

From Risk to Resilience: How Artificial Intelligence Transforms Internal Control Systems for Sustainability

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Abstract

Purpose

This study aims to examine the publishing trends on how artificial intelligence transforms internal control system for sustainability. Moreover, this paper explores the relationship between the research constituents using science mapping techniques and the role of artificial intelligence in transforming internal control systems.

Design/Methodology/Approach

Data has been extracted from the Scopus database using a bibliometric approach. To gather pertinent information, a comprehensive search strategy was designed. Data analysis has been performed using Excel, Bibliometric R studio biblioshiny package.

Findings

The findings of this study indicate a growing academic interest in research on Artificial Intelligence and internal control systems over the past few years. It also helps to understand about sustainable practices by integrating artificial intelligence with internal control system.

Research limitations/implications

The reliance on a single database for literature retrieval may limit the study's comprehensiveness, as some relevant studies may not be indexed in this database.

Practical implications

The qualitative insights generated by this study will empower education administrators to make data-driven decisions.

Originality/value

This study provides a comprehensive review of the current research landscape on AI in Internal Control System, identifying knowledge gaps and outlining a future research agenda to advance the field.

Keywords: Artificial Intelligence, Internal Control System, Sustainability, Internal Audit

1. Introduction

Under the rapidly changing business environment today, drastic growth occurs in the following aspects in corporate activities towards the risks of ensuring reliability of reporting, ensuring compliance and ensuring operation of internal control system. Amidst increasingly interconnected, volatile and commonly scrutinized global markets, and greater demands for environmental, social and governance (ESG) practices, companies are under pressure to strengthen their internal controls. Conventional methods for risk management are frequently not adequate in tackling these dynamic challenges, not least because they have to deal with ever-rising regulatory requirements and stakeholder demands for sustainability.

That's where technology comes in – and artificial intelligence (AI), specifically, as a game-changer for how companies tackle risk management and internal controls. The ability for AI to process large amounts of data, identify patterns, and learn from past events make it a key enabler in the development and implementation of more flexible, adaptable and predictive internal control systems. These AI driven systems can reduce risk and promote resilience, ensuring there is continuous oversight, real-time decision-making, as well as the ability to predict— which is ultimately indispensable for companies that seek profitable and sustainable practices.

The paper delves into the confluence of AI and internal control systems and discusses how AI is reforming risk management practices to enable implementation of resilience within organizations in response to constantly changing sustainable development needs. It explores how AI technologies such as machine learning, natural language processing, and data analytics are reshaping internal control systems to advance more than just compliance: value creation over time. Considering the growing AI involvement in business procedures, it is important to appreciate how the use of AI changes the position of internal controls from a reactive to proactive and sustainable posture by this being an added value of business activities.

The paper will also explore role of AI can play in helping to detect, address and predict risks surrounding ESG issues as well as in improving the effectiveness and efficiency of internal controls. But by bringing a more holistic approach to risk management, AI has the potential to not only help protect against short-term risks, but also help create a culture of sustainability and long-term resilience that would make organizations far more capable of facing challenges that lie ahead.

Based on a systematic review of the emergence of AI in internal controls, this study intends to provide valuable observations that allow enterprises to capitalise on AI to enable a more resilient, transparent, and sustainable future. The ascent of AI in internal controls is not just a new tech “thing but more of a change in the mindset regarding risk and resilience for organizations. To date, internal control processes have been developed to identify and address risks, often using inflexible manual processes that are reactive and backward-looking. Read More These types of systems often struggle to anticipate new threats or hidden risks, which means that businesses are at risk for potential business interruptions, particularly in regard to sustainability threats like climate change, resource constraints and evolving regulations.

With its capacity to process immense amounts of data and the capability to recalibrate on the fly, AI brings a proactive and, dare I say, a dynamic capability to risk management. Organizations can then go beyond the definition of internal controls in the traditional sense and predict and prevent threats before they are actualized. Leveraging AI to analyze past patterns, evaluate emerging risks, and track intricate webs of relationships both inside and outside the company, internal controls can thus be more adaptive, data-based, and forward-looking.

Moreover, artificial intelligence within internal control systems can effectively improve the organization's sustainability compliance capability. With pressure from stakeholders including investors, customers and the public sector on businesses to become more sustainable, AI can be a great tool to measure the social and environmental impact of operations. Companies can use AI algorithms to enhance monitoring and reporting, so they can comply with regulations and keep to their own sustainability objectives. For instance, AI can monitor carbon footprints, manage energy consumption, or find out where waste reduction measures can more efficiently be implemented considering stringent internal controls in order to adhere to sustainability standards.

In addition, AI allows internal control systems to move beyond financial risk, covering a more comprehensive range of risks, such as those related to sustainability and corporate accountability. In our increasingly connected world, companies that fail to meet environmental and social, governance (ESG) obligations can be just as dangerous to your portfolio as financial risks. That means AI can monitor a variety of indicators like ethical supply chains, labor practices and impact on the environment to give an organization a much more complete picture of how they are exposed. The result is a more cohesive company, better equipped to withstand both known and unknown challenges while working to be in business for the long haul.

This AI integration in turn allows for an ongoing enhancement of internal controls. AI systems can assist in pinpointing possible inefficiencies, deficiencies, or weaknesses in the current control system, via machine learning and predictive analytics. This in turn, allows them to suggest changes or enhancements, promoting an atmosphere of innovation and adaptability. This constant feedback loop strengthens the overall efficacy of the internal control system to ensure that it continues to be robust to the changing risk landscape.

"But on the flipside of AI's huge promise are serious challenges." We cannot underestimate the ethical issues involving and concerning the use of AI, especially when it comes down to data privacy, transparency, and bias. Further, as AI-enabled systems are being adopted, a strategic perspective to governance is required to ensure that these are in accordance with organization values and regulatory requirements, as appropriate. Therefore, the project will also investigate the issues and considerations that arise when implementing AI in internal control systems, such as the significance of ethical AI approaches, good governance mechanisms, and human control.

In summary, AI is an enabler of ICS evolution that will move organization from a reactive approach to risk to a more proactive, predictive and resilient one. The technology's ability to process vast amounts of data, identify emerging risks and promote sustainability-oriented decisions is fundamentally altering how businesses view risk and control. The Future, Today As companies struggle to get a handle on the complex risk and control environment we operate in today, AI presents us with the promise of a future where the systems that we put in place for compliance can actually be a driver of significant, long-term value and growth. This whitepaper will look specifically at how AI can accelerate this transformation and provides a blueprint for businesses that wish to leverage its promise to help create a more resilient, sustainable world.

Guiding Research Questions:

1. How artificial intelligence with internal control systems developed chronologically over the past decade?
2. Who are the most influential researchers and institutions shaping AI research in [internal control system](#)?
3. What dominant themes have shaped artificial intelligence integrated with internal control systems, and how have they evolved?
4. What emerging research trends in internal control system and artificial intelligence?

