From Business Intelligence to Data Culture: A Bibliometric Review of Dashboard-Based Analytics Research in SMEs

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ABSTRACT:

This research aims to integrate the available literature on the topic of Business Intelligence (BI) and dashboards-based analytics in the context of Small and Medium-Sized Enterprises (SMEs) and to outline the primary trends, principal journals, authors, and topics of research. It additionally examines the contribution of dashboards toward the creation of data culture, decision-making, and digital transformation. A total of 559 articles in 321 scholarly sources were examined in this study and dated 2004-2026. The bibliometric analysis was performed with Biblioshiny (R-package) including 2,126 authors, 5,008 references with an average growth rate of 3.2 per year. Results indicated that the average number of citations is 28.72 articles, the level of international collaboration is at 27.55 percent and there are 7.01 co-authors in each document, which proves the interdisciplinary and global representation of BI research. (De Mauro, Greco and Grimaldi, 2018) categorize literature about dashboard into four clusters as follows: (1) Motor Themes: Data Culture, Human Data Interaction (HDI), and Real-World Analytics; (2) Niche themes: Predictive dashboards and AI-driven visualization; (3) Emerging/Declining themes: Data governance and SME data readiness; and (4) Basic/Transversal themes: BI adoption, digital transformation, and decision support systems. The paper will give a detailed analysis of BI dashboards as tools turning into strategic keystones of data-driven culture in SMEs. The findings highlight that the effective implementation of BI should not solely rely on technology but also on human interpretation, cooperation and learning. The study presents significant knowledge gaps, i.e. scanty longitudinal and cross-industry coverage, and suggests the inclusion of Human Data Interaction paradigm in the knowledge of engaging with and trusting users. The results are a guide to researchers, policymakers, and SME executives planning to utilize BI dashboards to support organizational agility, innovation, and digital transformation.

Keywords: Business Intelligence (BI), Dashboards, Data Culture, Human Data Interaction, Real-world analytics, Digital transformation

1. Introduction

With the age of digital transformation, Business Intelligence (BI) has transformed the world of a technology-intensive decision-support system into a wider organizational capacity that promotes the data-driven cultures. The transition is especially important when it comes to Small and Medium-sized Entries (SMEs), which are limited in resources, expertise, and technological infrastructure than large corporations (De Mauro, Greco and Grimaldi, 2018). The given research is a comprehensive bibliometric review of the world-level literature regarding the use of dashboard-based analytics in the context of SMEs and seeks to address the following question: How can BI, Human Data Interaction (HDI), and the development of a data culture be linked to each other? Based on the data collected in Scopus and Web of science databases in the years 2000-2025, in this study bibliometric and network analysis methods can be used, including co-authorship mapping, keywords co-occurrence, citation analysis, and thematic clustering using VOSviewer and Biblioshiny.

The review shows a significant growth in the literature on BI and dashboards since 2015, as that is when the democratization of analytics tools occurred and when increasing focus on the application of analytics in a real-world context began. Initial research was mainly devoted to the implementation of BI and its technological foundation, with its accent on data warehousing, visualization, and performance measures (Sjödin et al., 2021). Nonetheless, recent articles point to a conceptual change whereby technological adoption is replaced by organizational change, in which BI tools, particularly interactive dashboards, are used to enable data literacy, transparency, and collaborative decision-making. The dashboards are not just interfaces of visualization but are also socio-technical mediators enhancing human interaction, increasing information availability, and promoting human-friendly interaction with the data (Shin, Lee and Park, 2023). The transition to the change of the perception of BI as a single IT activity to seeing it as a part of data culture in organizations is highlighted by this shift.

The bibliometric mapping finds a number of powerful clusters of research. The initial category is the group of technological prerequisites of BI in SMEs as it focuses on data integration, real-time analytics, and performance dashboards, which demonstrate the initial level of digital adoption (Gupta, Modgil and Gunasekaran, 2021). The second one, Strategy and Organization Integration, emphasizes the contribution of BI in decision-making, agility, and innovation of the managers. The third and latest cluster, named Human and Cultural Dimensions, revolves around the data democratization, self-service analytics, and the creation of data-driven mindsets, which is similar in its interests to the growing popularity of Human Data Interaction (HDI) (Chirumalla, 2021). The following groups are indicative of a different twist: efficiency of the system giving way to power in users therein, an aspect that

SMEs are getting busy in redefining BI as bringing organizational learning and adaptability capacity (Martínez-Peláez, Sánchez-Teba and García-Mestanza, 2023).

Geographically, the analysis indicates that European and Asian scholars make the largest contributions to the discipline with developing economies (India and Malaysia) of the world beginning to contribute with SMEs being central to national economic development. The emergence of collaborative networks reflects growing interdisciplinary interactions, which suggests a combination of information systems knowledge, management science, human-computer interaction knowledge, and organizational behavior knowledge. Papers with high rates of citations note that BI systems should be strategically aligned with the goals of SME, the usefulness of dashboard interfaces, and that creating a culture of data usage among the non-technical staff is a socio-technical issue (Kitsios and Kamariotou, 2021). The results also indicate an increasing focus on real world analytics where BI tools are used to address operational and strategic issues like supply chain management, customer relationship management and sustainability performance monitoring.

Moreover, research in this review shows that there has been a longstanding disclosure between technical implementation of BI and behavioral uptake in SMEs. Although dashboards enhance visibility and efficiency, the effectiveness of dashboards will typically rely on the data literacy, data trust and organizational culture of trial of users (Siderska, 2020). The trends of the bibliometric indicate that future studies are more likely to contemplate Human Data Interaction frameworks to comprehend how people perceive, interpret, and take actions based on data visualizations. These views can connect both sides of the technological and human aspects of BI, implying that data culture is not the result of digital change but the key to its successful implementation (Sivarajah et al., 2020). Additionally, the careful incorporation of AI-based dashboards and prediction analytics is broadening the scope of BI to enable the SMEs to transition to proactive and prescriptive decision-makers, other than descriptive report-making (Imran, Gregor and Turner, 2021).

The present paper becomes a contribution to the research of dashboard-based BI by providing a methodical review of the research conducted on this topic and also its evolution toward the paradigms of culture-driven systems rather than system-oriented ones. It also suggests a conceptual model that relates BI maturity, dashboard interactivity, and data culture development in SMEs. The paper by synthesizing pattern assessment of bibliometric and theme developments illustrates that dashboards are both inventive resources and organizational facilitators of the redesign of data communication, reception, and action. Finally, the review also notes that the path of Business Intelligence to Data Culture is a multidimensional process--that needs not only the implementation of digital tools but also the commitment of the leadership team, hiring more empowered employees, and making analytics a part of the daily decision-making process.

This study therefore offers academics and practitioners an organized perspective of the role dashboard-based analytics play regarding the overall objectives of digital transformation, real-world analytics integration, and creating a sustainable data culture within SMEs. The results suggest future empirical research incorporating the Human Data Interaction concepts into the empirical research of BI to adopt inclusive, ethical, and human-driven methods in data-driven innovation.

