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Research Article

Exploring Robo-advisory Research Landscape using Scopus Database: Query Formulation for Information Retrieval and Bibliometric Analysis

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Abstract
The current study is based on query formulation to retrieve information on Robo-advisors from the Scopus database. The information retrieved is used to perform the Bibliometric Analysis. Corpus of the study consists of 240 articles indexed in the Scopus database as of 11th December 2024. Bibliometric indicators like Keyword Co-occurrence Analysis, Co-citation Analysis, Co-authorship Network Analysis, etc. have been used and analysis has been performed using VosViewer and Biblioshiny. Publications on Robo-advisors have started gaining momentum from 2017 onwards. China, United States, and Germany are leading nations contributing to Robo-advisory theme. Keyword Co-occurrence analysis illustrates that "Robo-advisor", "Fintech" and "Artificial Intelligence" are commonly occurring keywords. Sustainability and Journal of Wealth Management are the two sources with the maximum number of published articles on this theme. It provides a gateway for investors and policymakers to harness the advantages of Artificial Intelligence in making informed portfolio management decisions to optimize returns.

Keywords: Artificial Intelligence, Bibliometric Analysis, FinTech, Information Retrieval, Robo-advisors

INTRODUCTION

The financial service sector has experienced a revolutionary transition due to Artificial Intelligence (AI) and Machine Learning (ML). Robo-advisors are a noteworthy advancement from several significant developments in the finance domain. By providing cost-effective investment advice to investors, they have become an innovative force in the financial sector, thus redefining how people manage their wealth and make investments. These automated investment platforms use technology and algorithms to manage the investment portfolio of investors and offer personalized financial advice. Users of Robo-advisors and assets managed by them have considerably increased in recent years (Ji, 2017). Robo-advisory services are based on sophisticated algorithms. Robo-advisors use online questionnaires to retrieve investors' data regarding risk preferences, expected returns, current financial standing, future financial goals, socio-demographic information, etc. Robo-advisors perform risk profiling of the investor after analyzing this data. The profile created is used as a base upon which Robo-advisors search for suitable investment opportunities for each investor among the available choices in the marketplace by using **Modern Portfolio Theory** (MPT) propounded by Harry Markowitz in 1952 (Beketov et al., 2018; Boreiko & Massarotti, 2020). Robo-advisors assist investors in financial decision-making**.** Robo-advisors reduce the entry barriers for low-net-worth individuals (Qi et al., 2024), therefore ending the cycle where investors require significant amounts of funds to obtain professional investment advisory services. In addition, several people are not able to invest and save money due to a lack of time, knowledge, and experience. Investors can now receive these services through a virtual financial advisor, and these services can be accessed even from a smartphone anytime and anywhere (Brenner & Meyll, 2020). Thus, eliminating the need for an investor to visit a physical venue (stock market, traditional bank offices) to invest money.

According to the Expected Utility Theory, individuals behave rationally while making any decision. However, this theory was challenged by Kahneman & Tversky by proposing the Prospect Theory. It states that in the event of gains, investors exhibit high-risk tolerance, and in the event of losses they become risk-averse. Therefore, various behavioral biases impact the investment decisions of investors. Robo-advisors may eliminate investor's behavioral biases as they are algorithm-driven, and they offer rule-based, unbiased financial advice (Jung et al., 2018). Researchers have applied various technology adoption theories to study the adoption intentions of Robo-advisors like the

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Technology Acceptance Model (TAM) (Belanche et al., 2019; Singh & Kumar, 2024), Unified Theory of Acceptance and Use of Technology (UTAUT) (Gan et al., 2021; Nain et al., 2024; Yeh et al., 2022), Technology Readiness Index (TRI) (Flavián et al., 2022), etc.

Despite the increasing importance of this innovative technology and growing research interest in this domain, there are only a few bibliometric analyses on Robo-advisors. Torno et al. (2021) analyzed 42 peer-reviewed articles on Robo-advisors. Darskuviene & Lisauskiene (2021) conducted a literature review to explore essential links between Robo-advisors and the behavioral biases of investors. These platforms are at the nexus of behavioral economics, technology, and finance. More collaborative research is required to investigate the domain of Robo-advisory services by integrating knowledge from these domains. Bibliometric analysis can assist in uncovering the essential gaps in existing literature, thus providing an elaborative overview of the up-to-date research on Robo-advisors, highlighting the major current trends and identifying popular researchers and sources. One such attempt has been made by Rico-Pérez et al. (2022) by conducting bibliometric analysis on Robo-advisors. The work focused on performance analysis of the documents in the realm of Robo-advisors using R programming. Nowadays, there is a significant rise in the available literature on Robo-advisors. Although the above-mentioned study is instrumental in gaining insights into Robo-advisory theme, the current study endeavors to offer additional insights into this domain. The present study aims to advance knowledge, encourage collaboration, and offer insightful information about this fast-developing innovative financial technology using a culmination of Performance Analysis (PA) and Science Mapping (SM) techniques. The work attempts to answer the following in relation to Robo-advisors:

Q1. What is the most effective search query to retrieve information on Robo-advisors from the Scopus Database?
Q2. What is the present research scenario of Robo-advisors and how is it advancing with time?
Q3. Who are prolific authors, countries and journals?
Q4. How is collaboration and co-authorship evolving?
Q5. What are the most widely used keywords?
Q6. What are the different citation-related metrics?

Bibliometric methodology is adopted in the present study. PA and SM techniques have been employed to provide an in-depth understanding and offer useful insights to researchers, practitioners, policymakers, and other stakeholders associated with the ever-evolving landscape of Robo-advisors. The required set of documents has been extracted using the Scopus database. The starting period of the study was kept open and includes all relevant articles available in the Scopus database till 11th December 2024. VOSviewer and Biblioshiny software are used for this analysis.

Organization of paper is: The procedure for conducting bibliometric analysis is presented in Section 2. Section 3 includes analysis and interpretation of the articles extracted by employing rigorous bibliometric tools. Section 4 encapsulates the conclusion.

RESEARCH METHODOLOGY

The present work is based on bibliometric methodology using four-step structured protocol proposed by Donthu et al., (2021). The steps include outlining the aim and scope, choosing techniques to be used for analysis, collecting the corpus of the study, conducting Bibliometric Analysis, and present results.

The current study aims to explore the present state of research on Robo-advisors and how is it advancing. For this, existing literature on Robo-advisors and publication trends (year-wise, author-wise, country-wise, etc.) needs to be analyzed. Bibliometric Analysis is the best-suited technique as it assists in exploring popular researchers, sources, articles, and countries concerning keyword(s) under analysis. Compared to other existing review methodologies such as systematic reviews and meta-analysis, Bibliometric Analysis uses quantitative tools and techniques to analyze bibliometric data (Broadus, 1987). It entails evaluating the significance of research on a theme using bibliometric indicators like Co-citation analysis, Keyword Co-occurrence analysis, Co-authorship analysis, Citation analysis, etc. as suggested by Donthu et al. (2021).

