelyi, M. A.	60	2	30.00
Tuttle, B. M.	58	1	58.00
Appelbaum, D.	53	4	13.25
Cao, M.	49	1	49.00
Chychyla, R.	49	1	49.00
Stewart, T.	49	1	49.00
Byrnes, P.	43	1	43.00

Moffitt, K. C.	43	1	43.00
Warren Jr, J. D.	43	1	43.00
Brown-Liburd, H.	42	1	42.00

Table 4. Author citations

4.4.1. Recent influential work

In Figure 5, which captures the overlay visualization, the different colors of the clusters highlight the years in which the authors published the greatest number of contributions. The yellow clusters highlight the authors who published the most in 2018; the light green clusters the authors who published the most in 2017; the dark green clusters the authors who published the most in 2016; and the purple clusters the authors who published the most in 2015. The most recent contributions which are influential in shaping the understanding of Big Data and accounting are those by Dumay, J., Botes, V. L., Garcia, L. and Daigle, R. J. These are followed by the works of Appelbaum, D. and others published prior to 2018, such as those by Kogan, A., Vasarhelyi, M., Brown-Liburd, H. and Cao, M. Furthermore, in terms of the number of documents, Dumay, J. published the most—four papers—and garnered five citations.
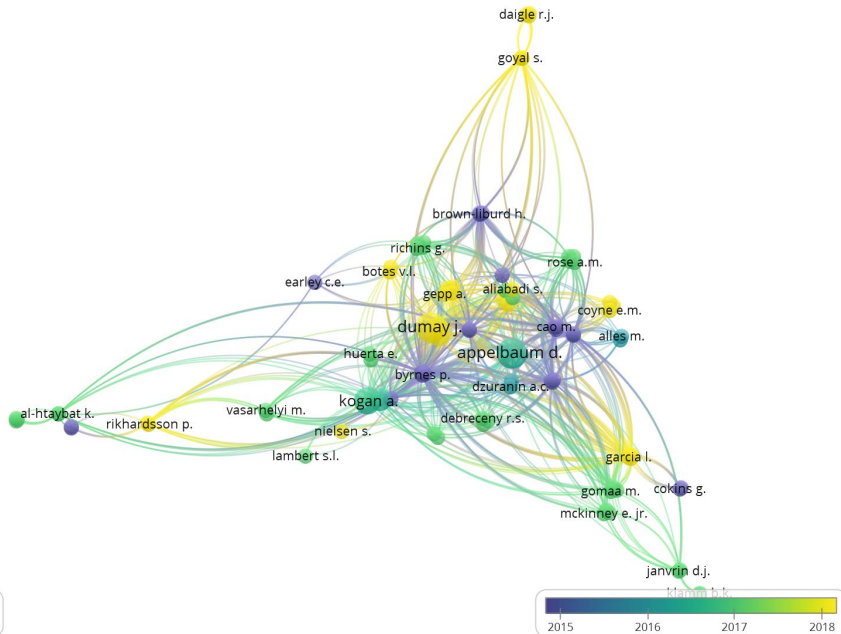

Figure 5. Author citation overlay visualization

4.4.2. Co-citation network of the most influential works

Co-citation means that two articles are both independently cited by at least one article. Co-citation helps identify similar topics and authors who share an interest in the field (Ramos-Rodríguez & Ruíz-Navarro, 2004). Table 5 shows the total link strength of the top 10 documents, which captures the total number of times a document is co-cited with other documents. According to this parameter, the prominent authors are Vasarhelyi, M. A., Kogan, A., Quattrone, P., Dumay, J., Goffman, E. and Guthrie, J.

Author	Total link strength	Citations
Vasarhelyi, M. A.	5463	77
Kogan, A.	3896	52
Quattrone, P.	2819	13
Dumay, J.	2752	40
Goffman, E.	2274	6
Guthrie, J.	2003	31
Bourdieu, P.	1900	5
Martin, J. L.	1900	5
Alles, M. G.	1880	24
Davenport, T.	1820	8