This study seeks to analyze the chronological development of how artificial intelligence transforms internal control system for sustainability, identify key contributors, and uncover dominant and emerging themes. The findings will contribute to academic discourse and inform practical strategies for leveraging artificial intelligence to enhance institutional resilience and align with the dynamic needs of auditors and professionals.

2. Theoretical Framework

Theory of Resilience

Resilience theory, and especially from the field of organizational studies, is aimed at analyzing the capability of an organization to sustain and recover from major disruptions. Resilience is also emerging as an important part of sustainable business, particularly in a world of constantly evolving regulatory requirements, economic conditions, and societal demands. Artificial intelligence (AI) facilitates organizational resilience by providing the capability for predictive modeling, scenario analysis, and real-time adjustment.

Relevance to Internal Control: AI enables organizations to be more capable of responding to disruptions, as well as more able to anticipate them. AI models may, for example, simulate the effect of various risk scenarios on the internal controls and offer guidance to decision makers' what's the right course of action to guard against them. By making this shift, internal control systems can shift from reactive to proactive, designed to build for, not just brave, known and unanticipated hurdles.

Sociotechnical Systems Theory

Sociotechnical systems theory focuses on the interaction of people, technology, and the organizational environment. It implies that effective systems are those which harmonise both the social (human) and technical (machine) aspects. In relation to AI and internal control systems, this theory highlights the need for controlling that AI technologies are not only technically reliable but also in sync with organizational culture, values and human decision making.

Relevance to Internal Control There is a necessity for the design of AI systems to be such that it preserves at least the potential for human oversight and intervention. When using AI in internal control systems, the improvement of efficiency is not the sole quest; human elements like the demand for transparency, the human accountabilities, or ethical decision-making are important. The AI system can support human managers but not replace them, which still have more accurate prior information for their decision making and control operations.

3. Methodology

This study leverages bibliometric analysis to investigate the scientific literature on Artificial intelligence and internal control systems, utilizing data from Scopus, a premier database for scholarly publications. A comprehensive analysis is ensured through the combined application of Biblioshiny with R. This integrated approach enables a robust examination of both quantitative and relational aspects of the literature, providing a panoramic view of research progress, trends, and key contributors in this field.

3.1. Research Design

This study employs bibliometric analysis to investigate research trends and patterns in artificial intelligence and internal control system. As a quantitative research method, bibliometric analysis examines scientific literature using metrics such as publication trends, citation patterns, and collaboration networks (Zupic & Čater, 2015). This approach provides a comprehensive overview of the field's development, revealing influential works, key themes, and emerging trends (Donthu et al., 2021). Through bibliometric analysis, this study aims to elucidate the evolution of artificial intelligence and internal control system, identify prominent contributors, and uncover dominant research themes.

This study utilizes a uni-tool approach, combining Biblioshiny, to perform a comprehensive bibliometric analysis. This integrated methodology captures both quantitative metrics and relational aspects of the scientific literature, aligning with established bibliometric protocols (Choudhary & Awasthi, 2018).

3.2. Data Collection

To ensure a focused and systematic approach, data were collected from Scopus, a comprehensive database known for its extensive coverage of peer-reviewed academic literature. This study was conducted using publicly available Scopus data. No ethical approval was required as no human subjects or confidential data were involved. The search was conducted using the following advanced query:

TITLE-ABS-KEY ("Internal control system" OR "audit" OR "auditing" AND "efficiency" OR "sustainability" OR "sustainable development goals" OR "ai" OR "artificial intelligence" OR "big data analytics") AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (OA , "publisherfullgold") OR LIMIT-TO (OA , "publisherhybridgold") OR LIMIT-TO (OA , "repository"))

This search strategy ensured that only documents containing both “Internal Control System” and “sustainability” and “artificial intelligence” in their title, abstract, or keywords were retrieved. The inclusion criteria applied are detailed in **Figure 1**.



Figure 1. Search strategy and inclusion criteria

This structured search initially retrieved 163 documents, consisting of journal articles. To refine the dataset, a systematic screening process was applied based on specific inclusion and exclusion criteria, ensuring alignment with the research focus on CRM applications in higher education (HE), particularly in student engagement, alumni relations, and organizational engagement. To ensure the relevance of the selected studies, a systematic screening process was applied based on specific inclusion and exclusion criteria, as shown in **Table 2**.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Document Types	Journal articles, book chapters and books	Conference papers, presentations
Relevance	and Studies explicitly focussing on CRM strategies in HE, especially academic achievement, technology-enabled change	Studies examining commercial CRM applications in non-educational settings
Publication period	1981-2025	Studies published before 1981
Language	English	Non-English studies
Availability	Full-text articles for detailed investigation	Studies with restricted access or incomplete full-text content

4. Analysis and Finding

4.1 Main Information

This dataset spans over four decades, from 1981 to 2025, and comprises 163 documents sourced from 121 journals, books, and other publications. The dataset has grown at an annual rate of 3.73%. The average age of the documents is 9.53 years, with an average of 25.74 citations per document. The dataset includes 327 Keywords Plus (ID) and 631 Author's Keywords (DE), indicating a diverse range of topics and themes. A total of 431 authors contributed to the documents, with 28 authors publishing single-authored documents. The average number of co-authors per document is 2.81, and 10.43% of the documents feature international co-authorships. The majority of the documents (163) are articles.