Bibliometric analysis is classified as: PA and SM (Cobo et al., 2011). PA measures the extent of research endeavors of various research constituents like authors, countries, sources, etc., and SM explores the connections and collaborations between research participants (Cobo et al., 2011; Donthu et al., 2021; Ramos-Rodrígue & Ruíz-Navarro, 2004).

Table 1 highlights steps followed in present study to conduct Bibliometric Analysis.

Table 1: Steps followed for Bibliometric Analysis

Step 1: Outlining the aim and scope
To answer the following in relation to Robo-advisors:
Q1. What is the most effective search query to retrieve information on Robo-advisors from the Scopus Database?
Q2: What is the present research scenario of Robo-advisors and how is it advancing with time?
Q3. Who are prolific authors, countries and journals?
Q4. How is collaboration and co-authorship evolving?
Q5. What are the most widely used keywords?
Q6. What are the different citation-related metrics?
Step 2: Choosing techniques to be used for analysis

Present study uses a culmination of the following two techniques: • **PA:** Publication trends (Annual Publications, Subject Area wise publications, Country-wise Publications), Most prolific authors, sources and countries, Citation Analysis) • **SM:** Keyword Co-occurrence Analysis, Co-citation Network Analysis, Co-authorship Network Analysis.
Step 3: Collecting the corpus of the study • **Database for Information Retrieval:** Scopus • **Mode of Collection:** Online query search • **Search Query Executed:** The query **"robo-advi*" or "automated investment advice*" OR "digital financial advice*" OR "automated investment manage*" OR "automated investment advice*" OR "automated financial advisor*" OR "AI-powered financial advisory" OR "AI-Based financial advisory" OR "Digital Financial Advisory" OR "AI-Based financial advice" OR "automated investment advisory*" OR "automated financial advice"** has been used on Scopus Database under the search sub-head Title, Abstract and Keywords (TITLE-ABS-KEY) • The initial search resulted in 494 documents as of 11th December 2024. After applying inclusion and exclusion criteria, only articles in the English language published in journals have been selected for analysis. After this, 242 documents were retrieved. **Data Cleaning**: From 242 documents, 2 documents were excluded as complete information was unavailable. After data cleaning, a sample of 240 articles was selected for final analysis.
Step 4: Conduct Bibliometric Analysis and Present Results

Source: Authors' compilation based upon the four-step protocol as proposed by Donthu et al. (2021)

Selection of Database for Information Retrieval

The study is based on information extracted using the Scopus. It is a registered trademark of Elsevier. Elsevier is a publishing house founded in 1888 with over 20,000 products like Science Direct, Mendeley, Scopus, etc.[1] Scopus is used in the present study to delineate research articles, as it consists of peer-reviewed documents from reputed publishing houses such as Taylor & Francis, Emerald, Elsevier, Springer, etc. Scopus has a wide scope as it deals with diverse domains. Due to the extensive coverage of peer-reviewed publications across several academic disciplines, several researchers (Abdullah & Naved Khan, 2021; Faruk et al., 2021; Gao et al., 2021; Hashem et al., 2023) have performed Bibliometric Analysis using articles extracted through Scopus.

Formulation of Search Query for Information Retrieval on Robo-advisors

The choice of appropriate keywords and the formulation of an effective search query is one of the most important aspects of conducting Bibliometric Analysis. Poorly used search queries can retrieve articles that do not match the theme of the intended study. To ensure exhaustive coverage, relevant synonyms, and related terms were identified from the literature on Robo-advisors. These terms are "robo-advisor", "robo-advice", "automated investment advice", "digital financial advice", "AI-Based financial advice" etc. After finalizing the keywords, seventeen search queries comprising these keywords were independently executed on Scopus on 11th December 2024 to observe the number of retrieved documents, as shown in Table 2. Keywords were then combined using the Boolean operator "OR". Finally, two search queries with the Boolean operator "OR" were formulated and executed on Scopus (Table 2).

The Boolean operator "OR" is applied to widen the horizon of the search query to retrieve a wider range of relevant documents. It enables the inclusion of synonyms and related terms associated with the theme under study, thus providing a thorough coverage of the theme. Comprehensive coverage is crucial to identify trends and patterns related to the topic. A wildcard character, asterisk (*) has been used to capture variations of terms. The term "robo-advi*" has been included to create variations in keywords like "robo-advisor", "robo-advice", and "robo-advisory", etc. which are commonly used in the literature. Synonyms like "automated investment advice" and "digital financial advice" were selected based on the literature to ensure coverage of studies that might use alternative terminology to address similar concepts.

Table 2 represents a comparative analysis of search queries executed on Scopus on 11th December 2024 and the corresponding number of documents retrieved. It highlights the iterative process of refining the search query to achieve comprehensive coverage of the literature on Robo-advisors. According to Table 2, search query "robo-advi*" OR "automated investment advice*" OR "digital financial advice*" OR "automated investment manage*" OR "automated investment advice*" OR "automated financial advisor*" OR "AI-powered financial advisory" OR "AI-Based financial advisory" OR "Digital Financial Advisory" OR "AI-Based financial advice" OR "automated investment advisory*" OR "automated financial advice" retrieved maximum number of documents (n=494) in comparison with other search queries. This query has been finalized for the present study due to its comprehensive coverage of literature on Robo-advisors.

[1] https://www.elsevier.com/en-in/about/our-business/history

Table 2: Search queries and number of documents retrieved

Search Query Executed on Scopus for Information Retrieval	Number of Documents Retrieved
"AI-powered financial advisory"	Zero
"AI-powered financial advice"	Zero
"AI-based financial advisory"	Zero
"AI-Based financial advice"	01
"Robo-investment"	02
"Digital Financial Advisory"	02
"automated investment advice*"	02
"automated investment advisory*"	02
"Robo-invest*"	04
"digital financial advice*"	05
"automated financial advisor*"	05
"automated financial advice"	06
"automated investment manage*"	06
"robo-advice*"	52
"robo-advisory"	146
"robo-advisor*"	411
"robo-advisor*" OR "robo-advice*" OR "robo invest*" OR "automated investment advice*" OR "digital financial advice*" OR "automated investment manage*" OR "automated investment advice*" OR "robo investment" OR "robo-advisory" OR "automated financial advisor*"	447
"robo-advi*"	490
"robo-advi*" OR "automated investment advice*" OR "digital financial advice*" OR "automated investment manage*" OR "automated investment advice*" OR "automated financial advisor*" OR "AI-powered financial advisory" OR "AI-Based financial advisory" OR "Digital Financial Advisory" OR "AI-Based financial advice" OR "automated investment advisory*" OR "automated financial advice"	494

Source: Authors' compilation

Figure 1 depicts a snapshot of the execution of the selected search query on the Scopus database on 11th December 2024. It resulted in 494 documents.