Table 5. Co-cited authors

Figure 6 shows the authors who have a common interest in this field of research. A thicker line connotes a more relevant link between two entities. The placement of a circle captures the cluster of that particular item.
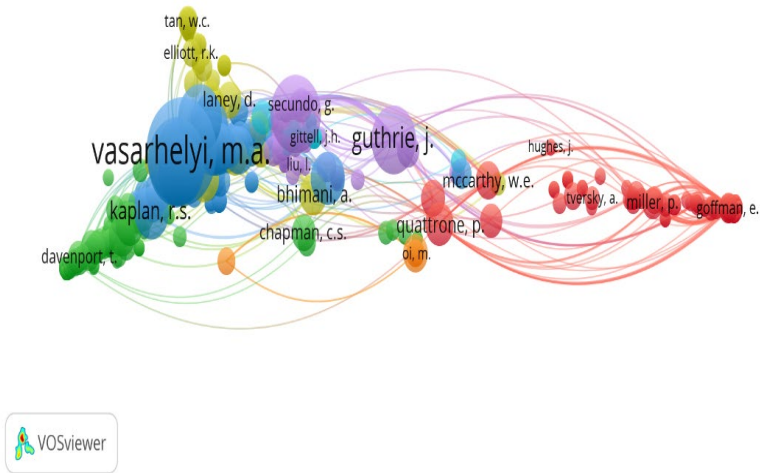
Figure 6. Co-citation cited authors net visualization

4.4.3. Bibliographical coupling network

Bibliographic coupling is widely used to visually analyse the knowledge network (Zhao & Strotmann, 2008). Bibliographic coupling happens when two articles both reference a common third paper in their bibliography. In terms of author-based bibliographical coupling, it is evident from Figure 7 and Table 6 that Dumay, J. is the top linked author, with four documents, five citations and a total link strength of 1415. La Torre, M. and Rea, M. A. follow, both with two documents, four citations and a link strength of 989.
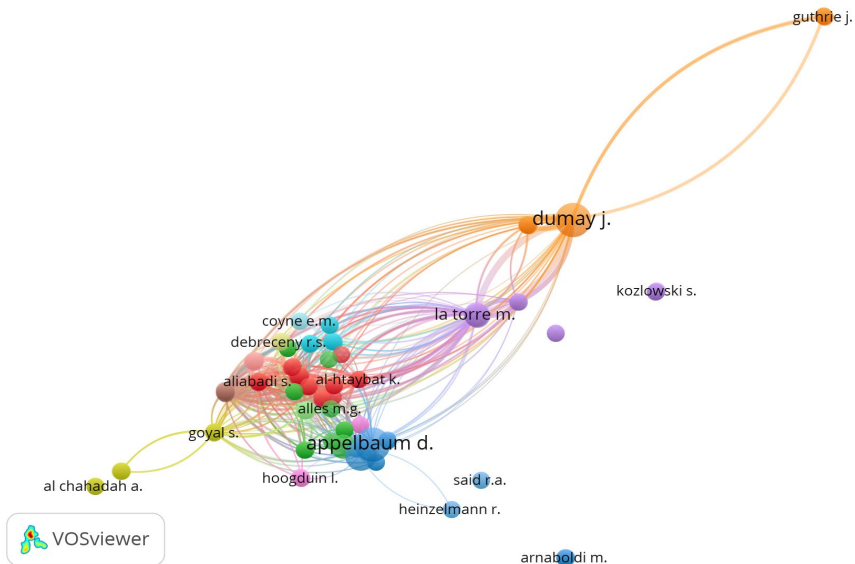
Figure 7. Author-based bibliographic coupling network visualisation

Author	Documents	Citations	Average article citations	Total link strength
Dumay, J.	4	5	1.25	1415
La Torre, M.	2	4	2.00	989
Rea, M. A.	2	4	2.00	989
Gepp, A.	1	6	6.00	783
Linnenluecke, M. K.	1	6	6.00	783
O'Neill, T. J.	1	6	6.00	783
Smith, T.	1	6	6.00	783
Kogan, A.	3	73	24.33	731
Appelbaum, D.	3	51	17.00	655
Botes, V. L.	1	2	2.00	537