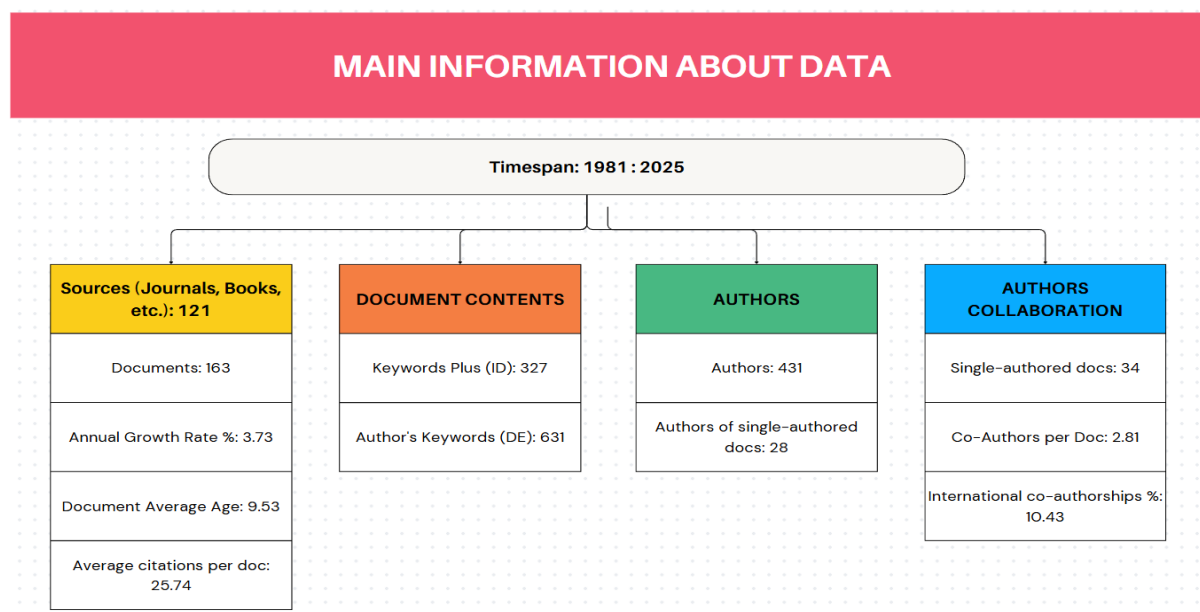


Figure.2: Main information about bibliometric data Source: Analysis Output from Biblioshiny

4.2. Annual Scientific Production

The dataset reveals a steady growth in publications over the years, with a noticeable surge in recent years. The first article was published in 1981, followed by a long gap until 1995, when another article was published. The early 2000s saw a gradual increase in publications, with 1-3 articles per year. However, from 2005 onwards, the number of publications increased significantly, with an average of 6-8 articles per year. The years 2018-2025 saw the highest number of publications, with 10-15 articles per year. As of 2025, the total number of articles published is 163.

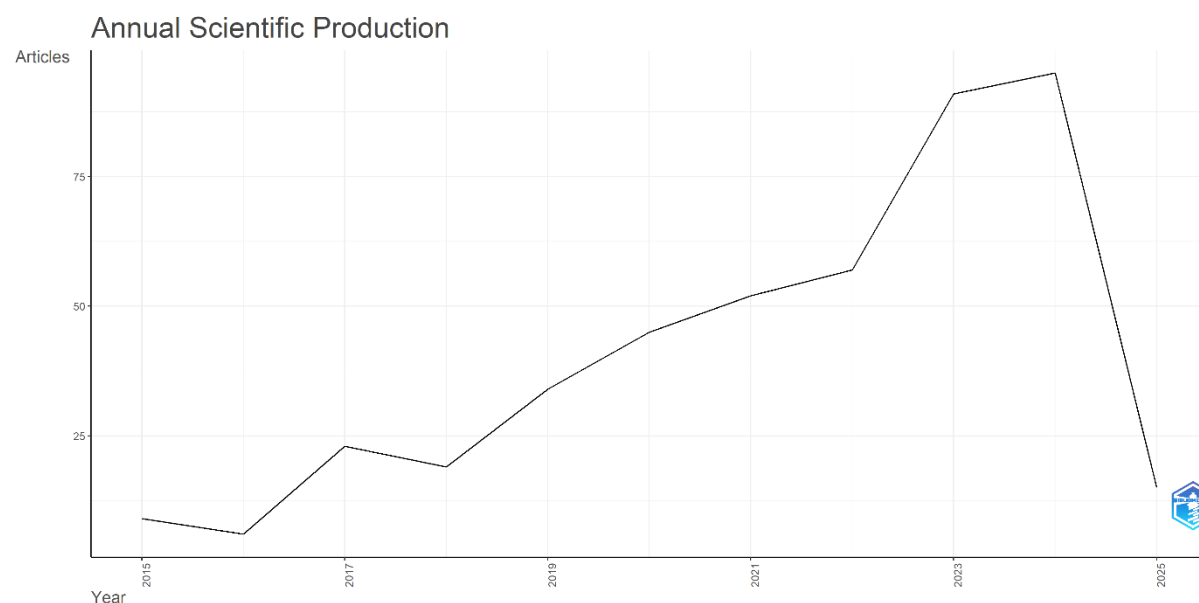


Figure 3: Annual Scientific Production (Source: Analysis Output from Biblioshiny).

4.3. Citation Trends

The data reveals a fluctuating trend in citation counts over the years. The average citations per article (MeanTCperArt) ranged from 0 (2025) to 133.67 (2003). The total citations per year (MeanTCperYear) also varied, with the highest being 5.95 (2007) and the lowest being 0 (2025). The number of citable years increased steadily from 1 (2025) to 45 (1981). The data suggests that the citation impact of articles in this field has decreased in recent years, with a notable decline in average citations per article and total citations per year since 2018.

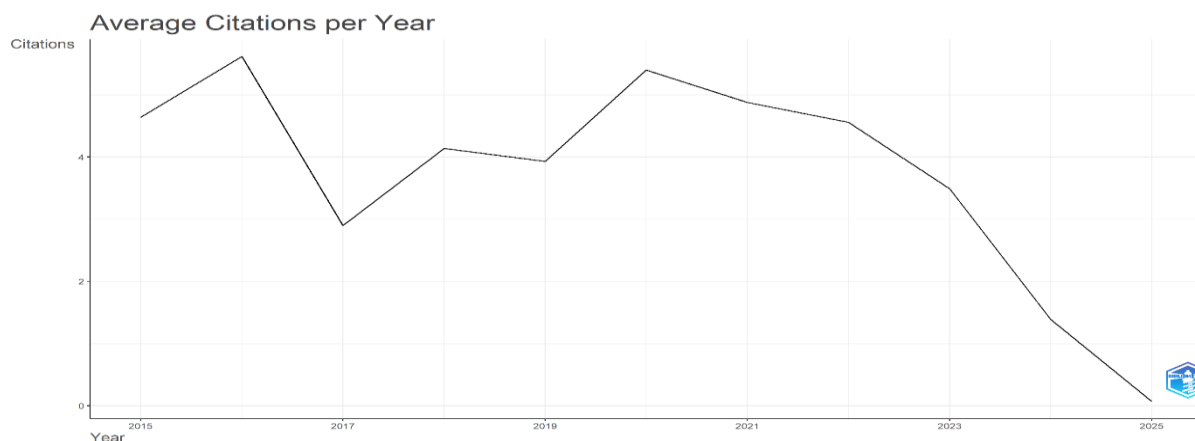


Figure 4: Citation Trends (Source: Analysis Output from Biblioshiny).

4.4. Most Relevant Sources

The data comprises 163 articles published across 121 sources, including journals, books, and other publications. The top 5 sources with the highest number of articles are Business Horizons (6), Cogent Business and Management (6), Journal of Retailing (5), Electronic Markets (4), and Journal of Consumer Marketing (4). The remaining sources have fewer than 4 articles each, with 76 sources contributing only 1 article to the dataset.