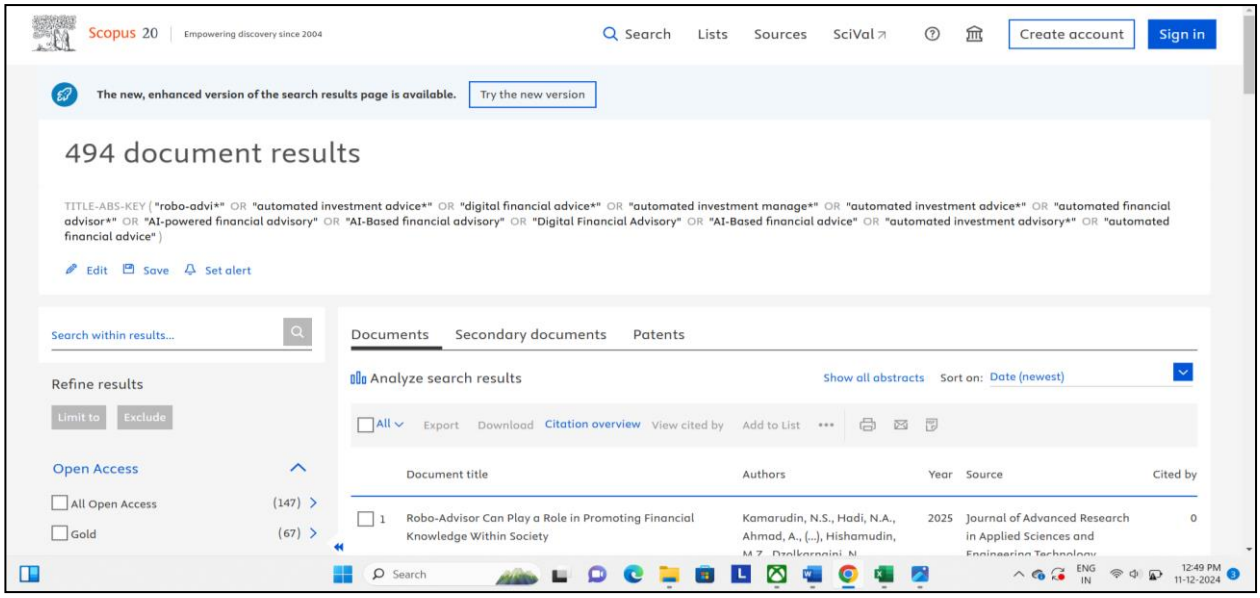

Figure 1: Snapshot of Execution of Selected Search Query on Scopus Database

Acceptance and Rejection Criteria

To suit the aim of the present work, several acceptance and rejection criteria have been used. Data source selection is an important aspect of Bibliometric Analysis as it impacts the quality and significance of the analysis. Only articles published in journals were selected. Journal articles represent 'certified knowledge' (Danvila-del-Valle et al., 2019; Ramos-

Rodrígue & Ruíz-Navarro, 2004). They are considered "up-to-date knowledge sources" and are commonly considered in review studies in the domain of management (Nova-Reyes et al., 2020). By focusing the analysis on journal articles, this study intends to provide a concise and pertinent assessment of academic contributions in the field of Robo-advisors.

Journal articles published in the English language have been chosen due to the language constraints of the Indian authors. It is a general practice adopted by other researchers who have conducted bibliometric analysis (Hashem et al., 2023; Kumari & Joshi, 2023; Mahato et al., 2022). There was one German-language article and two Turkish-language articles. Out of 494 articles, English-language articles constituted 99.39% of the dataset. So, the exclusion of three non-English articles is unlikely to impact the overall results or conclusions of the study. However, it is important to acknowledge that these exclusions may introduce some bias by omitting potentially relevant research published in other languages, thereby limiting comprehensiveness. A summary of acceptance and rejection criteria is depicted in Table 3.

Table 3: Criteria for acceptance and rejection of documents for Bibliometric Analysis

Criteria	Accept	Reject
1. Type of document	Article	Conference Paper, Review, Editorial, Erratum, Retracted
2. Document's Language	English	Turkish, German
3. Type of source	Journal	Book, Conference proceeding, Book series, Trade Journal

Source: Authors' compilation

After applying the inclusion and exclusion criteria on initially extracted 494 documents, 242 articles were retained. Extracted articles were imported in .csv (Comma Separated Value) format because it offers tremendous options for analysis including Co-authorship, Co-occurrence, Citation, Co-citation, and Bibliographic Coupling as compared to .ris (Research Information Systems) format which is only limited to author and Co-occurrence. Another quality check was conducted to further limit the number of articles by eliminating the articles that do not match the theme of the study. However, all the extracted articles matched the scope of the study. Manual inspection of the .csv file highlighted two articles that had missing information (authors and abstract unavailable). These articles were also excluded. Thus, a final corpus of 240 articles extracted till 11th December 2024 has been taken for the study.

DATA ANALYSIS AND INTERPRETATION

VOSviewer software (Jan & Ludo, 2010) and Biblioshiny (Aria & Cuccurullo, 2017) have been used for data analysis. VOSviewer has been extensively deployed for performing Bibliometric Analysis in the domain of Fintech, AI in Finance, and Wealth Management (Abdullah & Naved Khan, 2021; Barroso & Laborda, 2022; Brika, 2022). VOSviewer portrays larger bibliometric maps. Additionally, the software includes features to search, scroll, and zoom. This aids in the easy interpretation of results (Abdullah & Naved Khan, 2021). Biblioshiny is an open-source software that assists in producing descriptive data from bibliographic data (Fakruhayat & Rashid, 2022; Thangavel & Chandra, 2023). It is a visualization tool based on the R language Bibliometrix package.

Descriptive Information about Articles Retrieved

Table 4 highlights the characteristics of the articles retrieved from the Scopus database. The sample comprises 240 articles published from 2017 till 11th December 2024. 170 different sources have contributed to the sample. The average citation per document is 23.77. The sample includes 12035 references. Contributions to the field of Robo-advisors were made by 545 authors, of which 53 authors have authored single-authored documents, reflecting a strong trend toward collaborative research. 21.67% of the publications are involved in international co-authorship, highlighting global research interest in this field.

Table 4: Descriptive information of retrieved articles

Description	Results
Timespan	2017: 11th December 2024
Sources	170
Documents Retrieved from Query	240
Average citations per document	23.77
References	12035
Author's Keywords	668
Authors	545
Authors of single-authored documents	53
International co-authorships %	21.67%
Document Type: Article	240

Source: Authors' compilation (Extracted from Biblioshiny Package)

Annual Publication Trends

This section highlights the year-wise publications in the domain of Robo-advisors. Figure 2 highlights the articles published from 2017 to 11th December 2024. Article publication in the domain of Robo-advisors saw an upsurge from 10 articles in 2017 to 17 in 2018. The majority of the publications in this field are in the year 2023 (n=53) followed by 2024 (n=42) highlighting growing research interest in this field. However, no article has been found before 2017 emphasizing that research on this theme is in its infancy and is quickly making its presence felt among the researchers. This analysis helps to identify trends and patterns on a particular research topic (Devaki et al., 2024).

