

DOI: <https://doi.org/10.46793/6461-101.051R>

Scientific Meta-Analysis

TOOLS AND TECHNOLOGIES FOR THE DIGITALISATION OF MANAGEMENT ACCOUNTING PROCESSES: BIBLIOMETRIC AND PATENT DATA INSIGHTS

Sînziana-Maria RÎNDAȘU

Bucharest University of Economic Studies, Bucharest, Romania

e-mail: sinziana.rindasu@cig.ase.ro

<https://orcid.org/0000-0002-1783-6926>

Abstract: In today's increasingly competitive business environment, companies are leveraging technological advances to re-engineer activities and meet stakeholder and shareholder expectations regarding performance and sustainability. This study aims to shed light on the tools and technologies used to digitalise management accounting processes. It focuses on the relevant literature and a set of patents to provide an overview of the theoretical and practical tools and technologies available. The study's findings indicate consistent growth in the number of publications with a similar upward trend in patents, especially during the Covid-19 pandemic. By comparing the tools and technologies in the two datasets, we reveal a convergence between research and technological development with innovations primarily aimed at enhancing management accounting information systems to boost efficiency and reduce costs. Furthermore, we uncover that the recent focus is on artificial intelligence and automated learning techniques. While not exhaustive, this study enhances the understanding of the tools and technologies that are reshaping management accounting processes, providing valuable insights for scholars, practitioners, and educators.

Key words: *management accounting, digitalisation, Artificial Intelligence (AI), Machine Learning, management accounting information systems, patents analysis, sustainable development.*

INTRODUCTION

As the business environment has become more competitive, companies are leveraging technological advancement by re-engineering their activities to meet the stakeholders' and shareholders' expectations regarding performance and sustainability. In this context, management accounting (MA) activities are considered at the com-

panies' core, encompassing the vital data for the organisations' evolution and performance. Although the level of digitalisation in the MA field is considerable, expectations are that the activities will become further automated and rely more on artificial intelligence and machine learning techniques (Dai & Vasarhelyi, 2023; Nielsen, 2022; Ranta et al., 2022).

As a result, MA's digitalisation is a highly researched topic (AlAnsari et al., 2022; Fährndrich, 2022), especially in the context of Industry 4.0, given the significant changes determined in the manufacturing paradigm (Dai & Vasarhelyi, 2023). Focusing on essential control procedures, Bergmann et al. (2020) argue that the degree of digitalisation of budgeting activities is significantly influenced by the complexity of organizations' IT infrastructure, emphasizing that a successful implementation of a digital solution supports companies in overcoming the limitations of traditional budgeting systems. Also, considering the reporting component, Perkhofer et al. (2020) point out that by using effective technologies, such as big data, to improve data visualization, practitioners can provide decision-makers with an even more comprehensive overview that allows them to access data interactively, which would not have been possible without the use of these IT solutions. Similarly, aspects related to budgeting and reporting are confirmed by recent studies (George et al., 2022; Kaushik et al., 2022; Regona et al., 2022) which highlight the advantages of using IT solutions, such as decentralized ledgers, artificial intelligence and robotic process automation (RPA) technologies. Additionally, Schnegg and Moller (2022) argue that digitalisation can significantly improve data accuracy and operational efficiency, thus generating vital information in the decision-making process.

Despite the significant effect of Industry 4.0 in reshaping MA activities, recent research has been mainly limited at identifying the associated technologies through bibliometric research with limited key terms for digitalisation (Barreto et al., 2024; Costa & Pinho, 2025). To address this gap, the objective of this first study is to identify the main technologies used in the transformation of MA through the investigation of both the relevant literature and the main patented solutions published between 2020-2023.

RESEARCH METHODOLOGY

The study sought answers to the following research questions:

RQ1.1 What are the most widely used technologies and tools for the digitalisation of management accounting processes, as per the relevant literature?

RQ1.2 What technologies are being wielded in innovative solutions (patents) meant to digitalise management accounting processes?