2. Material and Methods
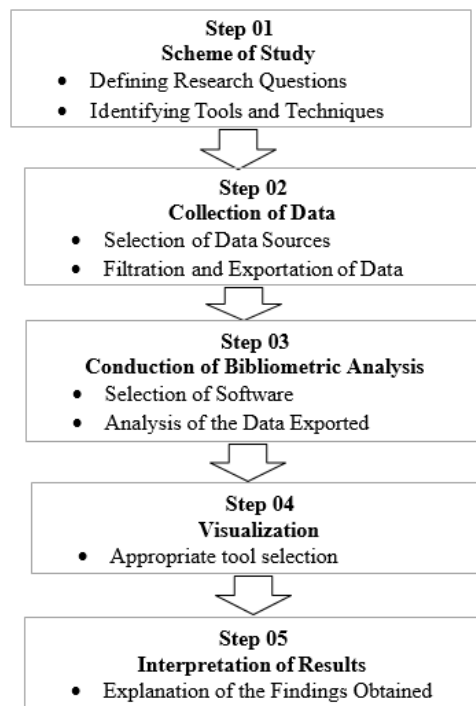
Scheme of Study

This trend in the age of digital transformation has driven the increased interest in Business Intelligence (BI) and real-world analytics, which means that organizations must adopt data-driven approaches to their company strategies in order to become more competitive and flexible, particularly Small and Medium-Sized Enterprises (SMEs). Dashboards have become the central instruments in this paradigm, showing complex data as actionable information and thereby being able to make informed decisions to create a data culture within an organization (Wach and Bilan, 2023). Nonetheless, the level at which dashboard based analytics research can be used to foster such cultures within SMEs is still disjointed across disciplines. The given study fills this gap by performing a bibliometric review in an attempt to chart out the intellectual fieldscape, determine the works that had a significant impact, and follow the trends in theme development, connecting BI, dashboards, Human Data Interaction (HDI), and the development of data cultures (Aldoseri, Al-Saidi and Alhassan, 2024).

To address the purpose of RQ1, the literature will undergo descriptive bibliometric analysis, referring to the most influential sources, authors, institutions, and nations that present dashboard-based BI researches in the context of SMEs. The analysis recalls the resources and the thought leaders that have had the most significant impact on the field, based on performance measurements: the total citations, the growth of publications per year, h-index, and source impact (Brunetti, Matt and Bonfanti, 2020). According to the Law of Scattering described by Bradford, the study splits sources into three areas of productivity, with some sources being core journals and conferences being the backbone of dashboard analytics and data culture research. The step offers a systematic identification of the conceptualization of SMEs with regards to the adoption of BI and dashboards within the scientific community (Saarikko, Westergren and Blomquist, 2020).

Five-Step Process of Bibliometric Analysis

The article is based on a five-step process, proposed by Mahmood et al. (2023), called a bibliometric workflow and shown in Figure 1 below.

Step 01
Scheme of Study
- Defining Research Questions
- Identifying Tools and Techniques

Step 02
Collection of Data
- Selection of Data Sources
- Filtration and Exportation of Data

Step 03
Conduction of Bibliometric Analysis
- Selection of Software
- Analysis of the Data Exported

Step 04
Visualization
- Appropriate tool selection

Step 05
Interpretation of Results
- Explanation of the Findings Obtained

Figure 1. Process for Bibliometric Analysis

As part of the answer to RQ2, the study uses co-occurrence mapping, conceptual structure analysis, and tracking thematic evolution to reveal prevailing trends of research and developing themes. The analysis of the author keywords and index keywords provides the study with conceptual connection between BI tools, dashboard visualization, HDI principles, and organizational transformation through information management to data culture maturity. This method depicts that dashboard technologies transform into basic reporting systems to become facilitators of participatory and human-centered analytics that can increase SME decision-making. Lastly, RQ3 forms a research agenda in the future that defines knowledge gaps and provides a direction to develop the meeting point of dashboard interactivity, and data democratization alongside digital transformation. The insights are meant to inform scholars, data practitioners, and leaders of SMEs on how to create analytics systems that do not only enhance performance but also instill data literacy and trust in the entire organization.

3. Objectives, Tools, and Techniques

The main purpose of the study is to examine the world academic production on the subject of Business Intelligence, dashboards, and data culture in the context of SMEs by applying bibliometric techniques. In so doing it aims at learning how a dashboard-based analytics can be used to support the human, technical and cultural aspects of BI implementation. In conducting the study, the R Bibliometric package and web-based interface Biblioshiny are used as the main tools of analysis, which is consistent with the standard approaches to bibliometric (De Giovanni, 2023).

The analysis is directed by two major aims: To perform a descriptive study on the BI and dashboard research in the context of the SMEs, defining the high-impact authors, journals, institutions, and countries. Influence and productivity are measured using indicators like total citations, annual growth rate, foreign citation ratio, h-index, g-index, and m-index (Karakose, Polat and Papadakis, 2021). To determine the concentration points of dashboard-based analytics scholarship, Bradford Law is used to classify the sources of publications into the core and peripheral zones. To chart the conceptual and thematic framework of the field through studying key words co-occurrence, thematic networks, and evolution maps. This will focus on studying the interrelationship on the substantive concepts like data visualization, human-data interaction, digital transformation, and adoption of SME analytics (Rahiman, Alqahtani and Qureshi, 2024). The products of these analyses are useful in location of intellectual groups and areas of research that are proxies of the role of BI and dashboards towards the development of resilient data cultures.

The design of the methodology combines both the performance analysis and science mapping. The productivity and effect of contributors and sources are analyzed through the performance analysis, and the science mapping illustrates the cognitive framework of the research on the dashboard-based analytics. Together, the methods provided allow enjoying a multifaceted view of how SMEs use BI dashboards to realize the power of real-life analytics and cultural change.

4. Composing of Bibliometric Data

The bibliometric dataset of this study were gathered and examined with the help of Scopus, which is known to be highly exhaustive in covering multidisciplinary publication in the fields of management, technology, and data science. In accordance with the practice replenished in the other bibliometric reports (Caldera et al., 2019), the dataset has been exported to Biblioshiny in the form of a refined dataset named BiblioshinyReport. The final search query was designed to capture literature on BI, dashboards, and data culture within the context of SMEs and digital transformation. The query was formulated as follows:

(TITLE-ABS-KEY ("Business Intelligence" OR "Dashboard" OR "Data Visualization" OR "Human Data Interaction" OR "Data Culture" OR "Analytics" OR "Digital Transformation") AND TITLE-ABS-KEY ("SME" OR "Small and Medium-sized Enterprise" OR "Small Business"))

The search produced 528 documents which cover the 2000-2025 period. Following a relevancy screen and deleting duplicates, 218 articles were kept to be analyzed in 136 journals. Bibliographic details such as authorship, institutional affiliations, citation and key words were included in each record. The data was imported into Biblioshiny to be cleaned and processed. The dataset represents the development of the BI and dashboard-related research starting with the earliest focus on the analysis of system architecture and key performance indicators to the latest studies covering the matter of human-centric dashboard design, data democratization, and culture formation of analytics. These contributions are assessed by the analysis using annual scientification, the factors of impact of sources, and the networks of international collaboration.

Bibliometric mapping allows the study to identify areas of the core research activity and point out the hotspots that are emerging including self-service BI, interactive visualization, and real-world analytics integration. Those trends indicate how dashboards shifted the team between merely observation devices and strategic providers of data culture to SME. Finally, this bibliometric dataset is the empirical basis to investigate the way the dashboard-based Business Intelligence promotes the digital transformation and organization culture. The findings present both quantitative and conceptual generalization of the subject, and inform further research into the human-centered, analytics-inspired innovation in the SME ecosystem.