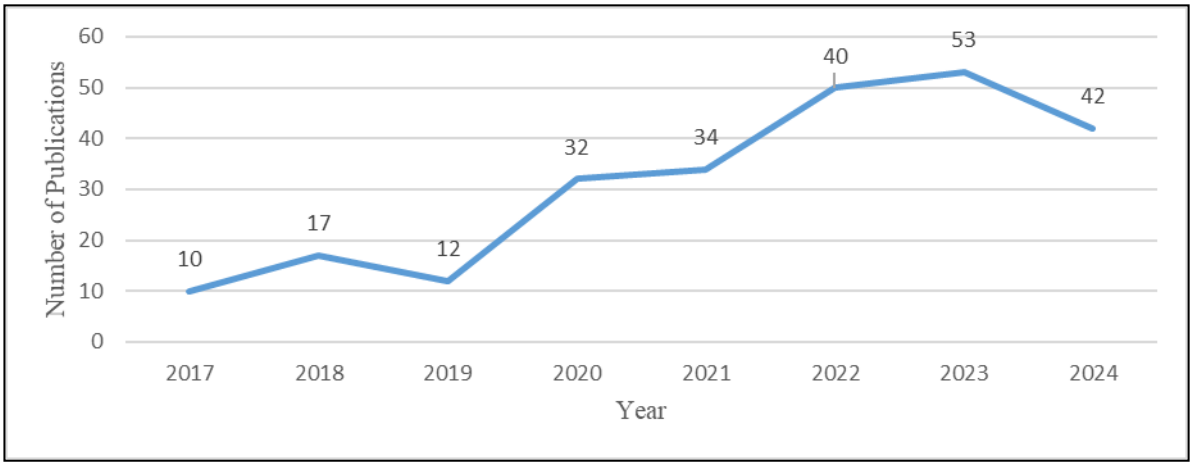

Figure 2: Year-wise number of publications

Source: Authors' Depiction

(**Note: The drop in research publications in 2024 is because this data was extracted on 11th December 2024. Hence, this graph only shows publications that were published till that date. It accurately does not reflect all the published work in the year 2024.)**

Publications based on Subject Area

The majority of the articles retrieved were related to Economics, Econometrics, and Finance (n=113) followed by Business, Management, and Accounting (n=104); Social Science (n=62), and Computer Science (n=62). One plausible reason for the same is that since Robo-advisors are Financial Technology (FinTech) tools that are designed to automate investment processes for investors, therefore they are closely linked to the disciplines of Economics, Management and Accounting, and Social Science. Also, being based on AI, research on Robo-advisors is linked to other disciplines such as Computer Science, Decision Science, Engineering, etc. Table 5 demonstrates prominent subject areas.

Table 5: Publications based on subject area

Subject Area	Number of Publications
Economics, Econometrics and Finance	113
Business, Management and Accounting	104
Social Sciences	62
Computer Science	62
Decision Sciences	28
Engineering	25
Mathematics	19
Environmental Science	10
Energy	8
Psychology	7

Source: Authors' compilation

Most Prolific Authors

The author with substantial contributions in a particular research field falls under the category of a prolific author. This analysis is based on the number of articles contributed by authors. Figure 3 illustrates the top 10 authors. Bhatia, A. and Chandani, A. are among the most prominent authors in this field with four articles each. Their research is of great importance to researchers and policymakers who aim to gain insights into leveraging the benefits of Robo-advisors to provide optimum investment solutions and portfolio recommendations to investors.

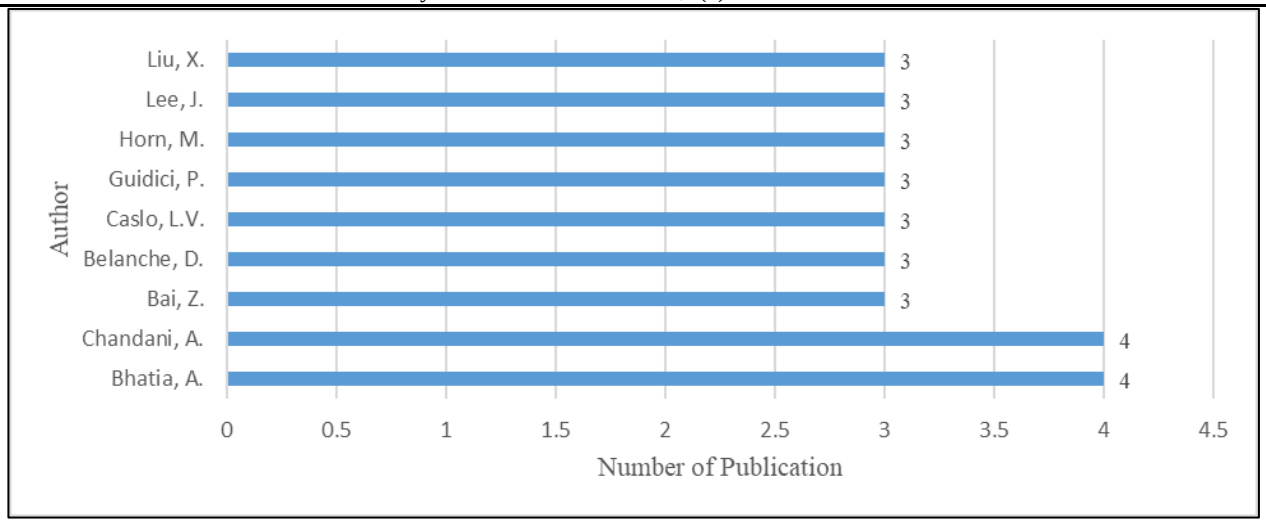

Figure 3: Most Prolific Authors

Source: Authors' Depiction

Most Influential Sources

Table 6 represents leading sources according to the frequency of articles published. Journal of *Sustainability* tops the list with 8 publications and 128 total citations. The *Journal of Wealth Management* holds the second position with 7 publications and 159 citations and the third position is occupied by *Frontiers in Artificial Intelligence*, which has 6 publications and 200 citations.

Table 7 depicts the most influential sources based on total citations. *Journal of Management Information System* garnered 900 citations, *Industrial Management and Data System* has 392 citations and *Journal of Behavioural and Experimental Finance* has 270 citations.