Data collection

To identify the relevant tools and technologies meant for the digitalisation of MA processes, we firstly conducted a bibliometric analysis, using the Web of Science (WoS) database (Clarivate Analytics, n.d.) as it contains more accurate and reliable research resources (Sánchez Núñez et al., 2020). The relevant papers were retrieved by using Boolean logic and different versions of the two key terms around which this research is defined: managerial accounting and digitalisation. As there is a variety of keywords under the umbrella of research in the field of managerial accounting, we used the search terms proposed by Balstad and Berg (2020). In the case of the digitalisation term, we employed the list of keywords proposed by Knudsen (2020), expanding it by adding other versions of the related terms. The terms were searched in the topic of each paper (title, abstract and keywords). Figure 1.1. contains the query used in WoS, which is limited to articles published in English between 2020 and 2023, with a total of 996 studies being identified.

```
(((TS=("managerial accounting" OR "management accounting" OR "cost accounting" OR "Managerial economics" OR "Management accounting and control" OR "Cost management" OR "Cost accounting" OR "Management control" OR "Performance management" OR "Performance measurement" OR "Business control" OR "Business controlling")) AND TS=("big data" OR "digital*" OR "analytics" OR "cloud" OR "cyber*" OR "mobile" OR "social media" OR "robotisation" OR "automatisation" OR "RPA" OR "Robotic process automation" OR "artificial intelligence" OR "blockchain" OR "decentralised ledgers" OR "platforms" OR "internet of things" OR "IoT" OR "text mining")) AND PY=(2020-2023)) AND DT=(Article OR Review)) AND LA=(English)
```

Figure 1.1. Query used in WoS

To answer the second research question, we analysed patent data published between 2020 and 2023 in the Espacenet database of the European Patent Office (EPO), which contains more than 150 million inventions. The data filtering was carried out using the terms proposed by Balstad and Berg (2020) and restricting the data to patents published after January 1, 2020, within four international classifications that include the main areas that can point to management accounting:

- G06F 15 - Digital computers in general; Data processing equipment in general;
- G06F 17 - Digital computing or data processing equipment or methods, specially adapted for specific functions;

- G06Q 10 – Administration; Management;
- G06Q 50 - Information and communication technology [ICT] specially adapted for implementation of business processes of specific business sectors.

Data analysis

For the bibliometric analysis we employed VosViewer together with the Biblioshiny package available in R. By using computer-aided analysis, in addition to the benefits related to the reduction of the time required for analysis and the improvement of the ability to work with a large volume of information (Lee et al., 2020), we could also observe links that are not as obviously highlighted by the manual examination (van Eck and Waltman, 2022). Also, the use of the Biblioshiny package offers a complementary series of statistical and data visualization techniques.

The information collected from the selected patents was analysed both manually, to identify the IT technologies used, and automatically, using VosViewer to examine the co-occurrence of the terms after data pre-processing. The initial search returned a total of 560 items, 42 of which were removed as they did not refer to the purpose of the study.

RESULTS AND DISCUSSIONS

Technologies for the digitalisation of management accounting processes identified in the relevant papers

Between 2020 and 2023, 996 articles aimed at digitalising MA processes were published in the WoS database, with a total of 3194 authors and an average of over 8 citations per publication. Throughout the examined period, there was a constant increase in the number of papers - in 2020 158 articles were identified, with an average annual growth rate of approximately 30%. In terms of the number of articles, the three most productive publications are represented by Sustainability, Applied Sciences, and IEEE Access.

For the terms co-occurrence analysis, we considered a minimum value of five. Of the 4899 terms, 300 elements met the established criterion, including both the authors' keywords and the keywords plus. Figure 1.2. presents the result of the analysis, with a total of nine groups, six of which have more than 30 elements.