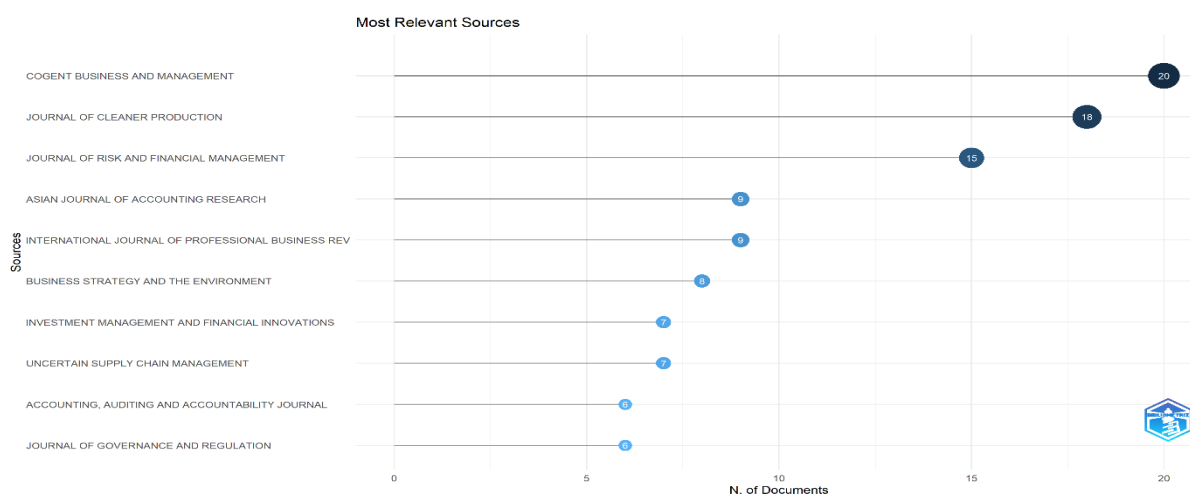


Figure 5: Most Relevant Sources (Source: Analysis Output from Biblioshiny).

4.5. Most Relevant Authors

The data comprises 296 articles written by 248 unique authors. The top author, SMITH AD, contributed 5 articles, while 221 authors contributed only 1 article each. The remaining 26 authors contributed between 2 and 4 articles. The data suggests a significant presence of single-article authors, with a small number of authors contributing multiple articles.

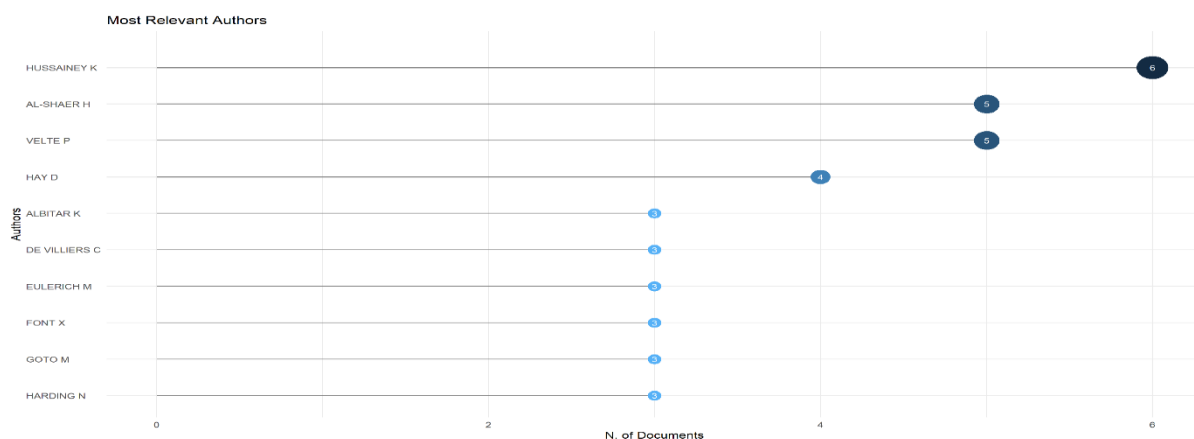


Figure 6: Most Relevant Authors (Source: Analysis Output from Biblioshiny).

4.6. Most Relevant Affiliations

The data comprises 296 articles affiliated with 163 unique institutions worldwide. The top 5 institutions with the highest number of articles are Universiti Teknologi Malaysia (UTM) (10), Queens University (9), Western University (8), Colorado State University (7), and National University Jorge Basadre Grohmann (6). The remaining institutions have fewer than 6 articles each, with 134 institutions contributing only 1 or 2 articles. This suggests a diverse range of institutional affiliations, with a small number of institutions contributing a larger number of articles.

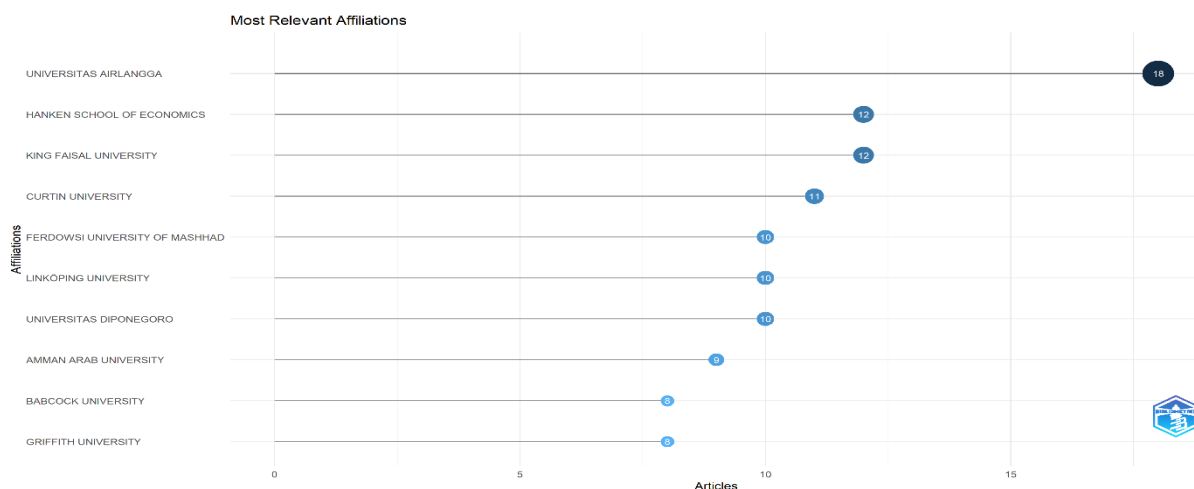


Figure 7: Most Relevant Affiliations (Source: Analysis Output from Biblioshiny).

4.7. Corresponding Author's Countries

The data comprises 163 articles from authors affiliated with institutions in 43 countries. The United States has the highest number of articles (40), followed by the United Kingdom (11), India (8), Canada (5), China (5), Australia (4), Indonesia (4), Iran (4), and Pakistan (4). The remaining countries have fewer than 4 articles each, with 23 countries contributing only 1 article. In terms of multi-country publications (MCP), the United Kingdom has the highest percentage (36.4%), followed by Korea (100%), Romania (100%), Saudi Arabia (100%), and United Arab Emirates (100%).