Table 6. Author-based bibliographic coupling

The bibliometric coupling based on countries shows an interesting trend (Figure 8). Authors based in the United States collectively account for the highest number of citations—413. However, Australian authors, with far fewer citations (23), have a higher link strength of 1412, compared to a link strength of 1144 for the American authors (Table 7). The Italian authors come third, with a link strength of 917 and a citation count of 16.
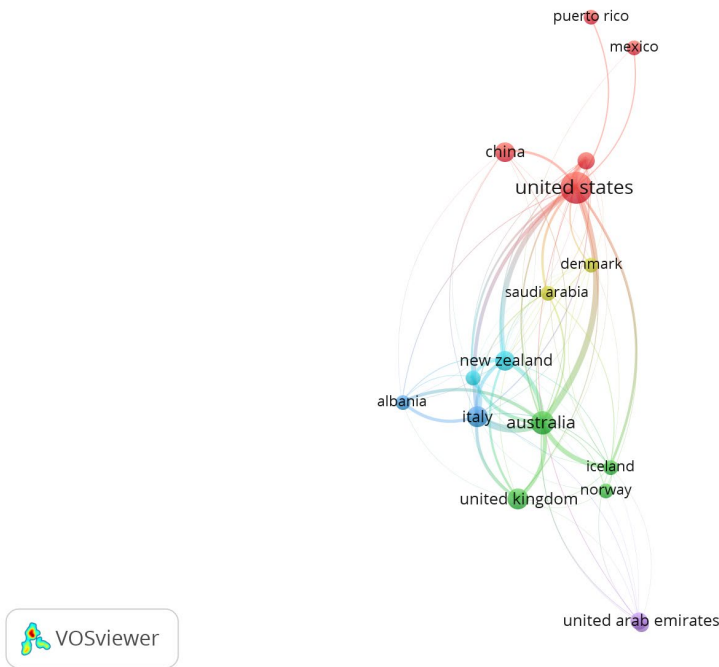
Figure 8. Country-based bibliometric coupling network visualisation

Countries	Total link strength	Documents	Citations
Australia	1,412	7	23
United States	1,144	33	413
Italy	917	4	16
New Zealand	635	3	4
South Africa	345	1	2
United Kingdom	305	4	52
Canada	287	2	4
Iceland	272	1	1
Albania	202	1	1
Saudi Arabia	117	1	7

Table 7. Country-based bibliometric coupling

Bibliographic coupling according to the source journal is presented in Table 8. The *Journal of Information Systems* is the most coupled journal, with a total link strength of 457. However, it is cited 24 times, which is much less than the 327 citations received by the authors in the journal *Accounting Horizons*. This means that the latter journal has published the majority of the highly cited works. The *International Journal of Accounting Information Systems* comes second with a total link strength of 216, followed by the *Journal of Emerging Technologies in Accounting,* with a total link strength of 179.

Table 8 also provides data on the ranking, percentile/quartile and h-index of each journal to evaluate their quality. This additional information shows the absolute (ranking) and the relative (percentile/quartile) standing of each journal in the field of accounting, and their relevance in terms of productivity and impact (h-index). As we can see, the top linked journals are also the top ranked and most relevant ones. In terms of a focus on information systems, the most linked journals are *Journal of Information Systems* and *International Journal of Accounting Information Systems*. The most linked journals focusing on accounting are *Meditari Accountancy Research* and *Journal of Accounting Literature*. It is noteworthy that the quality of a journal does not appear to be linked to its influence in the field of Big Data in accounting. For example, *Accounting Horizon*, the most cited journal, is not the highest ranked journal. Additionally, *Accounting, Auditing and Accountability Journal*, which is the top ranked journal in the dataset, has not collected the highest number of citations.

Journal	Total link strength	Documents	Citations	Ranking (/154)	Percentile/Quartile	H-index
Journal of Information Systems	457	9	24	#25	84th percentile/Q1	35
International Journal of Accounting Information Systems	216	4	19	#21	86th percentile/Q1	55
Journal of Emerging Technologies in Accounting	179	4	5	#63	59th percentile/Q2	16

International Journal of Accounting and Information management	160	2	0	#41	73rd percentile/Q2	23
Meditari Accountancy Research	160	3	5	#13	91st percentile/Q1	25
Journal of Accounting Literature	157	2	8	#16	89th percentile/Q1	19
Accounting Horizons	141	8	327	#46	70th percentile/Q2	77
Journal of Accounting Education	131	4	28	#32	79th percentile/Q1	41
Accounting, Auditing and Accountability Journal	95	3	18	#14	91st percentile/Q1	113
Journal of Accounting and Organizational Change	31	1	0	#85	45th percentile/Q3	28