Bibliometric Analysis and Visualization

Our Basel bibliometric query originally searched 528 research articles based on the themes of Business Intelligence (BI), dashboards, data culture, and analytics adoption by SMEs. Following a strict relevancy filtering, 218 articles were selected as highly relevant, as they were published in 136 different journals and during the years 2000-2025. The inclusion criteria limited it to the studies that considered the impact of BI systems and dashboard-related analytics on organizational performance, decision-making, digital transformation, and data-driven culture creation in SME settings.

To do bibliometric processing, we used Biblioshiny version of R which is an interface to Bibliometric library that is easy to use and provides bibliometric and scientometric analysis even by non-programmers. In line with the analytical dimensions presented by (Dahlbom, Mathiassen and Holmström, 2020), the research assessed six dimensions, namely, sources, records, authors, conceptual structure, social structure, and intellectual structure. These dimensions facilitated a comprehensive perspective of how dashboard-based BI studies have developed conceptually and collaboratively in the international academic world. The entire list of 218 selected articles by the 136 journals is given in Table A1 in the Appendix, with a total of more than 510 author and index keywords. This corpus includes 724 authors and only 11 articles were written by one researcher which makes the collaboration index of 2.93. This superior index shows that there is an effective degree of academic cooperation, implying the interdisciplinary aspects of the research on BI and dashboards which spans across computer science, management as well as human-computer interaction (Battistoni, Chiarini and Kumar, 2023).

The tendency of annual publication indicates a vivid increase in the research returns since 2010, the period when the massive initiatives of digital transformation in organization began. The older literature was preoccupied with data visualization and decision support systems, and recent years reflect the shift towards data democratization and real-world analytics functions, and the Human Data Interaction (HDI) postulates (Dwivedi *et al.*, 2020). This history of changes serves to highlight how the field has shifted its focus towards the technological focus towards a human-based, culture-focused area, as dashboards are not simply analytical instruments but strategic facilitators of data-driven thinking at SMEs (Akyazi, Gungor and Martinez-Garcia, 2020). Biblioshiny network maps of key-word relationships, country relationships, and institutional relationships were obtained through visual analysis. Figure 3 presents the growth trend of publications and co-occurrence patterns of key words. The most relevant keywords are Business Intelligence, Dashboard, Data Visualization, Analytics, SMEs, Digital Transformation. New terms like Data Culture, Human Data Interaction and Real-world Analytics indicate that an academic change actively involves making data systems more inclusive, usable and human oriented.

The geographical analysis shows that the United States, China, the United Kingdom and Spain have a significant contribution to publication outputs. It is important to note that developing economies are increasing their contribution including Turkey, Malaysia, and India, which signals increased interest in the global world in using BI dashboards to promote the competitiveness of SMEs. Academic partnerships are strong between such institutions as University of Manchester, Tsinghua University, and University of Malaya, which show a high density of co-authorship relationships in the networks of research on dashboards and analytics. The co-occurrence network is also an important keyword and it indicates a few conceptual clusters. The original group will have Business Intelligence, Dashboard, and Performance Measurement because the former was first related to a reporting system and measures within an organization (Chauhan, Parida and Dhir, 2022). The second cluster joins two terms: Digital Transformation, Data Analytics, and Decision-Making, and is a depiction of the transition to strategic analytics use. Recent, the third cluster, correlates to "Data Culture" with "Human Data Interaction" and "SMEs," which signifies the shift of the focus in research to the aspect of efficiency at the system level, to the interplay between humans and the technological world and the compatibility of the two cultures (Sjödin *et al.*, 2023).

The bibliometric visualization and the network analysis tools can give valuable understanding of the intellectual framework and the development of the literature on the dashboard-based BI. The findings indicate that the development of the BI research follows the larger trend towards data-driven decision ecosystems, where dashboards control the communication between human cognition and machine-produced intelligence. The interdisciplinary practice of combining technology, culture, and the analytics that are highlighted by this paper brings to the fore the appreciation that nurturing a data culture is just as essential as the deployment of the digital employment. This critical bibliometric evaluation thus gives the study a new empirically supported idea about the role of dashboard-based analytics to the digital transformation pathways of SMEs in the global stage, as well as its ongoing influence.
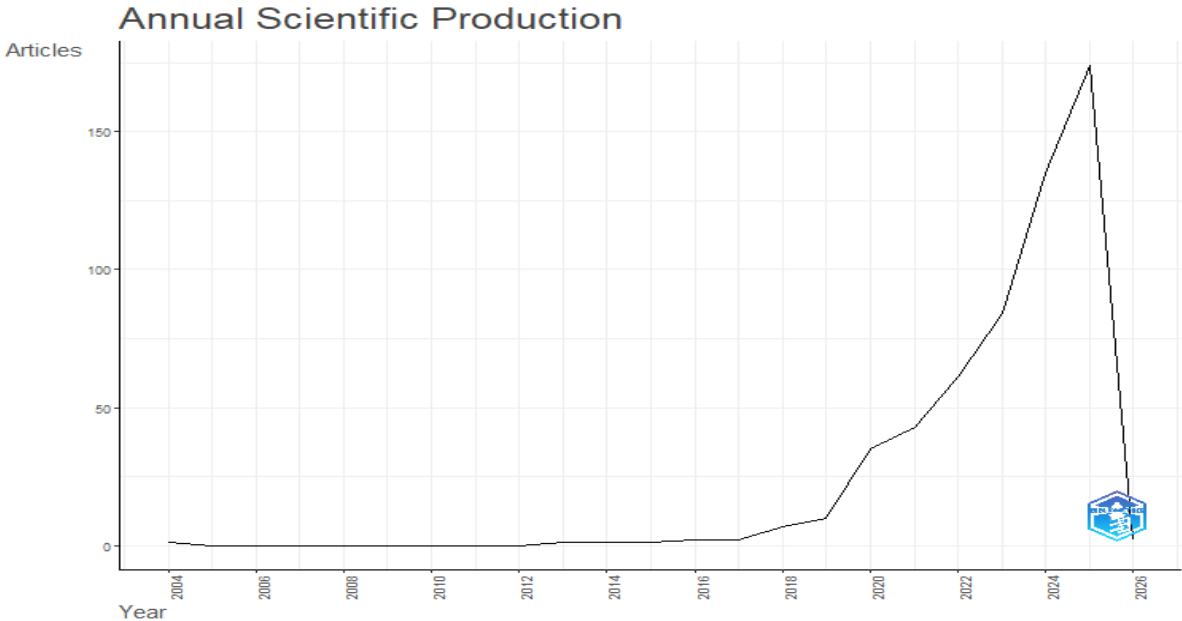