As can be observed, within the first cluster (red), which contains 63 elements, the key terms referring to IT solutions are mainly grouped, identifying here the following technologies: blockchain, cloud computing, Internet of Things (IoT), mobile technologies, smart contracts, wireless sensor networks, but also elements referring to data security and visualization tools and techniques. The second cluster (green) is focused on business models, dynamic capabilities, strategies, performance, and digital transformation of organizations. The next group (blue) focuses on data analysis including big data and business intelligence in the context of corporate governance and con-

trolling activities. The fourth cluster has at its core Industry 4.0, including elements related to adoption, benefits, performance management, and data quality. The next group (purple) addresses the barriers and challenges associated with the digitization of processes in the field of managerial accounting, including risk management, sustainability, and data security. The sixth cluster targets algorithms, artificial intelligence, machine learning techniques, and decision-making.

The presence of the nine overlapping clusters in the co-occurrence analysis suggests a complex interplay of correlated themes within the relevant literature. This phenomenon reflects the interdisciplinary nature of the research field, indicating a complex context of interconnected topics.

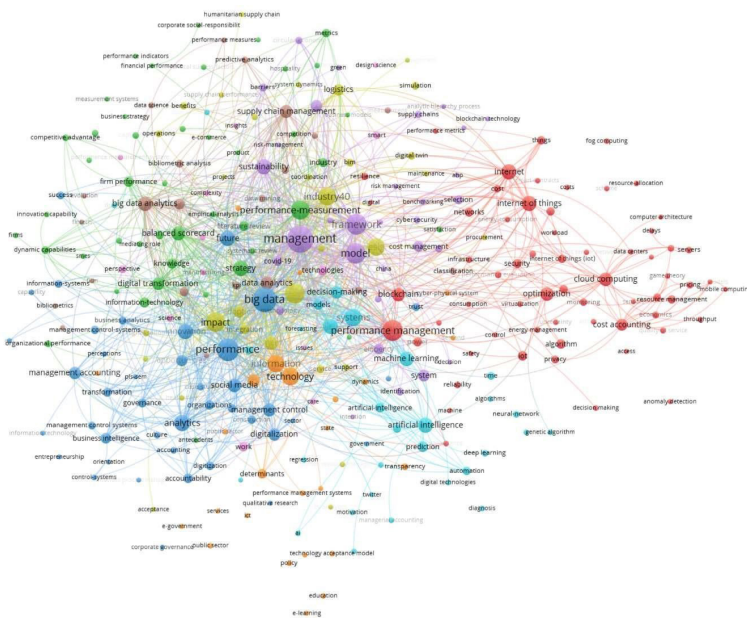


Figure 1.2. Results of the co-occurrence analysis based on the literature

The evolution of the key terms was examined by using the Biblioshiny package to identify the changes over the analysed period but also to highlight the research strategies, with only the authors' keywords leveraged for this examination as, unlike VosViewer, which allows the simultaneous analysis of the two categories of terms, Biblioshiny does not include this option and authors' keywords were considered to be a more reliable option. As presented in Figure 1.3, IT technologies and tools are highlighted in all three analysed periods. In the context of motor themes, the 2020-2021 period is characterized by the Internet of Things, data analysis techniques, business intelligence, blockchain, cloud computing, and Industry 4.0. Also, during this period, artificial intelligence and mobile technologies represent core themes which, starting in 2022, become motor topics. Since 2023, it can be seen that the focus shifted towards ERP systems, decentralized ledgers, Internet of Things, and machine lear-

ning methods. Additionally, an increase in research on data security and sustainable development can also be noticed.