Table 8. Source-based bibliometric coupling

4.5. Most cited papers

The top 10 most cited papers on the Big Data and accounting theme are mentioned in Table 9. The most cited paper (58 citations) on Big Data and accounting is "Big Data in accounting: An overview", authored by Vasarhelyi, M. A., Kogan, A. and Tuttle, B. M. This is followed by the paper "Big Data analytics in financial statement audits", authored by Cao, M., Chychyla, R. and Stewart, T., which was cited 49 times. From Table 9, we can also see that of the 10 most cited papers, 8 were published in the Accounting Horizons journal in the special issue of 2015.

This confirms that it has been one of the most influential journals on the topic, furthering the investigation in the auditing field.

Author(s)	Paper, source and year	DOI	Citations
Vasarhelyi, M.A., Kogan, A., & Tuttle, B.M.	Big Data in accounting: An overview Source: *Accounting Horizons, 29*(2), 381–396 Year: 2015	https://doi.org/10.2308/acch-51071	58
Cao, M., Chychyla R., & Stewart T.	Big Data analytics in financial statement audits Source: *Accounting Horizons, 29*(2), 423–429 Year: 2015	https://doi.org/10.2308/acch-51068	49
Warren Jr., J. D., Moffitt, K. C., & Byrnes, P.	How Big Data will change accounting Source: *Accounting Horizons, 29*(2), 397–407 Year: 2015	https://doi.org/10.2308/acch-51069	43
Brown-Liburd, H., Issa, H., & Lombardi, D.	Behavioral implications of Big Data's impact on audit judgment and decision making and future research directions Source: *Accounting Horizons, 29*(2), 451–468 Year: 2015	https://doi.org/10.2308/acch-51023	42
Bhimani, A., & Willcocks, L.	Digitisation, Big Data and the transformation of accounting information Source: *Accounting and Business Research, 44*(4), 469–490 Year: 2014	https://doi.org/10.1080/00014788.2014.910051	41
Yoon, K., Hoogduin, L., & Zhang, L.	Big Data as complementary audit evidence Source: *Accounting Horizons, 29*(2), 431–438 Year: 2015	https://doi.org/10.2308/acch-51076	35

Krahel, J. P., & Titera, W. R.	Consequences of Big Data and formalization on accounting and auditing standards Source: *Accounting Horizons, 29*(2), 409–422 Year: 2015	https://doi.org/10.2308/acch-51065	35
Zhang, J., Yang, X., & Appelbaum, D.	Toward effective Big Data analysis in continuous auditing Source: *Accounting Horizons, 29*(2), 469–476 Year: 2015	https://doi.org/10.2308/acch-51070	33
Alles, M. G.	Drivers of the use and facilitators and obstacles of the evolution of Big Data by the audit profession Source: *Accounting Horizons, 29*(2), 439–449 Year: 2015	https://doi.org/10.2308/acch-51067	32
Appelbaum, D., Kogan, A., Vasarhelyi, M., & Yan, Z.	Impact of business analytics and enterprise systems on managerial accounting Source: *International Journal of Accounting Information Systems, 25*, 29–44 Year: 2017	https://doi.org/10.1016/j.accinf.2017.03.003	13

Table 9. Most cited papers on Big Data and accounting

Vasarhelyi et al. (2015) gave an overview of the topic of Big Data in accounting and laid the foundation for subsequent essays that present the evolution of corporate data in Big Data. The paper deals with the impact of Big Data on financial accounting in terms of new accounting measurements, and on auditing and assurance services in terms of challenges and opportunities.

The majority of the most cited papers investigate audit issues related to Big Data, such as financial audit, audit opinion, continuous auditing, auditing standards, auditing evidence and the auditing profession. Cao et al. (2015) argued that Big Data is used for advanced analysis in many domains but is hardly used in auditing. They speculated that Big Data analysis may improve the efficiency and effectiveness of financial statement audits. Brown-Liburd et al. (2015) presented the behavioral implications of Big Data for audit opinion by addressing issues such

as information overload and information relevance. Zhang et al. (2015) focused on the gaps between Big Data and current data analysis capabilities in continuous audit by identifying four dimensions of Big Data and subsequent gaps and outlining possible solutions. Alles (2015) discussed facilitators of and obstacles to the use of Big Data in auditing, such as market forces and auditing standards. Yoon et al. (2015) provided a cost–benefit analysis of using Big Data as audit evidence, incorporating critical issues such as protection of privacy and problems with information transfer. Krahel and Titera (2015) argued that a shift from current standards that focus on the presentation of financial information to new standards that regulate the processes which generate and analyse financial data will add value to the accounting profession.