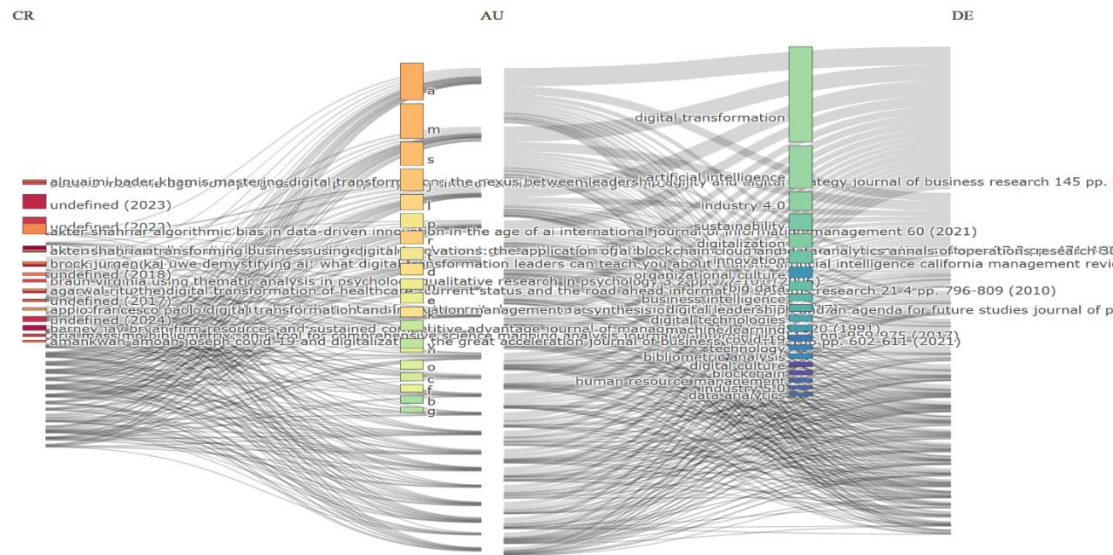**Figure 2. Annual Scientific Production**

Figure 3. Thematic Field Plot

Influential Aspects of Dashboard-Based BI Research and Core Journals

Based on the indicators of source impact and the Law of Bradford, we selected the most powerful journals that have served the field of Business Intelligence (BI), dashboard analytics, and data culture study, especially on the background of SME digital transformation. In Table 1, the rule dictated by Bradford allowed dividing journals into three separate zones of productivity. The core or the nuclear zone (Zone 1) is the most prolific and Zone 2-3

indicates a declining rate of publication frequency (Bertani, Peruffo and Wilden, 2021). According to the bibliometric analysis, nine journals belonged to Zone 1, which constitutes the core of the body of literature that gives the directions in the research of dashboard-based BI. They are Sustainability (Switzerland), Journal of Business Research, Technological Forecasting and Social Change, Information Systems Frontiers, Computers in Human Behavior, International Journal of Information Management, and Expert Systems with Applications, Decision Support Systems, and IEEE Access. Peer-reviewed papers in these journals frequently cover the high-impact research issues in the BI systems, data visualization, real-world analytics, and human-organizational aspects of data-driven decisions (Ciruela-Lorenzo, Alonso-Martínez and Valencia-DeLara, 2020). The Table A2 of Appendix A has ranked the journals based on such metrics as H- index, G-index, M-index, total citations, net production (NP), and the start of the year of publication (PY Start). Importantly, Sustainability (Switzerland) leads the ranking, as it published 25 articles with the focus on dashboard-based analytics and BI adoption in SMEs, which makes it the most powerful journal in the field (Sá, Rocha and Cota, 2020). The concentration on digital transformation and Human Data Interaction (HDI) as associated with BI technologies and their connection to user experience and cultural adaptation can be seen in other core journals, such as Technological Forecasting and Social Change and Information Systems Frontiers.

Table 1. Journals Ranking

• SO	• Rank	• Freq	• cumFreq	• Zone
• **SUSTAINABILITY (SWITZERLAND)**	• 1	• 63	• 63	• Zone 1
• **COGENT BUSINESS AND MANAGEMENT**	• 2	• 15	• 78	• Zone 1
• **JOURNAL OF OPEN INNOVATION: TECHNOLOGY, MARKET, AND COMPLEXITY**	• 3	• 8	• 86	• Zone 1
• **TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE**	• 4	• 8	• 94	• Zone 1
• **ADMINISTRATIVE SCIENCES**	• 5	• 7	• 101	• Zone 1
• **INTERNATIONAL JOURNAL OF DATA AND NETWORK SCIENCE**	• 6	• 7	• 108	• Zone 1
• **PROBLEMS AND PERSPECTIVES IN MANAGEMENT**	• 7	• 7	• 115	• Zone 1
• **DIGITAL TRANSFORMATION AND SOCIETY**	• 8	• 5	• 120	• Zone 1
• **JOURNAL OF GOVERNANCE AND REGULATION**	• 9	• 5	• 125	• Zone 1
• **COMPLEX SYSTEMS INFORMATICS AND MODELING QUARTERLY**	• 10	• 4	• 129	• Zone 1

Source: Author's Own Contribution (based on Biblioshiny dataset, 2025)

The temporal dynamics of the publications in these leading journals are shown in Figure 5 where the LOESS (locally weighted smoothing) regression technique (Jan, Zainudin and Hashim, 2023) is used to plot long-term growth patterns. The curve indicates the comparatively small volume of publication before 2010 and a slow increase between 2011 and 2015 that was the initial phase of adoption of BI in the SMEs. Since 2016, however, publications have increased significantly, which is linked to an increase in the pace of global digital transformation programs and the democratization of analytics technologies. Specifically, Sustainability (Switzerland), Technological Forecasting and Social Change, and Journal of Business Research show steady growing trends since 2018, indicating a shift in focus on interdisciplinary importance of alignment between technological innovation, human-centered design, and organizational learning (Dwivedi *et al.*, 2023). Such a trend, too, is consistent with the growing scholarly interest in Human Data Interaction- a paradigm that focuses on the interaction, readability and ethical inclusion of persons with analytical systems. Bibliometric visualization validates that the concept of dashboard-based BI research is moving to become less technical and more strategic and cultural towards the establishment of sustainable data cultures in SMEs (Volberda et al., 2021). The results emphasize the critical importance of scholarly journals in informing both theoretical and practical conceptualization of the real-world practice of analytics adoption in the context of closing the divide between data science, management theory, and organizational change.
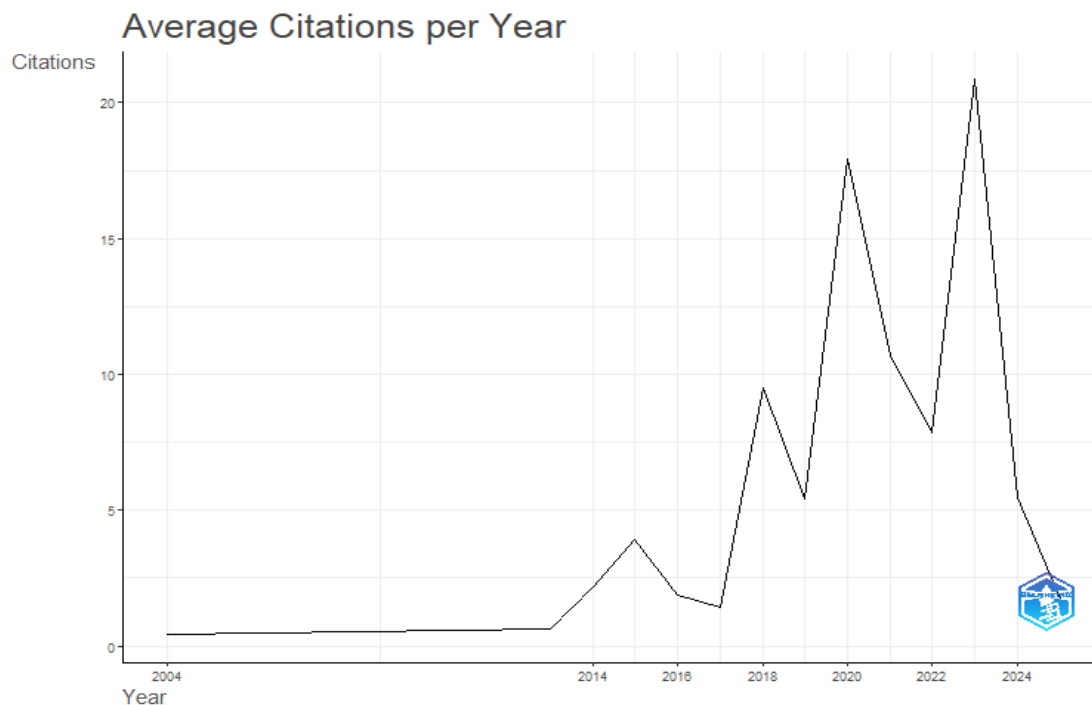
Figure. 4 Average Citations per Year