Table 6: Most influential sources

Source	h_index	g_index	m_index	TC	NP
Sustainability (Switzerland)	6	8	1	128	8
Journal of Wealth Management	4	7	0.5	159	7
Frontiers in Artificial Intelligence	6	6	0.86	200	6
Finance Research Letters	6	6	2	81	6
Journal of Behavioral and Experimental Finance	4	5	0.8	270	5
Risks	3	4	0.5	67	4
Financial Planning Review	2	3	0.33	88	3
International Journal of Bank Marketing	3	3	1	62	3
Journal of Asset Management	3	3	0.43	93	3
Journal of Business Research	3	3	1.5	46	3

Source: Authors' compilation

(TC-Total Citations; NP-Number of Publications)

Table 7: Influential sources based on total citations

Journal Name	TC
Journal of Management Information Systems	900
Industrial Management and Data Systems	392
Journal of Behavioral and Experimental Finance	270
Frontiers in Artificial Intelligence	200
Journal of Service Management	175
Journal of Wealth Management	159
Business and Information Systems Engineering	152
Computer Journal	152
Technological Forecasting and Social Change	142
Sustainability (Switzerland)	128

Source: Authors' compilation (**TC-Total Citations)**

Most Influential Countries

The influential countries contributing articles on the theme are depicted in Table 8. China has significantly contributed to the literature on Robo-advisors; publications from this nation account for 45.42% of all articles published worldwide followed by the United States which contributes 32.5% of the total documents published in the domain of Robo-advisors. The United States is in the lead with 1286 citations, while Germany is on second having 790 citations.

Table 8: Influential countries based on publications

Country	Number of Documents Published	Percentage (%) of Total Documents (n=240)	TC
China	109	45.42	424
USA	78	32.50	1286
Germany	61	25.42	790
India	56	23.33	198
South Korea	45	18.75	99
Malaysia	30	12.50	98
United Kingdom	26	10.83	339
Spain	21	8.75	600
Italy	20	8.33	203
Australia	19	7.92	46

Source: Authors' Compilation

TC-Total Citations

Document-wise Citation Analysis

Citation Analysis provides useful insights into the most influential articles about the study. Here, the influence of a research article is determined by the number of times it has been cited in other works. Scopus provides a citation overview for articles indexed in it (only articles published in 1996 and thereafter). Table 9 highlights the top five most cited articles.

Gomber et al., (2018) ranks first with 960 citations and Belanche et al. (2019) falls second with 387 citations. Another important contribution is Flavián et al. (2022) ranking third with 175 citations.

Table 9: Top five most cited documents in the domain of Robo-advisors

Title	Year	Source Title	Citations
On the Fintech Revolution……. Financial Services	2018	Journal of Management Information Systems	960
Artificial Intelligence in FinTech…..adoption among customers	2019	Industrial Management and Data Systems	387
Intention to use analytical artificial intelligence (AI) ……. awareness	2022	Journal of Service Management	175
Robo-Advisory: Digitalization …….Financial Advisory	2018	Business and Information Systems Engineering	152
Algorithmic Government: ……Data Science Technologies	2019	Computer Journal	152

Source: Authors' Compilation

Keyword Co-occurrence Analysis

This analysis finds the most frequently used keywords and identifies how these keywords are thematically related to each other (Donthu et al., 2021). After exporting the Scopus file containing 240 documents in VOSviewer, a Keyword Co-occurrence Analysis was performed. Initially, VOSiewer identified 1010 keywords. After applying a threshold of three occurrences, 98 keywords were extracted. Figure 4 depicts a network map of the most frequently used keywords in the Robo-advisory domain. Six clusters have been formed with a total link strength of 1471.

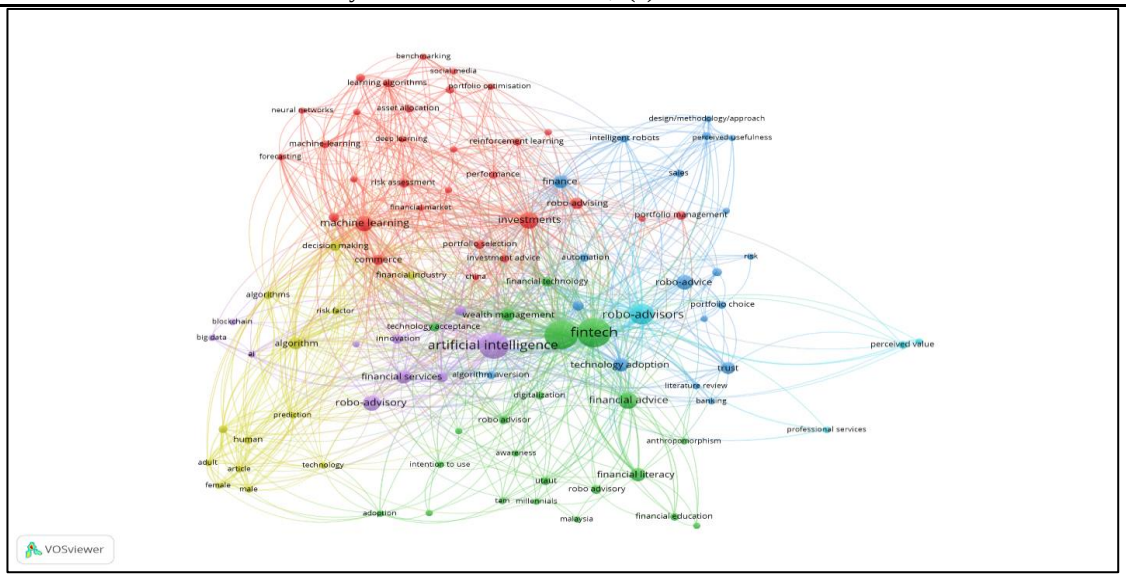

Figure 4: Keyword Co-occurrence Analysis
Source: VOSviewer

(Note: Node in this analysis represents a particular keyword that appears in the corpus of documents being analyzed.)

The largest cluster is the red cluster consisting of 30 keywords. “Investments”, “Machine Learning”, “Learning Algorithms”, “Portfolio Selection”, “Asset Allocation”, “Reinforcement Learning” and “Deep Learning” are some of the prominent keywords used by authors. This cluster focuses on the technical and computational aspects like ML, “learning algorithms”, “deep learning”, “reinforcement learning”, etc. that drive the functioning of a Robo-advisor. Robo-advisors assist in data-driven decision-making to optimize investment strategies.

The green cluster includes 22 keywords. Some of the frequently used keywords in this cluster are “Robo-advisor”, “FinTech”, “Financial Literacy” and “Financial advice”. The focus of this cluster is on the role of Robo-advisors in the finance domain. They are innovative “FinTech” product that offers “Financial advice” to investors. Investor’s “Financial Literacy” also influences Robo-advisor adoption.

The dark blue cluster consists of 19 keywords such as “Household Finance”, “Behavioural Finance” and “Structural Equation Modelling”. This cluster suggests that researchers are exploring how individual financial behaviors and their cognitive biases impact the acceptance and use of Robo-advisors. "Structural Equation Modelling" indicates that many studies in this area employ this technique to analyze the impact of various factors on Robo-advisory adoption.