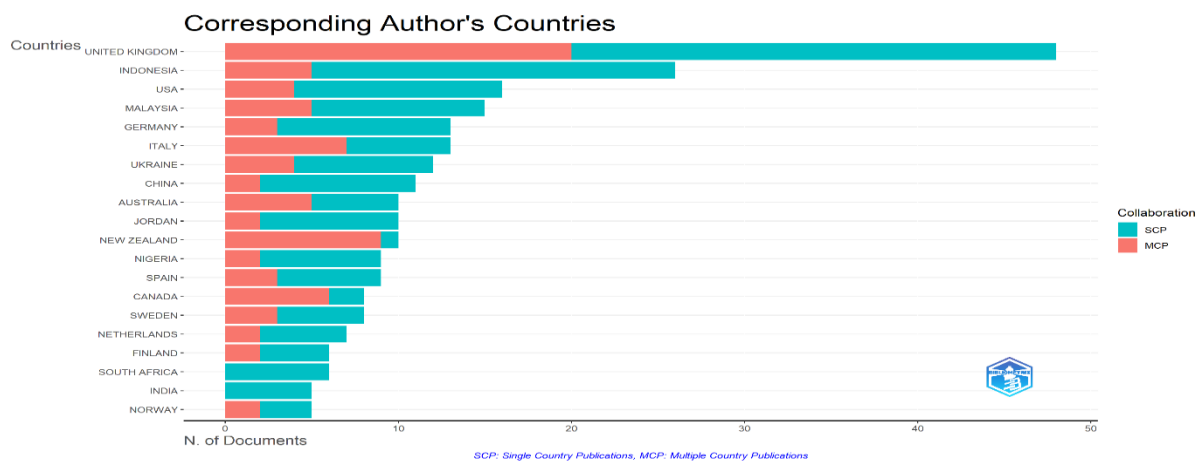


Figure 8: Corresponding Author's Countries (Source: Analysis Output from Biblioshiny)

4.8. Country Scientific Production

The data comprises institutions from 43 countries, grouped into regions. The most represented regions are North America (USA: 131, Canada: 25), Asia (India: 30, Indonesia: 21, Iran: 19, China: 16, Malaysia: 12), and Europe (UK: 35, Italy: 13, Finland: 10, Germany: 10, Austria: 6, Spain: 6, Netherlands: 5). Other regions include Oceania (Australia: 13), South America (Peru: 10, Brazil: 6), and Africa (South Africa: 2, Kenya: 2, Ethiopia: 2, Egypt: 1).

Country Scientific Production

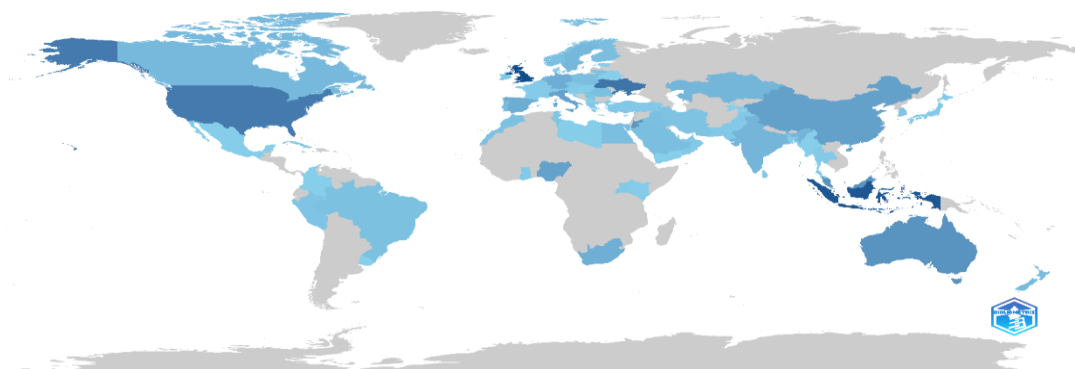


Figure 9: Country Scientific Production (Source: Analysis Output from Biblioshiny)

4.9 Most Cited Countries

The data comprises article citations from 43 countries. The United States has the highest total citations (2043) with an average of 51.1 citations per article. France has the highest average article citations (134.5), followed by Ireland (32), Korea (26), and Bosnia (22). Other countries with notable total citations include the United Kingdom (294), Germany (152), Australia (96), and India (82). The remaining countries have fewer than 50 total citations each.

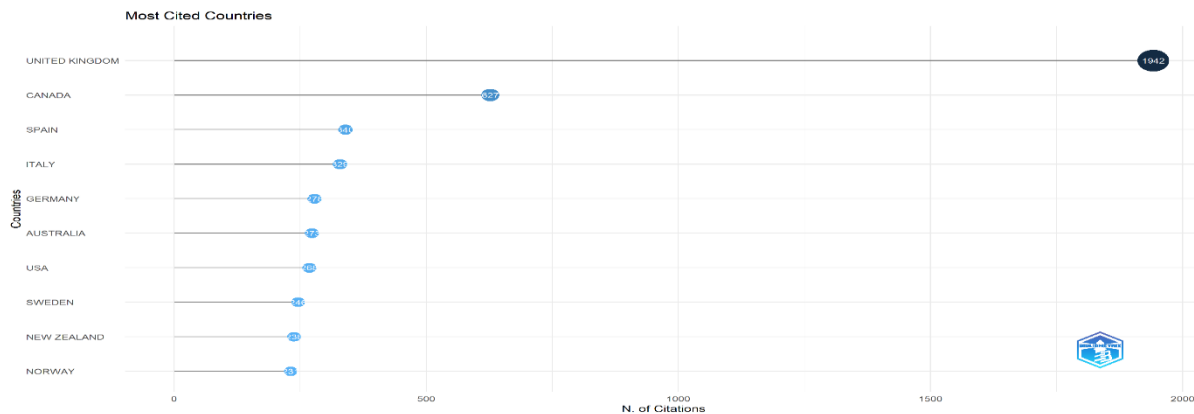


Figure 10: Most Cited Countries (Source: Analysis Output from Biblioshiny)

4.10 Most Relevant Words

The data comprises 296 articles with a total of 430 keywords. The top 10 most frequent keywords are: human (13), female (11), male (11), adult (10), humans (10), article (8), education (7), students (7), clinical competence (6), and internet (6). Other notable keywords include simulation training, Canada, curriculum, emergency medicine, medical education, and resuscitation. The data also reveals a diverse range of topics, including healthcare, education, technology, business, and social sciences.