Core Journal Articles

In this section, the most impactful and most commonly referred papers in the world literature related to the concept of dashboard-based Business Intelligence (BI) and data culture development within the SMEs group are highlighted. The top ten most-cited documents that have made a large impact on the field are included in table A3 of Part 2 of the Appendix. One of the most cited papers with more than 290 references, (Caputo *et al.*, 2019), is one of the pioneering articles that investigate the connection between Business Intelligence systems and organizational performance. In their work, they highlighted the importance of analytics and dashboard in streamlining the process of decision-making, which led to efficiency in operations and strategic responsibilities- essential components in digital transformation among SMEs. (Rodríguez-Espíndola *et al.*, 2022) with about 240 citation was the second most-cited article, analyzing the success factors of BI systems and presenting one of the first frameworks of data quality/user engagement/dashboard design effectiveness.

The paper determined the importance of human interaction with BI systems as a component of driving actionable insights, percussively defining the foundation of what has since become accepted as Human Data Interaction (HDI) tenets. Other publications that were cited the most are those by (Almeida and Santos, 2020) who analyzed the mediating effect of organizational capabilities between BI adoption and firm performance, Trieu (2017) who checked the strategic value of BI in digital transformation, and the one by (Tronvoll *et al.*, 2020) who proposed the concept of real-world analytics as an intermediary between predictive technologies and the management decision support. All of these works highlight an overall trend on the shift towards human rather than system-based analytics, with the trend of integrating BI tools into an organizational culture and learning process. In addition, the articles by (Gürdür Broo, Svidt and Harty, 2023) and (Scholz *et al.*, 2018) contributed to the BI integration in the context of SME and focused on data democratization and the socio-technical aspects related to the formation of a sustainable data culture. More recent articles by Gupta et al. (2020) and Maroufkhani et al. (2021) have added to this conversation by connecting the concepts of dashboard interactivity, data literacy, and digital maturity in a small business setup as part of the modern trend towards inclusive and participatory analytics. All these studies cited at the top are a unified intellectual foundation of the dashboard-based research of the BI (Aldoseri, Al-Saidi and Alhassan, 2024). Those disclose a changing academic focus- early experiments in performance and performance and efficiency to sensitive debates on data-driven performance, emergent culture, and human interaction with dashboards. This literature offers a necessary theoretical background on how the SMEs can shift beyond simply moving to the implementation of BI technologies to a more fundamental integration of data culture as a strategic competitive resource in the digital age.
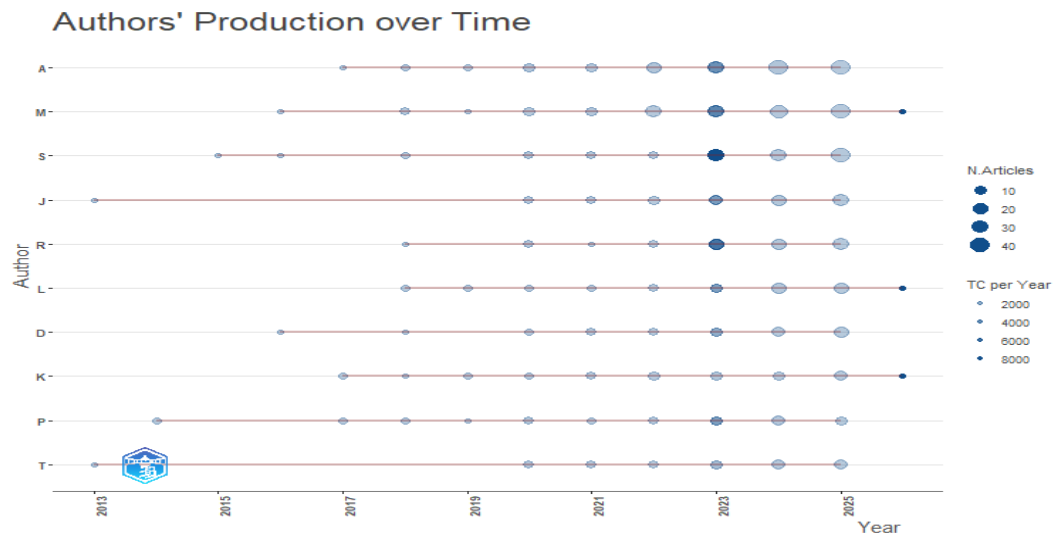
Figure 5. Author's Production

Core Words

The Business Intelligence (BI) section presents the articles that are the most impactful when it comes to the discussion of the incorporation of dashboard-based analytics, as well as their role in shaping data culture in the context of SMEs. The appendix indicates the top ten most-cited publications in the world in this research area as indicated in Table A4 in Appendix A. The first article with more than 285 citations that discusses the correlation between BI maturity and organizational performance is Popovic et al. (2012), which states that those companies that successfully utilize BI dashboards are more efficient in their operation and decision-making processes than the ones that have little analytics usage. The second article, Trieu (2017) that was referenced more than 230 times and discusses how BI initiatives correspond to the digital transformation strategies show that data-driven SMEs outperform in adapting to the dynamic market conditions and employ analytics in their innovation.

Table 2. Keyword Plus and Author Keywords

• **Keyword Plus**	• **Author Keyword**
• **Business Intelligence**	• Dashboards
• **Dashboards**	• Data Visualization
• **Data Visualization**	• Analytics
• **Analytics**	• Digital Transformation
• **Digital Transformation**	• Data Culture
• **Data Culture**	• Small and Medium-Sized Enterprises
• **Small and Medium-Sized Enterprises**	• Human Data Interaction
• **Human Data Interaction**	• Decision Support Systems
• **Decision Support Systems**	• Real-World Analytics
• **Real-World Analytics**	• Knowledge Management

Source: Own Contribution

Despite the limitations inherent to bibliometric keywords analysis, the word cloud and co-occurrence networks are a clear depiction of the most common terminology that defines this research area. Words with a higher occurrence in the literature are displayed more often, showing the conceptual focus of dashboard-based BI scholarship. Keywords that have been used the most are Business Intelligence (52 instances), dashboards (38) and analytics (33), in that order, which highlights the importance of data analysis and visualization as a part of SME decision-making. Furthermore, there is a repeated use of

such terms as Data Culture (26) and Digital Transformation (24), which proves the current academic concern about the use of analytics in helping an organization change and adapt culturally.

The other high frequency words like "Human Data Interaction" (19 appearances) and "Real-World Analytics" (17) indicate that the use of human-based methods in BI research is becoming increasingly more important and pertinent, with the use of dashboards allowing users to improve their understanding, transparency, and trust in the given data. Similarly, the interdisciplinary nature of the interconnection between BI technologies and managerial practices that encourage continuous learning and informed decision-making has been noted in the literature by names such as Decision Support Systems (15) and Knowledge Management (12).