The most popular keywords in the yellow cluster (consisting of 13 keywords) are “Algorithm”, “Technology”, “Decision Making”, “Financial industry”, “Female” and “Male”. This cluster depicts the significance of technology for enhancing decision-making in the financial industry. The inclusion of keywords such as “Female” and “Male” in this cluster indicates that gender differences are being explored by researchers.

The purple cluster (10 keywords) includes “Artificial Intelligence”, “Financial Services”, “Technology Acceptance” and “Innovation”. This cluster emphasizes that Robo-advisors are innovative financial services platforms based on AI. The keyword “Technology Acceptance” highlights that researchers are exploring the adoption of Robo-advisors using various technology adoption models such as TAM, UTAUT, etc.

Lastly, the light blue cluster has 4 keywords: “Robo-advisors”, “Perceived Risk”, “Perceived Value” and “Professional services”. This cluster depicts the perception of investors regarding value creation and risk concerns of Robo-advisors. It highlights that researchers are exploring customer attitudes towards Robo-advisors.

The tree map of the top 50 Author keywords is presented in Figure 5. The keyword “FinTech” appears 58 times, contributing 17% to the list of top 20 keywords. “Robo-advisor” is used 56 times, contributing 16% and “Artificial Intelligence” is used 41 times, contributing 12% to the list of top 20 Author keywords. This highlights that Robo-advisors are innovative Fintech products that are based on AI. They provide automated financial advice to investors.

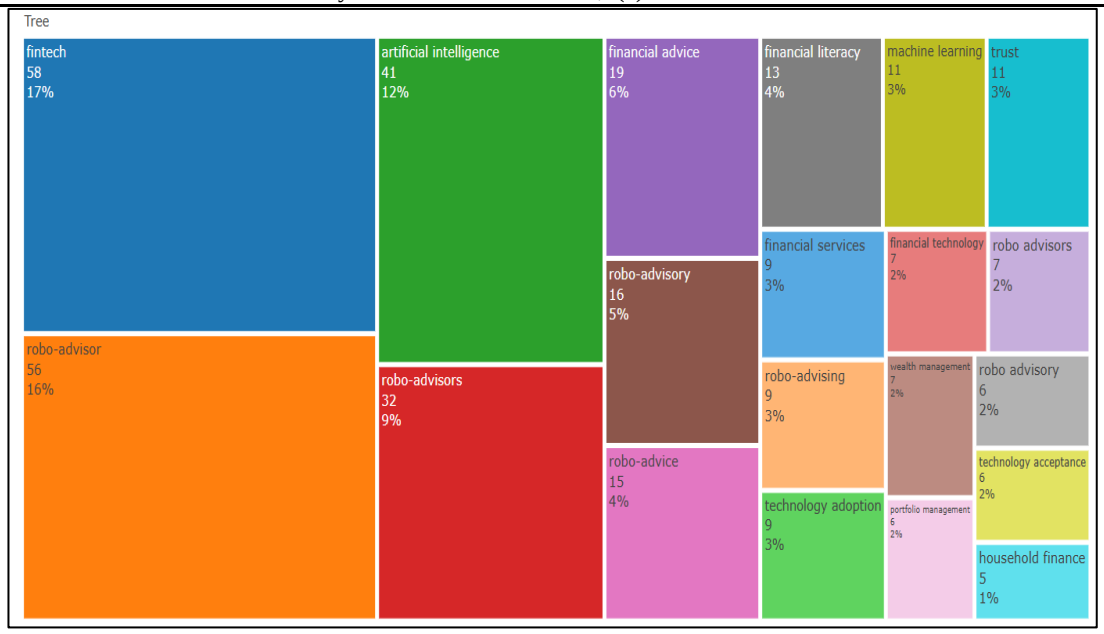

Figure 5: Tree Plot of top 50 authors

Source: Biblioshiny

Figure 6 depicts three field plot of Country (on the left), Keywords (in the middle), and Sources (on the right). The purpose of three field plot is to explore the keywords frequently used by different authors and journals. Most of the authors have used the keywords "Artificial Intelligence", "Fintech", "Financial Advice" and "Robo-advisor". Almost all the journals have equally contributed to this research field but some of the influential journals are *Finance Research Letters*, *Sustainability*, and *Frontiers in Artificial Intelligence*. Keywords such as "Financial Literacy" and "Trust" are less explored. Therefore, future research can focus on studying these factors to explore the adoption of Robo-advisors by investors.

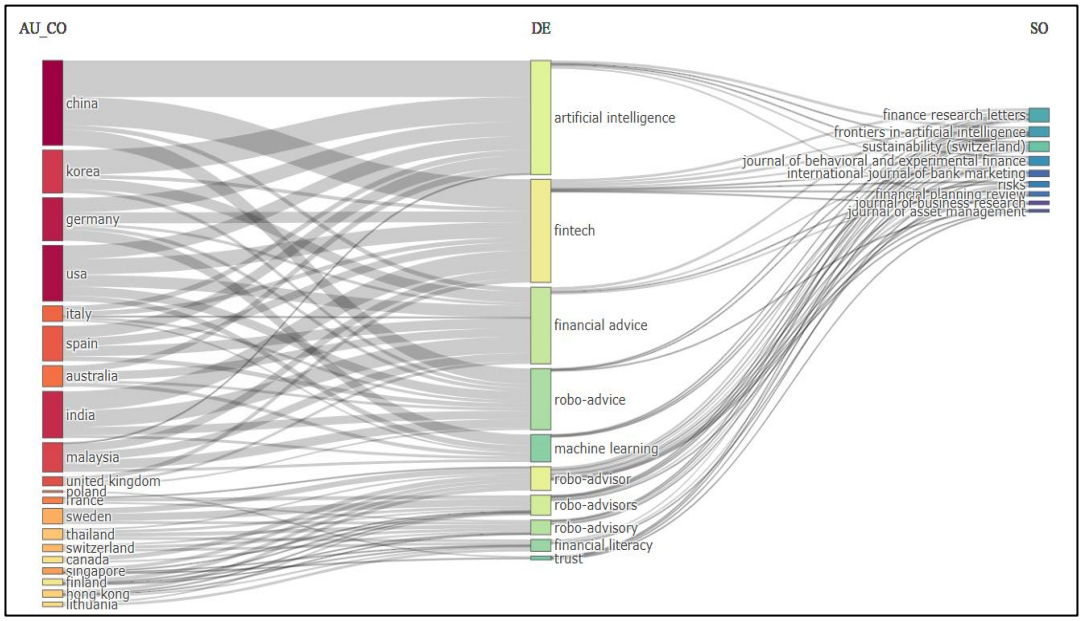

Figure 6: Three Field Plot

Source: Biblioshiny

Figure 7 depicts the Thematic Map which has been generated using the authors' keywords (the minimum cluster frequency threshold was kept to five). This map consists of four quadrants. First quadrant depicts the niche themes which are specific and isolated topics (Thomas & Rajini, 2024) while the second quadrant highlights the motor themes which are significant and well-developed research themes. Third quadrant represents emerging or declining themes that are comparatively weak primarily depicting newly developing or rapidly vanishing themes and fourth quadrant represents basic themes that are not fully developed but are pertinent to the research field.

