

# Scientific Development of Robo-Advisor: A Bibliometric Analysis

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**Abstract:** This study addresses Robo-advisor, a relevant and current topic. Robo-advisor is an emerging business model that aims to popularize the investment advisory service by fully automating it. This work investigates the main research topics and the most important authors, as well as the journals and countries where this scientific research is carried out. The study uses two authoritative, multidisciplinary databases, Web of Science and Scopus, to select 219 research papers spanning from 2015 to May 21, 2022. It presents an overview of research on Robo-advisor, using a bibliometric analysis. To study the main interest of Robo-advisor research, we have reviewed the abstracts of the analyzed articles. Furthermore, to provide a comprehensive overview of current research, we extracted the main objectives from the articles of our corpus published in 2022. This review identifies 2018 as the moment from which this topic begins to grow, both in terms of scientific research interest and assets under management. The analysis of the abstracts, allowed us to highlight three major topics that focus academic research on Robo-advisor at present, namely (1) Low-human factor related, which includes those concepts such as asset selection and Robo-advisor implementation; (2) High-human factor related, dedicated to those actions in which the human factor plays a major role; and (3) Compliance, which includes topics related to the regulatory aspects of Robo-advisor. Our findings may be useful for professionals, future researchers, and academics.

**Keywords:** Robo-Advisor, bibliometric analysis, investment advice service.

**JEL classification:** G20; G11; O33; G10; G21; G24.

## 1. INTRODUCTION

Technological changes are one of the main drivers of productivity growth in most sectors of economic activity (Link, 2013). In the financial sector, the term *fintech* (Financial Technology) offers connection between Internet-related technologies, such as cloud computing or mobile Internet, with business activities of the financial services industry—including, for example, money lending or transaction banking (Gomber et al., 2018). Among these financial services, investment advice (IADs) stands out. Traditionally, this service was only offered to a niche of clients with a high level of wealth. Fintech's new service, known as Robo-advisor (RA), has been developed to popularize IADs.

Beketov et al. (2018) define RA as an automatic investment platform that uses quantitative algorithms to manage investor portfolios. Therefore, RA is a financial advisor offering an online investment portfolio management service through algorithms and automation. The RA service aims to transform a niche business, scaling it to a volume one. The expectation for growth in income offered by this new way of advising have proven to be very attractive for financial institutions. According to Statista.com, the volume of assets under RA management (AURAM) in 2021 reached 1.4 trillion

dollars, and annual growth of 18.78% is expected until 2025. These numbers indicate that robo-advice is a reality that has come to stay. This transformation of the IADs service poses great challenges, the most important being those related to the client, or the tools used to carry out certain parts of the IADs process.

In this study, the scientific activity on RA is analyzed from a systematic literature review of the documents indexed in the Web of Science (WoS) and Scopus databases. We investigate the main research topics and the most important scholars, as well as the journals and countries in which this scientific research is being carried out. To achieve this, we use the bibliometric techniques of quantitative analysis and statistical indexing to perform a systematic and reproducible review process, allowing us to create a general overview of the research field (Wallin 2005, Baier-Fuentes et al. 2019). These bibliometric techniques are common tools for tracking research activities in all fields of knowledge (Zyoud and Fuchs-Hanusch, 2017; Ariaa and Cuccurullo, 2017; Martínez-López et al., 2020; Wang et al., 2020). In relation to technological changes in the financial sector, these techniques have been applied by scholars in many studies, including: 1) *fintech* (Li and Xu, 2021; Nasir et al., 2021a); 2) *big data in finance* (Nobanee, 2021; Tseng et al., 2021); 3) *bitcoin* (Liu, 2016; Merediz-Solà and Bariviera, 2019; Orăștean et al., 2019; Aysan et al., 2021); 4) *cryptocurrency* (Guó and Donev, 2020; Nasir et al., 2021b); and 5) *financial innovation* (Li and Xu, 2022). Studies of RA by D'Acunto

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Table 1. Search Protocol.