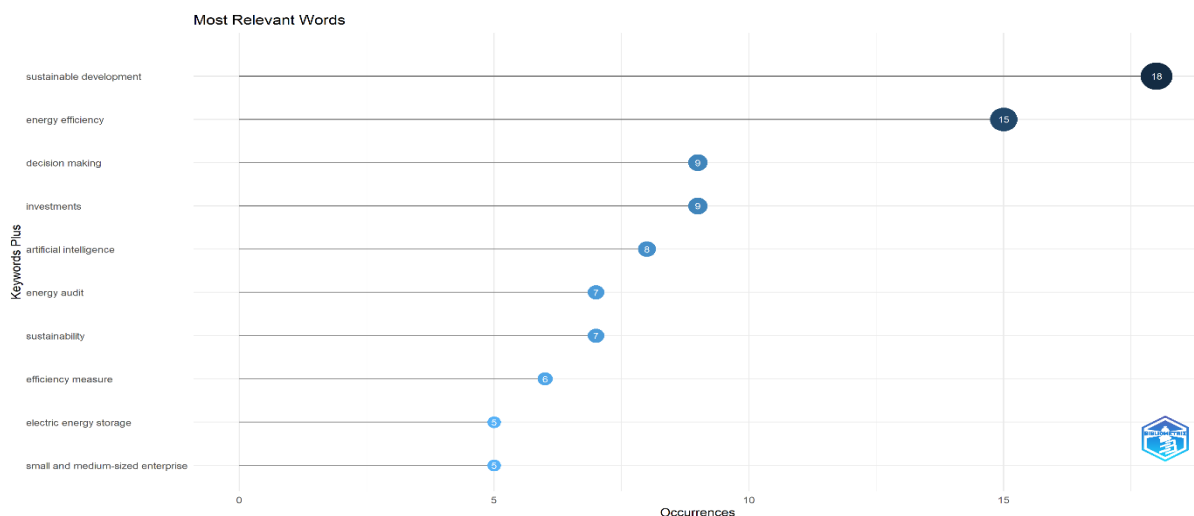


Figure 11: Most Relevant Words (Source: Analysis Output from Biblioshiny)

4.11 Coupling Map

The network analysis on a dataset of 250 documents presents the results to identify clusters or labels that represent different themes. Three clusters were identified, each characterised by a set of keywords. The first cluster, labeled "e-learning" and "academic libraries," contains 9 documents and exhibits high centrality and impact measures. The second cluster, focused on "circular economy," "climate change," and "comprehensive disaster and climate risk management," comprises 3 documents and shows moderate centrality and high impact. The third cluster, encompassing "simulation," "crisis resource management," and "assessment," consists of 13 documents and displays high centrality and moderate impact.

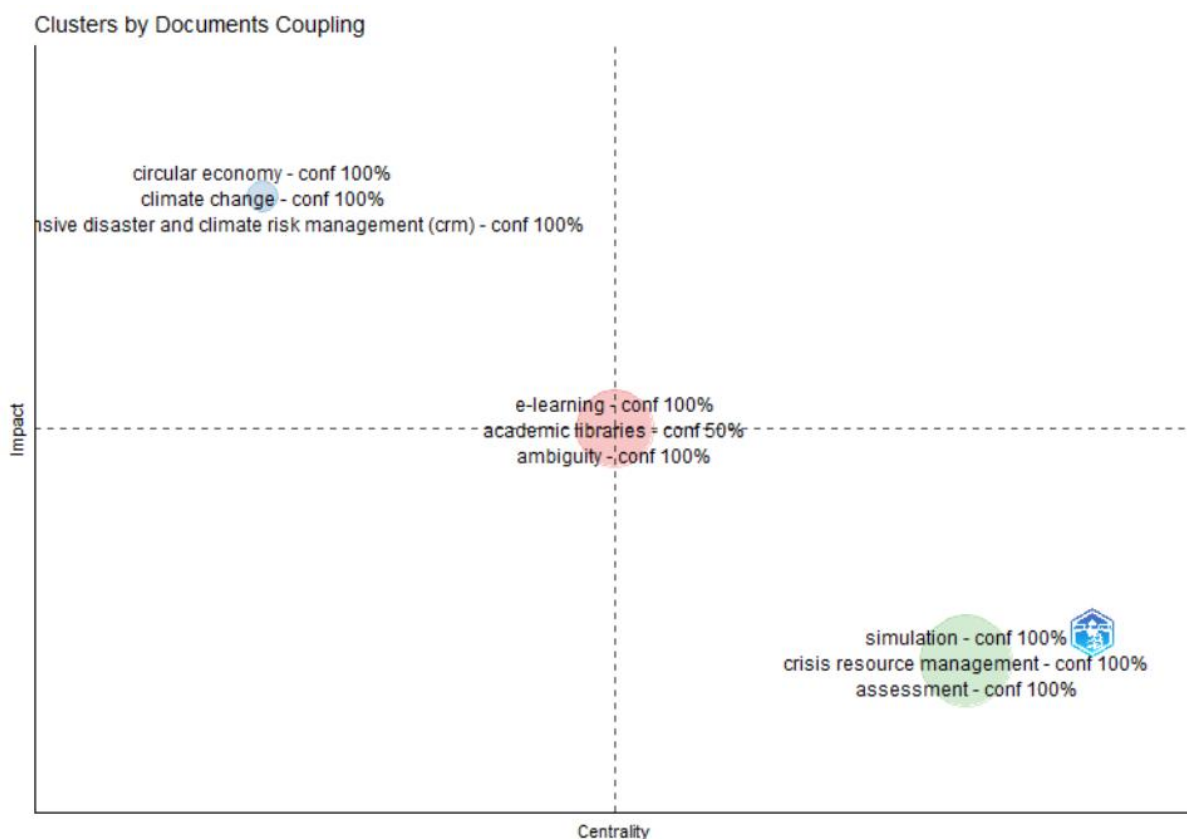


Figure 12: Coupling Map (Source: Analysis Output from Biblioshiny).

4.12 Coupling Network

The dataset lists 30 research documents with their authors, publication years, journal titles, and NormalizedLocalCitationScores. The scores indicate the citation impact of each document that covers various topics, including sustainability, environmental management, industrial engineering, medical education, health sciences, and community health.