It can be observed from Figure 7 that the **first quadrant (Niche Themes)** includes keywords such as "Structural Equation Modelling", "Continuance Intention", "Initial

Trust" and "Young Retail Investors". The niche theme consists of keywords that represent specialized areas of research. Researchers focusing on these themes are exploring specific aspects of investor behavior including trust and adoption of Robo-advisors among young retail investors using advanced statistical methods like Structural Equation Modelling. **Second Quadrant (Motor Themes)** includes keywords such as "Artificial Intelligence", "Robo-advisors" and "FinTech". This quadrant highlights the core or central themes in the field of Robo-advisors. The keywords included indicate a strong focus on AI and FinTech indicating that the working of Robo-advisors is centered around AI and FinTech. **The third quadrant (Emerging or Declining Themes)** includes "investment advice", "asset allocation" and "genetic algorithm" suggesting that these are the areas where research is either budding or declining. Keywords like "Financial Literacy", "Machine Learning", "trust", "Financial Advice" etc. appearing in the **fourth quadrant (Basic Themes)** highlight that Financial advice, Financial literacy, and Trust, though highly relevant, are less developed, indicating potential for future research.

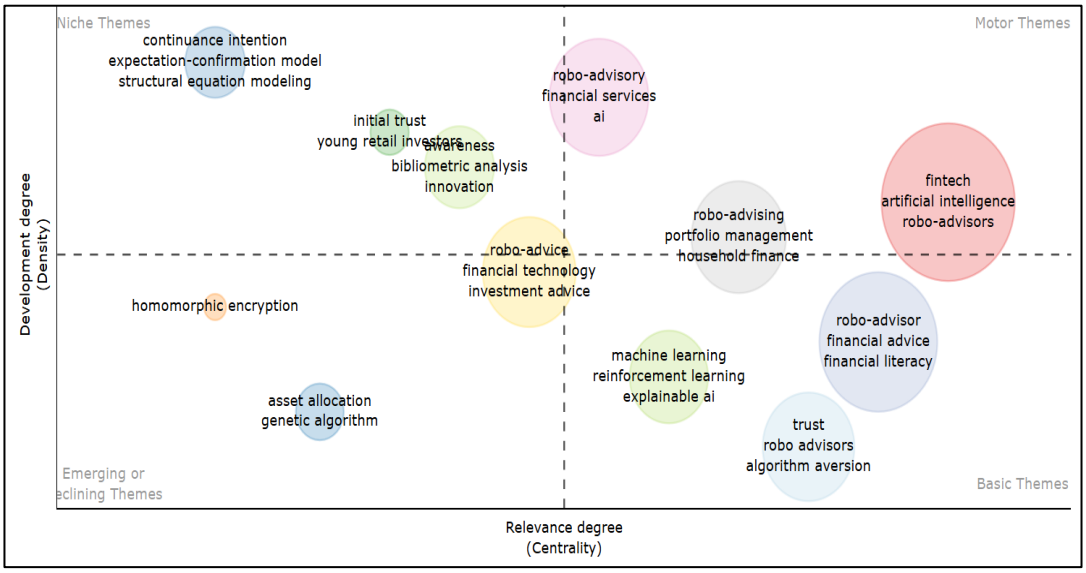

Figure 7: Thematic Map of author keywords

Source: Extracted from Biblioshiny

Co-citation Network Analysis

Co-citation analysis put forth by Small (1973) is used to examine the relationships between documents, authors, or journals based on their frequency of being cited together. Co-citation occurs when a document refers to a particular pair of documents in its list of references simultaneously (Small, 1973). This assumes that when two articles are cited together, they are contextually similar (Ramos-Rodrígue & Ruíz-Navarro, 2004). It significantly helps to visualize the intellectual structure of a domain. This analysis can be of various types: "Document co-citation analysis" focuses on connecting similar work documents, "Author co-citation analysis" focuses on connecting authors who are working on similar themes and "Journal co-citation analysis" focuses on journals publishing similar types of work (Zupic & Čater, 2015)

Interpretation from present work: For the present study, author co-citation analysis has been performed with a threshold limit that an author must have been cited at least 20 times. Out of 17196 authors identified by Vosviewer, 112 authors met the limit. Figure 8 depicts the Co-citation network analysis. Four clusters were formed (Red, Yellow, Blue, and Green). **Red Cluster** is the largest cluster having 46 authors. The influential author in the red cluster is D'Acunto with 93 citations followed by Lusardi, A and Rossi, A.G. **Green Cluster** is second with 34 authors. Of these 34 authors, Flavian, C. and Belanche, D. are the most prominent. In **Blue Cluster** consisting of 16 authors, Belanche, Flavian, and Caslo are among the most cited authors.

Yellow Cluster is having 8 authors. Among these 8 authors, Oehler is the most prominent author.