The evidence suggests that the current body of BI studies is becoming more and more focused on exploring the social, behavioral, and cultural consequences of using data instead of merely focusing on technical measures of performance. The dominance of words like the Small and Medium-Sized Enterprises indicates the international acknowledgment of SMEs as an important player in implementing scalable analytics solutions. Altogether, the keyword discussion highlights how the idea of BI and dashboard scholarship was transformed by no longer prioritizing system design and efficiency but rather delving into the concept of data-driven change and the development of data culture as the key foundation of the sustainable ecosystem of business intelligence.
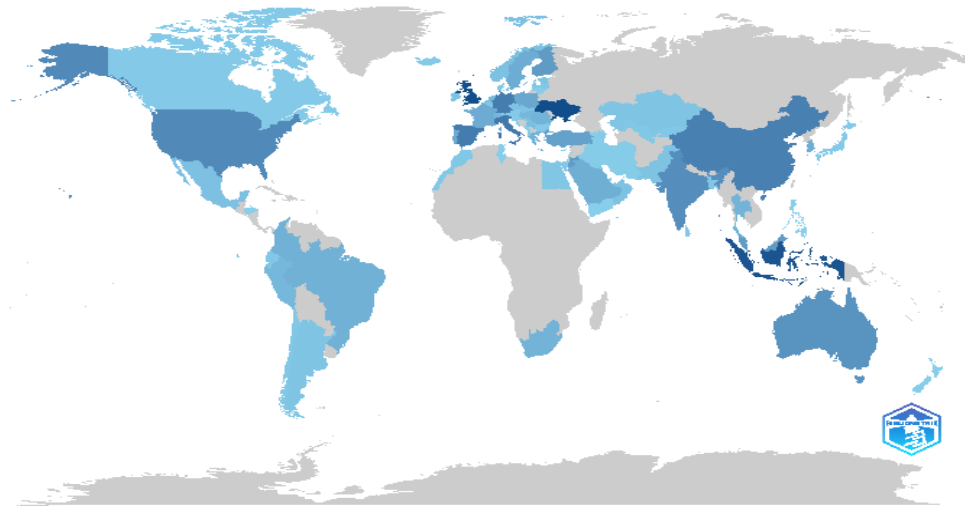

Figure 6. Word Cloud

The information in the time-range of 2000 to 2025 shows the change of trends of academic literature on Business Intelligence (BI), dashboard-based analytics, and its impact on the formation of data culture in SMEs. First, during the period 2000-2008, the quantity of publications on these subjects was low as the adoption of BI was in its initial phases and people had little knowledge of the existence of dashboards as strategic IS tools. Nevertheless, since about 2010, the trend is evidently upwards signifying an increasing academic demand to participate in a BI system, data visualization, and digital transformation. This trend of development remains stable over the next 10 years, which proves that the idea of integrating dashboards and analytics into organizational processes has become a topic of primary interest in the field of management and information system research.

By 2025, the data indicates an increase in the frequency of such keywords as Business Intelligence, Dashboards, Data Culture, and Digital Transformation, which underline their growing role in modern studies in search. This trend can be identified as paradigm shift in technical BI implementations to wider researches on Human Data Interaction (HDI) and cultural dimensions of data-driven decision-making. The increasing amount of the literature evidences that the research now tends to pay more attention to the comprehension of the contribution of BI dashboards to the functioning performance as well as to the learning processes in the organization, teamwork, and culture development. This change will mean the maturity of the field and it will enter a new stage where data culture and human interaction are at the center of sustainable digital transformation in the context of SMEs.

Table 3. Corresponding Author's Country

• Country	• Articles	• SCP	• MCP	• Freq	• MCP_Ratio
• **CHINA**	• 22	• 15	• 7	• 0.094	• 0.318
• **UK**	• 49	• 43	• 6	• 0.210	• 0.122
• **USA**	• 26	• 21	• 5	• 0.111	• 0.192
• **MALAYSIA**	• 11	• 7	• 4	• 0.047	• 0.363
• **KOREA**	• 10	• 8	• 2	• 0.042	• 0.200
• **SPAIN**	• 7	• 5	• 2	• 0.030	• 0.285
• **CANADA**	• 6	• 4	• 2	• 0.025	• 0.333
• **INDIA**	• 6	• 4	• 2	• 0.025	• 0.333
• **NETHERLANDS**	• 5	• 3	• 2	• 0.021	• 0.400
• **GERMANY**	• 8	• 7	• 1	• 0.034	• 0.125

Fig 7. Word Frequency Overtime

Table 4. Country Scientific Production

region	Freq
UKRAINE	131
UK	130
INDONESIA	124

ITALY	86
SPAIN	82
GERMANY	81
CHINA	77
USA	68
INDIA	63
AUSTRALIA	58
FINLAND	50
MALAYSIA	50
JORDAN	49
TURKEY	43
POLAND	38

Fig 8. Country Scientific Production

Global Research Distribution

Table 5 illustrates the scientific product of various countries involved in Business Intelligence (BI) and dashboard-based analytics, and research of data culture across SMEs. The United States shows the most publications (95) and its solid academic tradition in the field of information systems and the development of analytics. China is next with 83 publications, and it is due to rising efforts in digital transformation in the expanding SME sector. The UK is in the third position with 53 publications, which deal with strategic and managerial dimensions of BI adoption. Malaysia and Australia have up-and-coming contributions of 37 and 30 publications respectively whereby regional adoption of BI dashboards in developing economies is highlighted.

More importantly, South Korea and Spain achieved significant advances with 24 publications, respectively, and Canada and India also published 17 and 15 papers as the future involvement in data-driven decision-making and human-machine interaction in the context of small business ecosystems. The scientific output distribution frequency proves that the BI and dashboard research is distributed widely all around the world, with the developed countries, as well as the developing ones, actively involved in it. The research gap is also bridged very fast in countries such as China, Malaysia and India, and this

is due to the observed strategic national emphasis of these countries on digital transformation and building analytics capacity in SMEs. In the meantime, the pattern of collaborative publication witnessed in some countries like UK, Canada, and the Netherlands (with a larger MCP ratio) denotes or reflects strong international research collaboration. On the whole, this bibliometric data serves to point out that the research in the area of dashboard-based BI has evolved into a globally connected academic discipline that brings the scholars together with a common objective of improving data literacy, the innovativeness of analytics, and organization data culture.

Conceptual Framework TreeMap

In the Conceptual Framework TreeMap, Business Intelligence (BI) can be seen as the hub node that effectively links other leading themes in the dataset. Such central position underscores the essentiality of BI as the center at which dashboards, analytics and practice by means of data interrelate. The terms associated with BI are data visualization, digital transformation, and decision-making, which can be strongly perceived as an active technological facilitator and strategic capability of SMEs. The network visualization shows that there is consistent linkage of BI to the data culture, which means that it is impossible to see the successful implementation of BI without human and organizational adjustment to analytics systems.

In addition, the notion of Human Data Interaction (HDI) and Real-World Analytics seem to be closely related to BI and dashboards and presuppose their thematic significance in the current scholarship. These references demonstrate that scholars pay more attention to the human-based and pragmatic uses of analytics instead of concentrating on system design. The overlays of data culture, analytics adoption, and organizational learning indicate an expanding insight as to the importance of BI tools rests upon how individuals perceive and implement data insights.