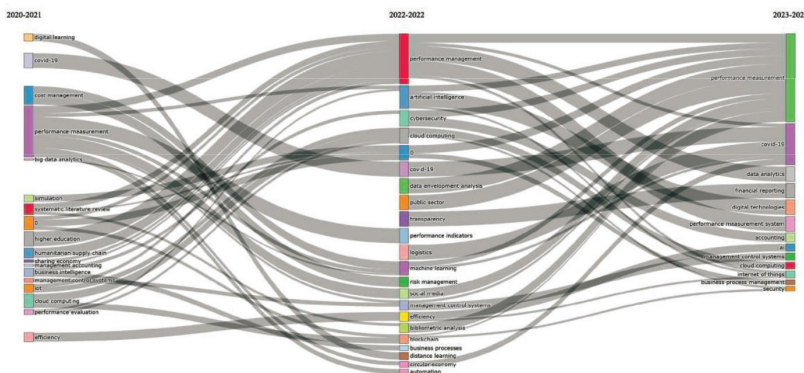


Figure 1.3. Analysis of the evolution of key terms

The factor analysis of key terms (Figure 1.4.) allows the examination of the keywords' proximity and highlights emerging research topics. Negatively correlated variables are positioned in opposite quadrants of the chart axes. Instead, positively correlated variables are grouped together, thus allowing thematic structures to be revealed between keywords (Niknejad et al., 2021).

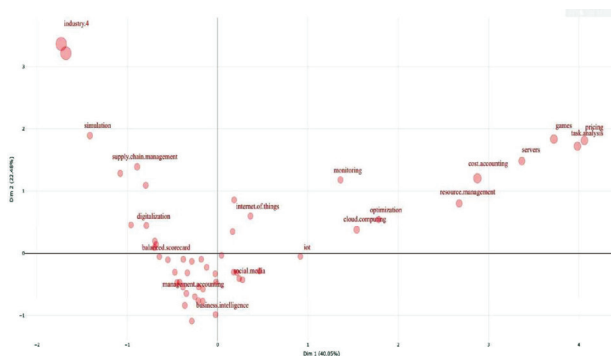


Figure 1.4. Factor analysis of key terms

Technologies and tools for digitalising management accounting processes identified in patent data

From an academic research perspective, integrating patent data within the study of the MA processes' digitalisation contributes to the deepening and broadening of the topic understanding. By examining patents, researchers have access to practical applications and implementations of theoretical concepts which might be less explored in the academic literature. This not only validates the theoretical frameworks but

also provides insights into the challenges and solutions encountered in the field. In addition, patent data analysis provides insights into emerging technologies, trends, and innovations, which can contribute to future directions of theoretical research and development.

Most of the selected patents were published in 2021 and 2022 (152 and 160 respectively). In 2020, 109 patents were registered, and in 2023 only 93.

In contrast to the data available for the articles analysed, no keywords are mentioned in the case of patents. To overcome the limitations, we employed the VosViewer feature that allows researchers to examine the terms co-occurrence within corpus files, by using the patents' abstracts, which were available in English. As in the case of the literature review, a limit of at least five keyword occurrences was set, resulting in 322 items (Figure 1.5.) that met the criterion, which were allocated in seven groups, five of which with more than 30 items.

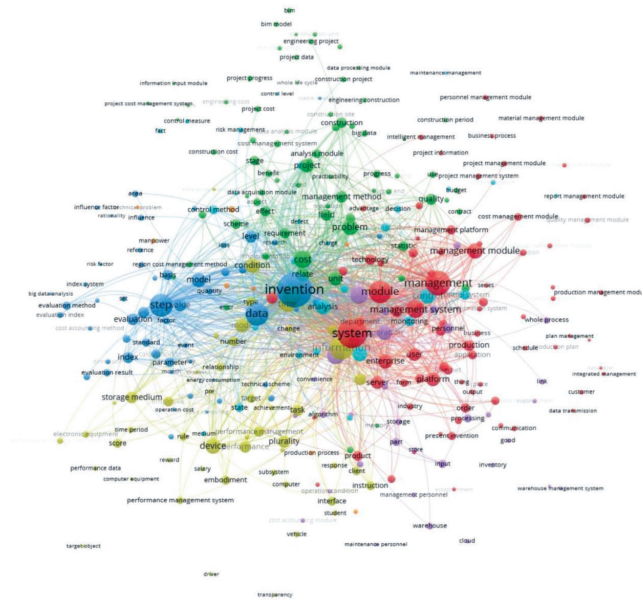


Figure 1.5. Patent-based co-occurrence analysis results

Considering the research purpose of this paper, unlike the previous analysis in which a series of keywords related to digitalisation were provided to identify the solutions and technologies used, in this case the filtering was carried out exclusively on the basis of the key terms referring to managerial accounting. Thus, the objective in this context was to exclusively analyse IT solutions intended for digitalisation, without examining any other links. Therefore, during this stage, the following IT technologies were identified, mainly used within the information systems for performance, operational efficiency, and cost management:

CONCLUSION

The research objective focused on identifying the main tools and technologies for digitalising managerial accounting processes through an in-depth approach that allowed an extensive examination of the research topic. Analysing both relevant literature and patent data intended to streamline this investigation, provides both theoretical and practical perspectives. Thus, the present research has an important contribution to the understanding of the wide range of digital tools and technologies that reshape management accounting and contribute to improving the decision-making process of organizations in their evolution towards developing competitive advantages.

A first implication of the study is presented by the increased degree of similarities between the two datasets analysed. In terms of the technologies used, there are no significant differences, although the expectation would have been that we would identify new perspectives in patents. This result could, however, be justified by a convergence of research with technological development, but it could also be driven by regulatory aspects, in particular in the case of technologies based on artificial intelligence. It was thus observed that the development efforts are mainly aimed at improving the management systems within the organizations by increasing the degree of efficiency and reducing costs. Secondly, the relatively rapid changes in the topics of interest in the field are pointing to disruptions in MA, which might be fuelled by the organisational needs to remain competitive, suggesting the importance of pressure factors within and across industries. While in 2020 artificial intelligence and machine learning were core themes mainly associated with big data, in 2023 an increase in the level of attention to these technologies could be observed, transitioning from core to motor themes, determined by the obvious advances made in recent years, especially driven by the emergence of generative artificial intelligence. Another important implication is represented by the link between the digital tools and technologies identified with the sustainable development of organisations, a topic increasingly discussed in the literature given that digitalisation can lead to an increase in the efficiency of environmental impact monitoring, assisting companies in identifying opportunities to improve their sustainable performance.

Since the study examined the timespan 2020-2023, there was just a limited overlap with the emergence and evolution of generative artificial intelligence. Therefore, future research could seek to examine to what extent such solutions are now being wielded in the field of management accounting. Further, widening the search across additional literature and patent databases would enhance the comprehensiveness and robustness of the study findings. Notwithstanding these limitations, this study offers important insights into the current landscape of management accounting innovation, clarifying prevailing themes, evidencing early impacts, and highlighting where evidence remains thin.