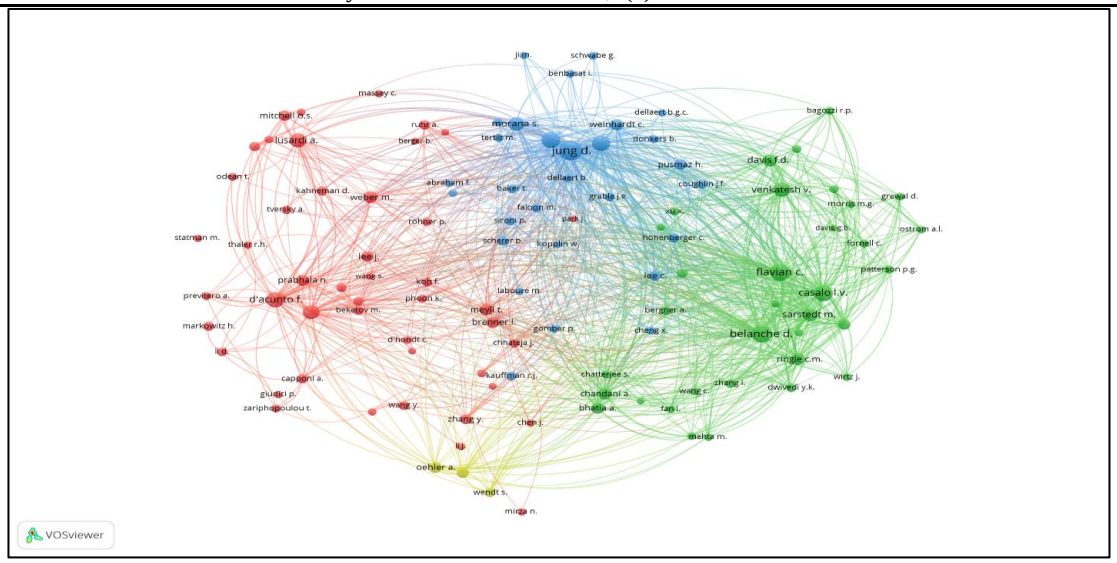

Figure 8: Co-citation Network Analysis

Source: VOSviewer

Co-authorship Network Analysis Based on Country

This analysis highlights the collaborative patterns between authors, institutions, and countries. It is also an important metric to understand collaborations across boundaries as it demonstrates how authors and institutions from different countries collaborate to work on a particular research topic (Hassan & Duarte, 2024). **Interpretation from present work:** The threshold limit for performing this analysis included a minimum of one publication per country and at least 20 citations per country. Out of 56 countries identified by VOSviewer, 27 countries satisfied the threshold requirements. The United States has the highest link strength among all selected countries followed by Germany. This highlights that authors from the United States and Germany are involved in cross-country collaboration on the theme of Robo-advisors. However, there exists no collaboration on the theme of Robo-advisors from countries like India, Poland, and Lithuania (Figure 9). Future research should encourage collaboration among researchers from India, Poland, and Lithuania with the rest of the countries. It would facilitate the broadening of the understanding of Robo-advisors and would uncover how its functionalities and benefits vary across countries.

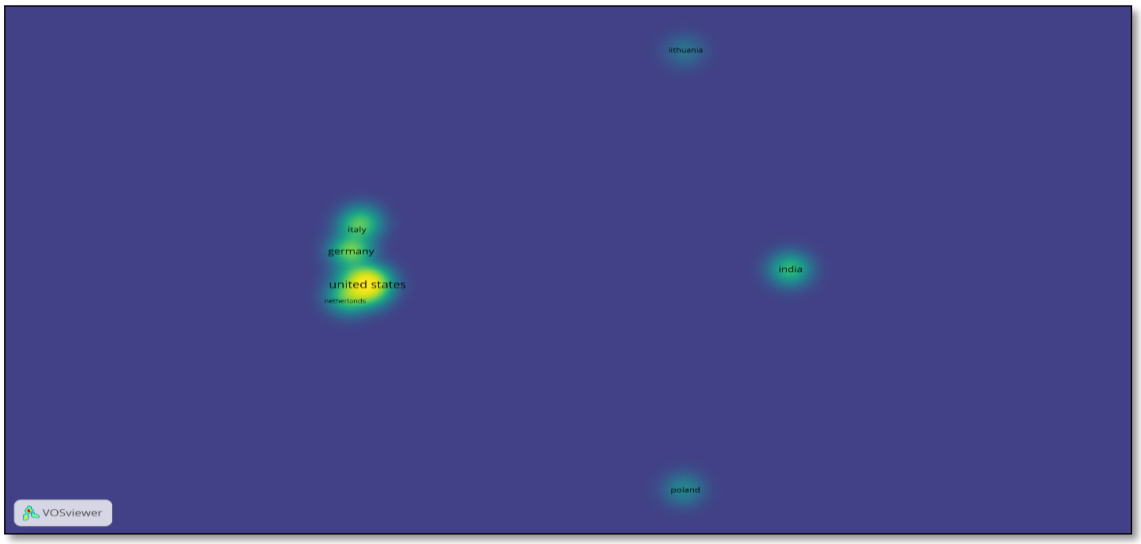

Figure 9: Co-authorship Network Analysis based on country

Source: VOSviewer

CONCLUSION

With the advent of the digital revolution, the financial industry has seen a dramatic transformation. This paradigm change is being led by a FinTech innovation called "Robo-advisors". They offer investment advice based on pre-defined algorithms rather than relying on emotions, thereby eliminating behavioral biases. In the current study, 240 articles have been analyzed using PA techniques and SM tools.

The results demonstrate that the first article on Robo-advisors was published in 2017 and since then the extent

of publications in this field has seen an upsurge. The past couple of years have witnessed significant academic contributions in this domain. This rising trend is because Robo-advisors have gained attention due to an increase in demand for non-face-to-face FinTech products after the global pandemic of COVID-19 (Gan et al., 2021; Nguyen et al., 2023). Also, Robo-advisors have risen dramatically, and their Assets Under Management (AUM) is also increasing at a faster pace. The study found that Bhatia A. and Chandani A. with four publications each are amongst the most prolific authors. Their papers are centered mainly on whether Robo-advisors are capable of mitigating the behavioral biases of investors. In terms of total citations, the article by Gomber et al. (2018) garnered maximum citations and the article authored by Belanche et al. (2019) falls second.

On further examination of the most prolific sources, the journal named *Sustainability* ranks first with maximum publications (n=8) and the *Journal of Wealth Management* (n=7) ranks second. In terms of total citations, the *Journal of Management Information System* has maximum citations followed by *Industrial Management and Data System*. China, USA, and Germany are leading countries contributing to the Robo-advisory theme. In terms of Citation Count, the USA is in the lead with 1286 total citations. Furthermore, strong collaboration links exist between United States and Germany.

Keyword Co-occurrence analysis exhibits that FinTech, Robo-advisor, and AI are among the most frequently used keywords. The domain of Robo-advisors is multidisciplinary connecting finance with technology and behavioral economics. The results of Bibliometric Analysis have highlighted the multifaceted nature of research on Robo-advisors, demonstrating the relevance of cross-disciplinary collaboration in understanding the complexities of this financial innovation. Economics, Econometrics, and Finance followed by Business, Management, and Accounting; Computer Science and Social Science are among the prominent subject domains associated with publications on Robo-advisors. The current bibliometric analysis has uncovered various prospects for further research. The results of the thematic plot and three field plot has highlighted factors such as “Financial advice”, “Financial literacy” and “Trust” are less explored in Robo-advisory research. Future research can focus on studying these factors for exploring the adoption of Robo-advisors. Majority of the research regarding Robo-advisors is concentrated in developed countries warranting the need for research endeavors in this domain in developing countries too. The analysis of Keyword Co-occurrence warrants the need for conducting qualitative studies by future researchers focusing on focus group discussions and interviews with either investors or industry experts to get an in-depth understanding of the Robo-advisors. Co-authorship Network Analysis underscores the need for cross-country collaborations facilitating a comprehensive discussion on Robo-advisors and a comparative analysis of the functionalities of Robo-advisors across countries.

This research offers various contributions. Theoretically, the current work presents a comprehensive landscape of up-to-date research on Robo-advisors. This research will aid future researchers in gaining useful insights into the multifaceted nature of Robo-advisory financial services. By highlighting the most prominent authors, documents, sources, and countries, the present work supplements to the existing research by promoting collaborations among all stakeholders associated with this financial technology. Also, this study has highlighted the research gaps in the present literature on Robo-advisors and suggested prospects for further research that will prove fruitful for other researchers in taking up the untouched areas for their research work. Practically, this research will assist policymakers and financial institutions to suggest and improvise suitable policies and guidelines surrounding Robo-advisors.

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