The article by Warren et al. (2015) claimed that using new technologies, such as Big Data, will increase a company's productivity and value. Bhimani and Willcocks (2014) discussed the potential and the complexities of Big Data in relation to the financial function in general. They suggested that Big Data and data analysis techniques allow managers to act on both structured and unstructured information. Appelbaum et al. (2017) proposed an accounting data analysis framework based on the balanced scorecard theory in a business intelligence context. This framework gives accountants the opportunity to use business data analysis to conduct performance measurements and provide information on business decisions taken.

5. CONTRIBUTION AND DISCUSSION

This study has major theoretical and practical contributions to offer. It fulfils the need to identify the relevant ideas and prominent paradigms that lead to the advancement of knowledge in a domain (Belhassen & Caton, 2009).

According to Martinez-Lopez et al. (2018), bibliometric analysis provides a comprehensive understanding of publication trends and patterns and helps in identifying the key themes in a domain. The Big Data and accounting theme is an established topic of interest in the research community. However, it can contribute much more to the digital accounting literature as the related debates are far from settled. There are interesting unexplored areas for future scholars and researchers; the emerging field of Big Data and accounting and its peripheral themes hold tremendous potential for future studies.

This research was motivated by the scientific belief that Big Data can promote value creation in firms when it supports decision-making processes by being integrated into accounting information systems and by improving predictive techniques. We used a bibliometric methodology to present the state of the knowledge on and implications of the connection between Big Data and the accounting domain. In doing so, we answered some relevant questions.

Which journals are pioneering this domain?

In our dataset, the journal that first published an article on the relationship between Big Data and accounting was Accounting and Business Research in 2014, with the contribution of Bhimani, A. and Willcocks, L. entitled "Digitisation, Big Data and the transformation of accounting information". However, the first journal to publish an entire special issue on the topic was Accounting Horizons in 2015.

The bibliometric data analysis showed that these two accounting journals are leading this domain in terms of total citations and average citations. However, the information systems domain journal, the Journal of Information Systems, has the highest link strength of 457, which makes it the most linked journal. This is understandable since Big Data and accounting studies find an audience in both information systems journals and in accounting journals. This finding suggests that the conversation has largely revolved around the information technology perspective. In fact, after the pioneering articles published in Accounting and Business Research and Accounting Horizons, the most productive journals in the following years were those specialising in the accounting and technology domains. This is largely due to the fact that Big Data technology originates from the computer science domain.

It is also noteworthy that there are not many general management journals or behavioural accounting journals in the list of top journals. This suggests the absence of behavioural/human aspects of technology adoption as a theme for papers.

Which countries are the leaders in Big Data and accounting research?

The country that is leading the research in this field is the United States. The concentration of authors from the United States highlights the need for more international collaboration between scholars and practitioners from other countries. This will enhance the collective understanding of the opportunities and challenges in the use of Big Data in accounting. Collaborations between researchers from non-

English-speaking countries and big emerging economies could produce interesting and different insights on the topic. Our findings also highlight the need for more intensive collaboration between researchers from European countries. This will enrich the field and bring fresh perspectives to this developing field of research. Furthermore, considering the relevance of Big Data to economic development, such collaborations could contribute to a more inclusive and sustainable future.

What are the key peripheral themes of Big Data and accounting?

The key peripheral themes of Big Data and accounting are data analytics and auditing. Both these themes are contextually relevant in understanding the journals that are favoured by authors. The presence of auditing as a key theme is not surprising. The auditing process in most modern multinational firms has greatly benefited from the use of Big Data. This two-way relationship between practice and industry is also reflected in authors' research themes. The key themes confirm that, to date, research has focused on the technology perspective.