REFERENCES

1. AlAnsari, A., Alqadhi, B., Aljawder, A. and Wadi, R.A., 2022. Management Accounting in the Digital Era: Literature Review. In: A.M.A. Musleh Al-Sartawi, ed. *Artificial Intelligence for Sustainable Finance and Sustainable Technology*. [online] Cham: Springer International Publishing. pp.512–521. https://doi.org/10.1007/978-3-030-93464-4_50.
2. Balstad, M.T. and Berg, T., 2020. A long-term bibliometric analysis of journals influencing management accounting and control research. *Journal of Management Control*, [online] 30(4), pp.357–380. <https://doi.org/10.1007/s00187-019-00287-8>.
3. Barreto, A., Gomes, P., Quesado, P. and O’Sullivan, S., 2024. Management Accounting and Digital Technologies: A Science mapping review. In: *6th International Conference on Advanced Research Methods and Analytics - CARMA 2024*. [online] Universitat Politècnica de València. pp.305–316. <https://doi.org/10.4995/CARMA2024.2024.17814>.
4. Bergmann, M., Brück, C., Knauer, T. and Schwering, A., 2020. Digitization of the budgeting process: determinants of the use of business analytics and its effect on satisfaction with the budgeting process. *Journal of Management Control*, [online] 31(1–2), pp.25–54. <https://doi.org/10.1007/s00187-019-00291-y>.
5. Clarivate Analytics, n.d. *Clarivate*. [online] Available at: <<https://www.webofscience.com/wos/woscc/smart-search>>.
6. Costa, M. and Pinho, M., 2025. Management accounting and the paradigm change - a journey through the age of digitalization. *Procedia Computer Science*, [online] 263, pp.564–574. <https://doi.org/10.1016/j.procs.2025.07.068>.
7. Dai, J. and Vasarhelyi, M.A., 2023. Management Accounting 4.0: The Future of Management Accounting. *Journal of Emerging Technologies in Accounting*, [online] 20(1), pp.1–13. <https://doi.org/10.2308/JETA-2023-009>.
8. Fährndrich, J., 2023. A literature review on the impact of digitalisation on management control. *Journal of Management Control*, [online] 34(1), pp.9–65. <https://doi.org/10.1007/s00187-022-00349-4>.
9. George, M., Nhi, L.K.Y., Ngoc, N.M., Tung, V.N.D., Truc, L.P.T. and Nayak, R., 2022. Digital Technologies for Lean Manufacturing. In: R. Nayak, ed. *Lean Supply Chain Management in Fashion and Textile Industry*. [online] Singapore: Springer Nature Singapore. pp.219–267. https://doi.org/10.1007/978-981-19-2108-7_10.
10. Kaushik, K., Bhardwaj, A., Dwivedi, A.D. and Singh, R., 2022. Machine Learning-Based Regression Framework to Predict Health Insurance Premiums. *International Journal of Environmental Research and Public Health*, [online] 19(13), p.7898. <https://doi.org/10.3390/ijerph19137898>.
11. Lee, L.W., Dabirian, A., McCarthy, I.P. and Kietzmann, J., 2020. Making sense of text: artificial intelligence-enabled content analysis. *European Journal of Marketing*, [online] 54(3), pp.615–644. <https://doi.org/10.1108/EJM-02-2019-0219>.
12. Nielsen, S., 2022. Management accounting and the concepts of exploratory data analysis and unsupervised machine learning: a literature study and future directions.

- Journal of Accounting & Organizational Change*, [online] 18(5), pp.811–853. <https://doi.org/10.1108/JAOC-08-2020-0107>.
13. Niknejad, N., Ismail, W., Bahari, M., Hendradi, R. and Salleh, A.Z., 2021. Mapping the research trends on blockchain technology in food and agriculture industry: A bibliometric analysis. *Environmental Technology & Innovation*, [online] 21, p.101272. <https://doi.org/10.1016/j.eti.2020.101272>.
 14. Perkhofer, L., Walchshofer, C. and Hofer, P., 2020. Does design matter when visualizing Big Data? An empirical study to investigate the effect of visualization type and interaction use. *Journal of Management Control*, [online] 31(1–2), pp.55–95. <https://doi.org/10.1007/s00187-020-00294-0>.
 15. Ranta, M., Ylinen, M. and Järvenpää, M., 2023. Machine Learning in Management Accounting Research: Literature Review and Pathways for the Future. *European Accounting Review*, [online] 32(3), pp.607–636. <https://doi.org/10.1080/09638180.2022.2137221>.
 16. Regona, M., Yigitcanlar, T., Xia, B. and Li, R.Y.M., 2022. Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review. *Journal of Open Innovation: Technology, Market, and Complexity*, [online] 8(1), p.45. <https://doi.org/10.3390/joitmc8010045>.
 17. Sanchez-Nunez, P., Cobo, M.J., Heras-Pedrosa, C.D.L., Pelaez, J.I. and Herrera-Viedma, E., 2020. Opinion Mining, Sentiment Analysis and Emotion Understanding in Advertising: A Bibliometric Analysis. *IEEE Access*, [online] 8, pp.134563–134576. <https://doi.org/10.1109/ACCESS.2020.3009482>.
 18. Schnegg, M. and Möller, K., 2022. Strategies for data analytics projects in business performance forecasting: a field study. *Journal of Management Control*, [online] 33(2), pp.241–271. <https://doi.org/10.1007/s00187-022-00338-7>.
 19. Van Eck, N.J., & Waltman, L. (2022). VOSviewer manual. https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.18.pdf