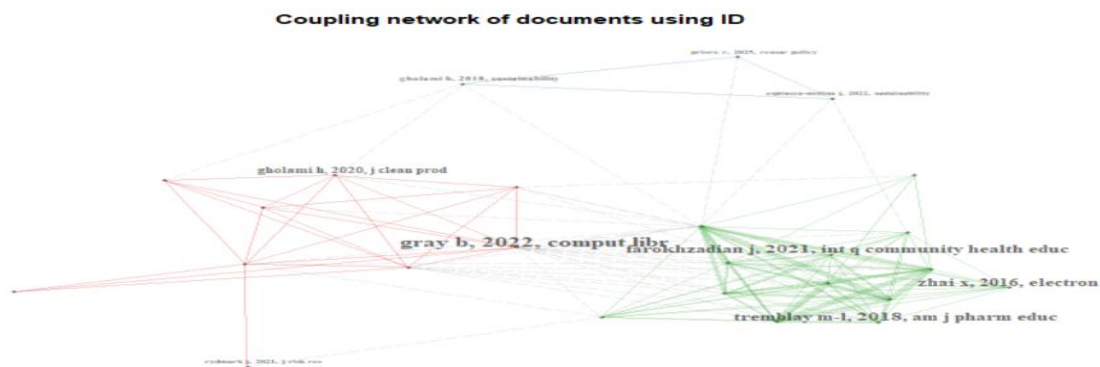


Figure 13: Most Relevant Sources (Source: Analysis Output from Biblioshiny)

4.13 Thematic Map

This bibliometric analysis reveals the characteristics of various research topics, with cluster sizes ranging from 2 to 114 documents. The top clusters, including "Human" with 114 documents, "Students" with 48 documents, and "Customer Relationship Management" with 20 documents, exhibit high centrality and density, indicating well-connected and influential clusters. In contrast, smaller clusters like "Risk Assessment" and "Curricula" show lower centrality and moderate density, suggesting relatively isolated or small but cohesive clusters. The analysis provides insights into the structure and characteristics of the clusters, helping to identify influential and cohesive research topics.

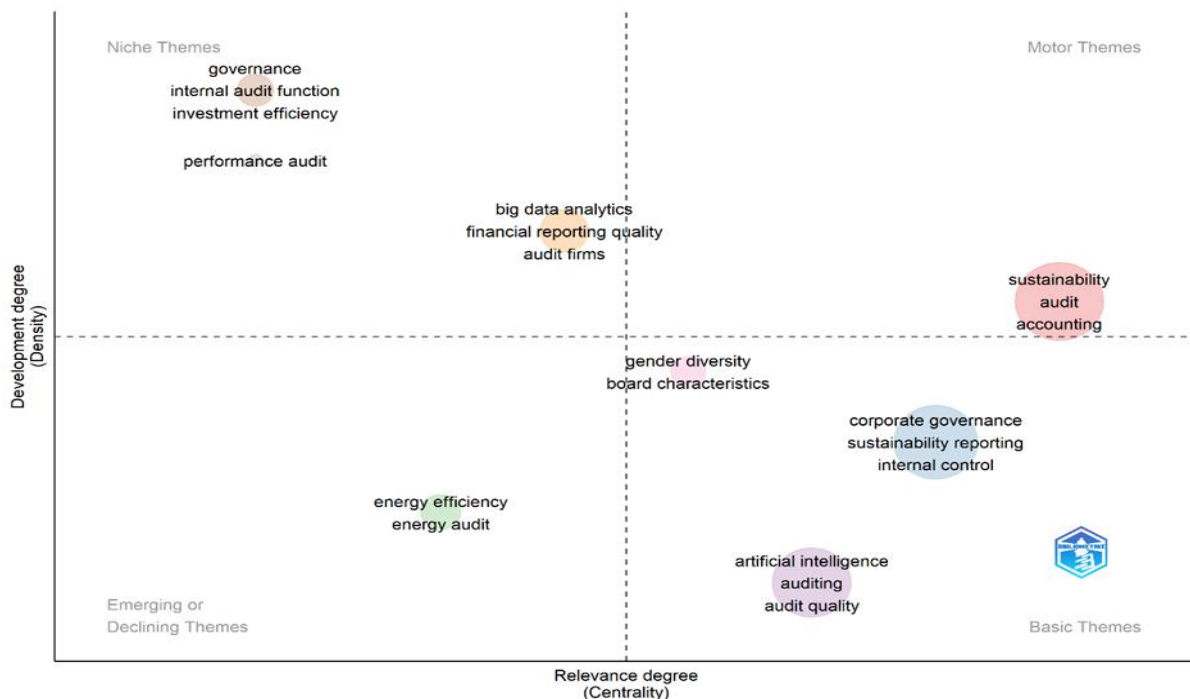


Figure 14: Thematic Map (Source: Analysis Output from Biblioshiny)

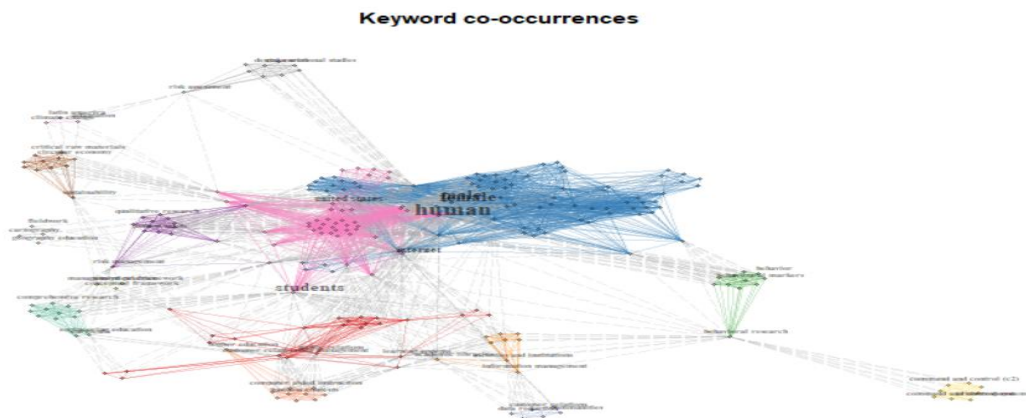


Figure 15: Keyword co-occurrences (Source: Analysis Output from Biblioshiny)

4.14 CoWordNet

This dataset presents a network analysis of various research topics, with each node representing a topic and its corresponding cluster, betweenness centrality, closeness centrality, and PageRank. The top nodes, including "Human", "Students", and "Medical Education", exhibit high betweenness and closeness centrality, indicating their importance as connectors and influencers within the network. Other notable nodes, such as "Customer Relationship Management" and "Sustainability", show moderate centrality measures.