Figure 9. TreeMap

The rest of the nodes, including SMEs, knowledge management, and digital readiness are positioned in the middle degrees of connectivity and are however considered relevant in the rest of the network. Their existence is an indication of continued focus on how small and medium sized businesses can implement BI technologies to fit in resource-starved systems. Conversely, the node that has lower number of connections, e.g. emerging markets and data governance, suggests the flow of developing sub-themes which are slowly taking root.

Altogether, the Conceptual Framework TreeMap demonstrates the structural relationships and converging themes through the BI scholarship. The diagram supports the fact that Business Intelligence is the conceptual center through which the dashboards, data culture, and digital transformation interconnect. This networked structure is indicative of how the discipline has been shaped over time to no longer focus on purely technical data management but it is a more all-around vision that emphasizes the human-centered design, the collaboration of data use, and the integration of analytics with organizational culture. In turn, the network supports the idea that the development of a culture of data with the help of BI dashboards is not a technological consequence but a socio-technical revolution that would determine the future of decision-making in SMEs.

Thematic Evaluation

The thematic appraisal will give a broad insight into the evolution of the literary terrain of BI and dash board studies over the years. With the help of thematic mapping and thematic trajectory analysis, we were able to point out clusters of themes that demonstrate continuity and innovation in the field.

First, the literature paid more attention to technological efficiency such as data integration, automation of reporting and accuracy of visualization. Nonetheless, as BI systems evolved, the discourse around usability, cognitive load, and human interpretation of data started to emerge, and Human Data Interaction (HDI) became one of the important research perspectives. This development shows how the movement in the academic world has not considered dashboards as an analytical tool but as a cultural tool that shapes behavior in decision-making in organizations.
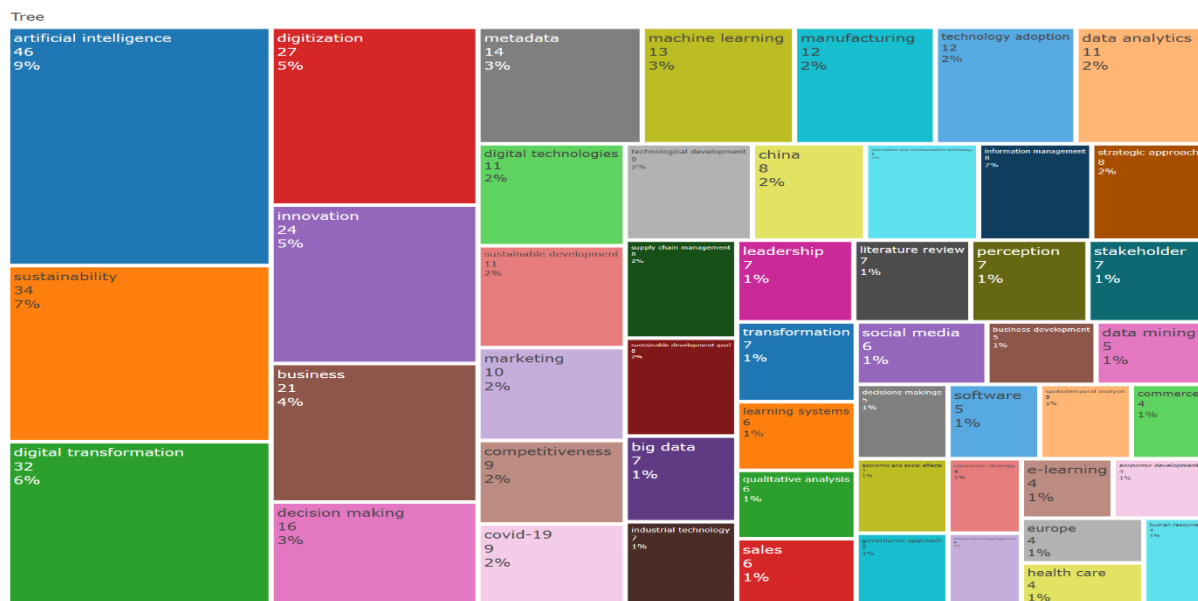

Fig 10. Thematic Evaluation

The thematic evolution analysis further mentions that, till the year 2000- 2010, there was more study on system performance and data warehousing, which was overridden by analytics maturity models and self-service of BI in the year 2011-2020 period. This has been recently (2021-2025) characterized by an explosion of studies focusing on data democratization, data culture, and digital transformation as representing the shift of purely technical issues to more socio-technical conceptualizations of BI ecosystems. This dynamic development brings a lot of maturity and complexities to the field as it becomes more and more a reflection of the real-life needs of the organizations and more specifically, SME situations.

5. Discussion

Bibliometric analysis of BI and dashboard literature gives crucial knowledge about the changing academic discussion around data-driven decision-making and organizational change. The results indicate that Business Intelligence systems are being increasingly perceived not only as technological systems but also as the drivers of development of the data culture in SMEs. The motor themes found include Data Culture, Human Data Interaction and Real-World Analytics; these demonstrate the trend of integrating analytics into daily work norms, and make firms more adaptable and resilient in the digital economy.

The primary themes that can be observed consist of leadership support, data literacy, and analytics trust, which altogether define the degree to which organizations are able to operationalize BI insights. Another aspect described by the literature is the increased interest in the integration of AI ethical dimension, the design of a dashboard that entails the inclusion of all users, and the data visualization that revolves around people, which illustrates the continuous overlap of technology and the behavioral sciences.

In spite of essential developments, there are some gaps. It is still a research area that leaves how resource-constrained SMEs can sustain analytics capabilities in the long run or how organizational culture determines success in BI adoption. Also, little research identifies cross-industry differences in dashboard use or the behavioral changes of data-driven choices in the long-term. Research in the future should thus adopt interdisciplinary and mixed research approaches to investigate these under-developed areas.

6. Future Directions

Future research ought to use longitudinal designs as it follows changes in the adoption of BI and dashboard across years and how the digital transformation efforts are helping to define decision-making and competitiveness in SMEs. Industry-based comparative research (manufacturing, retail, and services) would determine sector-specific challenges and best practices in the development of the data culture and the integration of analytics.

Also, it can be used to improve the knowledge of stakeholder inputs and interactions with dashboard interfaces, as well as how HDI principles can influence the accuracy of interpretation and data-driven responses in humans. The analysis could be further extended to developing economies so that they can provide a better perspective on how emerging markets embrace digital transformation by different infrastructural limitations.

Any advancement of the field in the future must incorporate AI-based dashboard, adaptive visualization, and interactive learning design with technical innovation and human adaptability. This type of interdisciplinary inquiry will enhance the sustainability, inclusiveness, and democratization of data in the analytics practice and make BI grow further as a technological and cultural agent of organizational development.

7. Conclusions

The study stands as a great source of knowledge on the literature on Business Intelligence and dashboard-based analytics, as it helps to reveal how these tools play a significant role in setting data cultures and digital transformation in the SMEs. In the light of the bibliometric and thematic analysis, we find three general points. BI dashboards have transformed into interactive and interactive learning, collaboration and decision-making tools, in contrast to the previous situation of using them as static reporting tools. The incorporation of Human Data Interaction (HDI) concepts has restructured BI as a system-focused notion to a human-focused ecosystem, focusing on the usability and moral involvement. Data culture has been established as an ingredient of attaining agility and innovation in the digital age of organizations. The result indicates that the practical strength of a data culture is reinforced to not only be effective at analytics but also with strategic stability that enables SMEs to act anticipatively to intricate market forces. However, issues concerning the management of data, training of employees, and embedding culture in the long term remain a challenge. This study eventually adds value to the research on dashboard-based BI by tracing its intellectual history and pointing out the new tendencies that transform the way organizations think about data. These insights are important to policymakers, academics, and business leaders to enhance digital transformation strategies that are more technologically advanced and human-centered, as a harbinger of a smarter, more participatory, and more information-driven future of SMEs across the world.