Findings from the keywords analysis confirm that research on the topic of Big Data in the accounting field is at an embryonic stage. Some streams of research in the accounting field are underdeveloped, including management control, management accounting, financial accounting and intellectual capital. Other arguments of the accounting studies tradition, such as corporate governance and performance measurement, are still non-existent in this field.

Who are the prominent scholars researching this field?

The prominent scholars researching the theme Big Data and accounting include Kogan, A. and Vasarhelyi, M. A., with 73 and 60 citations, respectively. The analysis of the contributions of the 10 most influential authors revealed 8 papers in total. Kogan, A. collaborated with Vasarhelyi, M. A. and Appelbaum, D. for the publication of two articles, and with both of them for a third article. Tuttle, B. M. collaborated with Kogan, A. to write an article. Cao, M., Chychyla, R. and Steward, T. authored one paper, as did Brynes, P., Moffitt, K. C. and Warren Jr., J. D. Our findings explain why research has mainly focused on the challenges of using Big Data in auditing and continuous auditing. The most cited authors have contributed to shaping the conversation in this field. Their papers discuss how Big Data can improve the efficiency and effectiveness of financial audits and how audit activity can provide evidence of the reliability and security of data. However, considering

the most influential contributions in recent years, our findings show the growing interest in studies on Big Data and intellectual capital.

Which are the most cited papers that have contributed greatly to the development of the field of Big Data and accounting?

The most cited paper was "Big Data in accounting: An overview", authored by Vasarhelyi, M. A., Kogan, A. and Tuttle, B. M. This was followed by the paper "Big Data analytics in financial statement audits", authored by Cao, M., Chychyla, R. and Stewart, T. These articles underline the implications, opportunities and challenges of Big Data in relation to measurement and assurance. Even though there are different themes associated with Big Data and accounting in our dataset, we demonstrated that the focus is mainly on the possible consequences of using Big Data in the auditing field.

What are the Big Data and accounting topics that are not covered and should be included in the research agenda?

The bibliometric analysis conducted helped to identify some underexplored issues related to the intersection between Big Data and accounting to construct a fruitful research agenda for the future. Keyword network analysis unveiled some emerging peripheral themes that need more investigation.

Most of the studies in the dataset questioned the costs, benefits and implications of Big Data usage in accounting subfields (such as auditing, corporate reporting, management accounting, management control and intellectual capital). The subfield of research studied in the most structured way is auditing, although it is still a promising area for further research.

From an accounting perspective, Big Data does not automatically generate value for firms; it must be integrated into accounting information systems and support decision making. Therefore, this article calls for additional research which investigates Big Data not as a black box, but as a "package" of different types of data (structured and unstructured) generated by a "package" of data sources often related to other smart technologies (such as blockchain, the Internet of Things and social media).

This article specifies the following research questions for the future research agenda on Big Data in the accounting domain. They concern the four research pathways of smart technologies in the SMATECHacc framework (Mancini et al., 2021):

● Big Data as an innovation to be managed in the accounting domain to stimulate firms' competitive advantages in an effective, timeliness and efficient way:

- o Which types of data should be considered to improve the effectiveness of accounting processes?

- o Which data sources can better respond to different decision-making needs?

● Big Data as an accounting tool that affects the accounting environment only under certain circumstances:

- o What firm-specific factors can determine an effective, timely and efficient adoption of Big Data to support decision making?

- o What context-specific factors can determine an effective, timely and efficient adoption of Big Data to support decision making?

● Big Data's implications for the accounting domain in the future:

- o What are the factors that contribute to the successful implementation of Big Data innovations in accounting subfields?

- o Which mix of Big Data or data sources is useful to improve the effectiveness of accounting processes?

● Big Data as a factor that requires new and renewed skills and capabilities for its value to be fully realised in the accounting environment:

- o What are the key skills and capabilities that accountants need to fully exploit the value of Big Data?

- o What is the influence of gender on accountants' adoption and use of Big Data?

6. CONCLUSION

The aim of the present study was to adopt a bibliometric approach to visually analyse the current state of knowledge on Big Data in the accounting domain. We used the Scopus database, employed "Big Data" and "accounting" as keywords and searched for articles published in English. We analysed the following dimensions of the collected articles: keywords, name of the journal and country of the author(s).