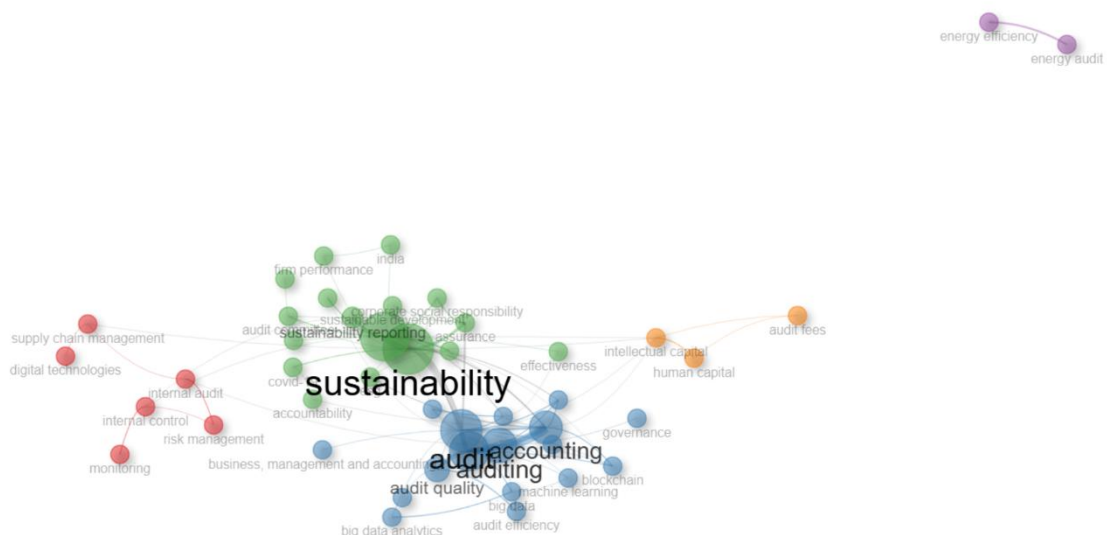


Figure 16: CoWordNet (Source: Analysis Output from Biblioshiny)

The word cloud effectively visualizes the key themes and terms from a body of research, highlighting their relative importance and providing a quick snapshot of the main subjects, including health, education, and related factors. This word cloud represents a comprehensive overview of research, education, and healthcare, incorporating demographic and institutional aspects. Central themes include human-centered studies, clinical competence, medical education, and simulation training. Supporting terms provide context, indicating the data originates from healthcare and education studies, reports, and articles. Demographic and geographical terms suggest a focus on specific age groups and regions. The presence of organizational and institutional terms implies research on structural and administrative aspects within these sectors.



This three-field plot graphically illustrates the interconnected relationships between countries of origin, authors, and departments within an academic context, likely representing publication or research contribution data. The graph displays countries, authors, and departments, with connecting lines visualizing relationships between them. The length of bars and thickness of lines may indicate the volume and strength of contributions, respectively. This visualization enables analysis of contribution distribution, identification of key authors, and recognition of research focus areas. It can also facilitate exploration of trends, collaborations, and regional or author-specific impacts within various academic fields.

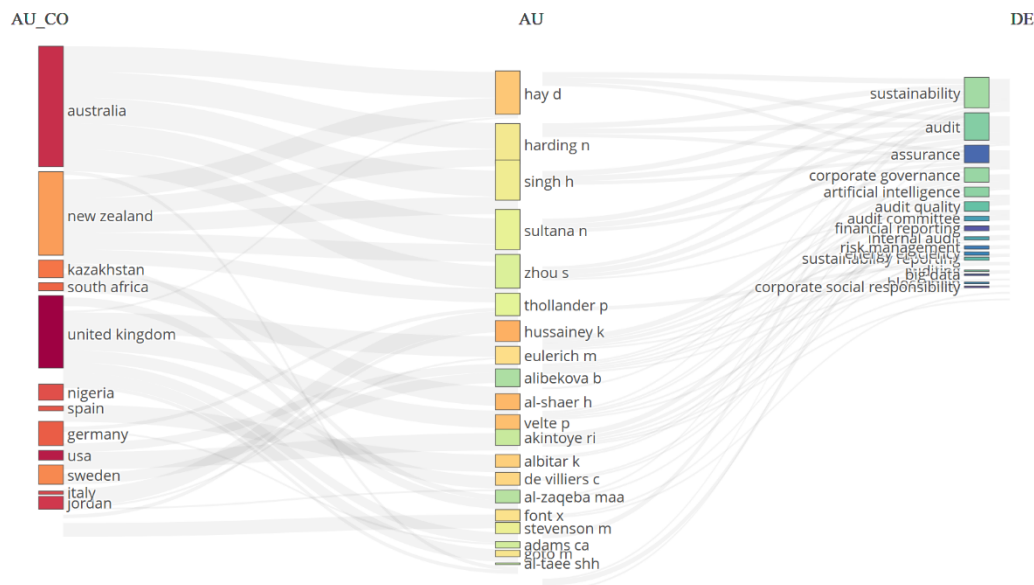


Figure 18: ThreeFieldsPlot (Source: Analysis Output from Biblioshiny)

Conclusion

The bibliometric analysis of customer relationship management (CRM) research in higher education (HEs) reveals the chronological development of CRM research, identifies key contributors, and uncovers dominant and emerging themes in the literature. The findings highlight a significant evolution in CRM research, marked by a progression from foundational concepts such as service quality and academic reputation to advanced applications including social media integration, multi-channel communication, and AI-driven strategies. This growth underscores the increasing recognition of CRM as a transformative tool for addressing student needs and driving broader institutional goals.

The study highlights the key contributors, including authors, institutions, and countries, who have substantially influenced CRM research in higher education (HEs). The bibliometric analysis of CRM research in HEs reveals a steady growth in publications over the past 45 years, with a significant surge in the last two decades. The citation landscape indicates a maturing field, with an increasing number of highly cited publications. The study's findings provide a comprehensive understanding of the evolution of CRM research in HEIs, identifying key contributors, dominant themes, and emerging trends. The analysis underscores the global relevance of CRM, its adaptability to diverse educational ecosystems, and its potential to drive institutional resilience. The analysis reveals a growing interest in CRM, with a significant increase in publications over the past few decades. The sources cited demonstrate the global relevance of CRM, with contributions from authors and institutions worldwide. This study provides a foundation for future research, emphasizing the need for further exploration of CRM's applications in higher education institutions and its potential to drive institutional resilience.

The contributions of 236 authors from various institutions and countries underscore the global relevance of CRM. The fractionalized count highlights the collaborative nature of CRM research, with many authors contributing to multiple articles.

The analysis of citations by country reveals a significant disparity in the impact of CRM research globally. The United States leads in total citations, while France stands out for its exceptionally high average article citations. Other countries, such as the United Kingdom, Germany, Australia, and India, also demonstrate notable citation totals. These findings suggest that CRM research is concentrated in a few countries, with the United States and Europe being hubs of influential research. Future studies may explore factors contributing to these disparities and opportunities for growth in CRM research globally. The dominant clusters, such as "Human", "Students", and "Customer Relationship Management", demonstrate high centrality and density, indicating their influential and well-connected nature. In contrast, smaller clusters like "Risk Assessment" and "Curricula" show potential for growth and development. Three-field plot offers a valuable visualization of the complex relationships between countries, authors, and departments in academic research. By illustrating the interconnectedness of these entities, the graph provides insights into the global distribution of research contributions, identifies prominent authors and departments, and highlights areas of research focus.

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