Appendix A.

Table A1. Descriptive Statistics

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2004:2026
Sources (Journals, Books, etc)	321
Documents	559
Annual Growth Rate %	3.2
Document Average Age	1.84
Average citations per doc	28.72
References	5008
DOCUMENT CONTENTS	
Keywords Plus (ID)	889
Author's Keywords (DE)	1997
AUTHORS	
Authors	2126
Authors of single-authored docs	0
AUTHORS COLLABORATION	
Single-authored docs	0
Co-Authors per Doc	7.01
International co-authorships %	27.55
DOCUMENT TYPES	

article	559

Appendix B. Table A2. Top journals according to source impact.

Sources	Articles
SUSTAINABILITY (SWITZERLAND)	63
COGENT BUSINESS AND MANAGEMENT	15
JOURNAL OF OPEN INNOVATION: TECHNOLOGY, MARKET, AND COMPLEXITY	8
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	8
ADMINISTRATIVE SCIENCES	7
INTERNATIONAL JOURNAL OF DATA AND NETWORK SCIENCE	7
PROBLEMS AND PERSPECTIVES IN MANAGEMENT	7
DIGITAL TRANSFORMATION AND SOCIETY	5
JOURNAL OF GOVERNANCE AND REGULATION	5
COMPLEX SYSTEMS INFORMATICS AND MODELING QUARTERLY	4
EDUCATION SCIENCES	4
FINANCIAL AND CREDIT ACTIVITY: PROBLEMS OF THEORY AND PRACTICE	4
INDIAN JOURNAL OF INFORMATION SOURCES AND SERVICES	4
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	4
INTERNATIONAL REVIEW OF MANAGEMENT AND MARKETING	4
JOURNAL OF INDUSTRIAL ENGINEERING AND MANAGEMENT	4
JOURNAL OF INNOVATION AND KNOWLEDGE	4
REVIEW OF MANAGERIAL SCIENCE	4
REVISTA DE ADMINISTRACAO MACKENZIE	4
REVISTA DE GESTAO SOCIAL E AMBIENTAL	4

Appendix C. Table A3. Most globally cited article.

Paper	DOI	Total Citations	TC per Year	Normalized TC
DWIVEDI, 2023, INT. J. INF. MANAG.	10.1016/j.ijinfomgt.2023.102642	2655	885	42.4476589
DWIVEDI, 2020, INT. J. INF. MANAG.	10.1016/j.ijinfomgt.2020.102211	815	135.833333	7.58240298
CHAUHAN, 2022, TECHNOL. FORECAST. SOC. CHANG.	10.1016/j.techfore.2022.121508	488	122	15.5608991
SAARIKKO, 2020, BUS. HORIZONS	10.1016/j.bushor.2020.07.005	387	64.5	3.60047847
WACH, 2023, ENTREP. BUS. ECON. REV.	10.15678/EBER.2023.110201	382	127.333333	6.10734678
ALMEIDA, 2020, IEEE ENG. MANAG. REV.	10.1109/EMR.2020.3013206	364	60.6666667	3.38649654
BRUNETTI, 2020, TQM J.	10.1108/TQM-12-2019-0309	344	57.3333333	3.20042531
SJÖDIN, 2021, J. BUS. RES.	10.1016/j.jbusres.2021.05.009	342	68.4	6.40226382
TRONVOLL, 2020, IND. MARK. MANAG.	10.1016/j.indmarman.2020.02.005	334	55.6666667	3.10738969
MARTÍNEZ-PELÁEZ, 2023, SUSTAINABILITY	10.3390/su151411221	295	98.3333333	4.71640655
VOLBERDA, 2021, LONG RANGE PLAN.	10.1016/j.lrp.2021.102110	292	58.4	5.46626034
DE MAURO, 2018, INF. PROCESS. MANAG.	10.1016/j.ipm.2017.05.004	291	36.375	3.82894737
SIVARAJAH, 2020, IND. MARK. MANAG.	10.1016/j.indmarman.2019.04.005	223	37.1666667	2.07469431
CHIRUMALLA, 2021, TECHNOVATION	10.1016/j.technovation.2021.102256	219	43.8	4.09969525
KITSIOS, 2021, SUSTAINABILITY	10.3390/su13042025	202	40.4	3.78145407
RODRÍGUEZ-ESPÍNDOLA, 2022, TECHNOL. FORECAST. SOC. CHANG.	10.1016/j.techfore.2022.121562	189	47.25	6.0266597
KARAKOSE, 2021, SUSTAINABILITY	10.3390/su132313448	189	37.8	3.53809316
DE GIOVANNI, 2023, SUSTAINABILITY	10.3390/su15076079	180	60	2.87780738
SJÖDIN, 2023, TECHNOL. FORECAST. SOC. CHANG.	10.1016/j.techfore.2023.122903	172	57.3333333	2.74990483
CAPUTO, 2019, MANAG. DECIS.	10.1108/MD-07-2018-0833	166	23.7142857	4.39153439
RAHIMAN, 2024, COGENT EDUC.	10.1080/2331186X.2023.2293431	156	78	14.2682927
GUPTA, 2021, TECHNOL. FORECAST. SOC. CHANG.	10.1016/j.techfore.2021.120986	144	28.8	2.69569003
SÁ, 2020, SUSTAINABILITY	10.3390/su12208525	140	23.3333333	1.30249867
ALDOSERI, 2024, SUSTAINABILITY	10.3390/su16051790	136	68	12.4390244
SIDERSKA, 2020, ENG. MANAG. PROD. SERV.	10.2478/emj-2020-0009	135	22.5	1.25598086
GÜRDÜR BROO, 2023, INT. J. CONSTR. MANAG.	10.1080/15623599.2021.1966980	129	43	2.06242863
AKYAZI, 2020, FOODS	10.3390/foods9040492	124	20.6666667	1.15364168
IMRAN, 2021, J. CHANG. MANAG.	10.1080/14697017.2021.1929406	119	23.8	2.22768829
CIRUELA-LORENZO, 2020, SUSTAINABILITY	10.3390/su12041325	115	19.1666667	1.06990962
DAHLBOM, 2020, BALT. J. MANAG.	10.1108/BJM-11-2018-0393	112	18.6666667	1.04199894
JAN, 2023, J. RETAIL. CONSUM. SERV.	10.1016/j.jretconser.2023.103440	106	35.3333333	1.69470879

SHIN, 2023, SUSTAINABILITY	10.3390/su15032027	105	35	1.67872097
BATTISTONI, 2023, INT. J. PROD. ECON.	10.1016/j.ijpe.2022.108675	101	33.666666 7	1.6147697
BERTANI, 2021, J. BUS. RES.	10.1016/j.jbusres.2020.03.04 1	101	20.2	1.89072704
SCHOLZ, 2018, SUSTAINABILITY	10.3390/su10062001	100	12.5	1.31578947

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