This study has both theoretical and practical implications. From a theoretical perspective, some interesting considerations emerged regarding the state of the research. To the best of the authors' knowledge, this study is one of the first to adopt a bibliometric and visualisation approach in investigating the research field of Big Data and accounting to identify the main opportunities to advance the knowledge. Therefore, our analysis should provide a starting point for researchers interested in the relationship between Big Data and accounting. It provides information about the leading journals, countries and authors in this field. The journals that are pioneering this domain are Accounting Horizons and the Journal of Information Systems. The prominent scholars researching this field include Kogan, A., Vasarhelyi, M. A. and Tuttle, B. M. Countries which are leading the field are Australia, the United States and Italy (based on the criteria of total link strength). Moreover, by analysing the connections between keywords, we identified key peripheral themes of Big Data and accounting: data analytics and auditing.

The study also brings to the fore what is lacking in the research on the Big Data and accounting domain. There is not much scholarly work in this field being conducted in emerging markets; the field is dominated by the United States and other English-speaking countries, except for China and Italy. Furthermore, the themes studied to date are technical themes. As the field evolves, more themes based on the human aspects of Big Data adoption and accounting practice are likely to emerge.

This study offers a methodological contribution by providing a visual analysis of the current state of knowledge on Big Data and accounting. Data visualisation helps a broad academic audience contextually appreciate a theme and its developments to date. The study used VOSviewer to visualise the bibliometric data so that, after reading this paper, future scholars can be better prepared when they embark on their research journey.

From a practical standpoint, this study can help actors in the accounting profession (accountants, auditors, risk managers, compliance officers, chief financial officers, etc.) better understand the implications of Big Data for their profession. In particular, these actors can ponder how to use Big Data to improve their activities and their contributions to their firms' decisions, enhancing opportunities for firms' value creation. Furthermore, this study can raise practitioners' awareness of the lack of knowledge on the intersection between Big Data and accounting and help them identify possible fields for knowledge co-creation in collaboration with universities, research centres and researchers.

The study also has some limitations; future scholars are encouraged to build on these shortcomings. The first limitation is that we only considered the Scopus database until April 2019 and excluded Web of Science and other databases. Second, since the study aimed to improve accounting scholarship, it focused only on the "Big Data and accounting" theme, omitting other disciplines, such as computer science and information technology, that also interface with Big Data. The third limitation is that the study considered only one of the smart technologies that will improve business productivity in the future—Big Data. As highlighted by Moll and Yigitbasioglu (2019), the cloud, blockchain and artificial intelligence are all examples of such technologies. The authors believe that these technologies individually and collectively offer novel pathways of inquiry for future researchers interested in probing their links to accounting. The fourth limitation is that although clusters were identified, they were not analysed in detail, as this was beyond the scope of the study. Finally, in line with the contemporary norm, the study only took into consideration articles published in journals in English and omitted conference proceedings, book chapters and papers published in languages other than English.

In future research, it would be interesting to extend the bibliometric analysis to other keywords in order to look inside the black box of Big Data and outside it, to its relationship with other technologies. From the first point of view, it is clear that Big Data can improve the decision-making process and contribute to firms' value creation. However, there is a challenge in that Big Data includes a big volume of data and different types of data, such as audio, video, text and data from sensors. Therefore, we need to discover which mix of Big Data types is best for certain types of accounting problems or decisions. From the second point of view, the availability of Big Data to enhance decision making depends on other technologies, such as

cloud computing, blockchain, artificial intelligence, social media and the Internet of Things, that could be sources of Big Data. Therefore, a comprehensive map of the knowledge from this perspective could be helpful in understanding which mix of Big Data sources is best for which types of accounting problems or decisions.

More generally, other promising areas of study are information quality and the information security vulnerability of clients' classified financial accounting information when Big Data is used along with cloud technologies. The Big Data and accounting theme lends itself equally well to legacy management accounting techniques, such as budgeting, pricing and performance evaluation. Big Data and accounting can also assist in the correct valuation of intangible assets and in undertaking benchmarking exercises in the context of high-quality accounting disclosures. There is currently great interest in the application of Big Data and accounting in auditing activities, while less attention is being paid to this theme as it pertains to management accounting, risk management, intellectual capital and other fields of the accounting domain, such as corporate governance, accounting information systems, financial accounting and financial statements.

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