Database	Period	Document Type	Search criteria	Keywords
WoS	Until 05/21/2022	Article, Proceedings Papers, Review Articles, Book Chapter	Theme	Robo Adv <sup>i</sup> *
Scopus		Article, Conference Paper, Book Chapter, Review, Book	Article title, Abstract, Keywords	

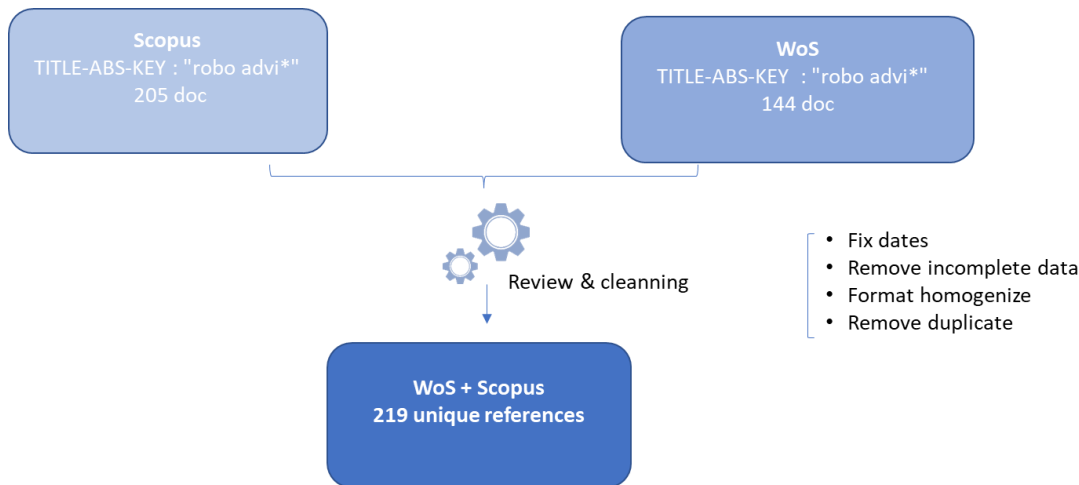


Fig. (1). Database creation: Scopus + WoS.

and Rossi (2020) and Torno et al. (2021) summarize the extant knowledge of this new technology, but in both cases the approach followed by the authors is different from the one used here. Concretely, we aim to answer more *summative* questions about the state of the field, asking the following research questions: *How mature is the research on RA? Is there a concentration of the research topic in relation to authors, countries, or journals?*

From the abstracts of the works in our database, we have identified three main lines of research. On the one hand, papers linked to relationship problems or human behavior and, on the other, those that focus on the application of new quantitative algorithms related to the ability to estimate profitability and risks, interpretation of financial variables and objectives of optimization of investment portfolios. Finally, a group of works that refer to legal and regulatory aspects of RA have been detected. This aspect is essential for RA and its users since the judicial regulations on financial advice are complex and manifold. With this analysis we answer a new research question *which are the central subjects inside the research?* Finally, to know *which are the hottest topics and patterns in the research field*, we have extracted from the articles published in 2022, their main objectives.

Starting from a description of the data and methodology used, this article studies the status of the knowledge around RA. It sums up its key findings, extracting the main topics and the latest research trends. Finally, the paper ends with the conclusions of the study.

2. DATA AND METHODOLOGY

The data was retrieved from Scopus and WoS, the most frequently used databases academics (Chadegani et al., 2013; Visser et al., 2021). The search was done May 21, 2022 (see Table 1). We have chosen WoS and Scopus because of their very similar metadata structure, which allows us to combine

search results into a single corpus. In this way, the quantity of data is greater, resulting in a more informed and higher quality analysis (Moral-Muñoz, et al., 2020).

The search conditions included all the research documents having the term ‘Robo Adv<sup>i</sup>\*’ in their title, keywords, or abstract<sup>1</sup>, and the consultation has been limited to documents in English. The oldest documents indexed using the expression ‘Robo Adv<sup>i</sup>\*’ in WoS and Scopus databases were published in 2015 (Chew, 2015), indicating that research on RA is still in its very early stages.

To merge both databases, it was necessary to clean the data, fixing erroneous dates and eliminating incomplete records in some of the databases’ main metadata. It has also been necessary to homogenize the treatment that each database gives to the Tag AU (authors). The final sample consisted of 219 research documents<sup>2</sup> (see Fig. 1). In this part of the study, the R language packages *writexl*, *readxl*, *Stringr* and *tidyverse* have been applied.

Table 2 shows the distribution of documents by type. Although scholarly articles are the most common in the sample (with 127, accounting for 57.99%), the findings reveal that conference/proceeding papers—with 64 papers, accounting for 29.22% of the documents—have the second-highest number of publications.

3. RESULTS AND DISCUSSION

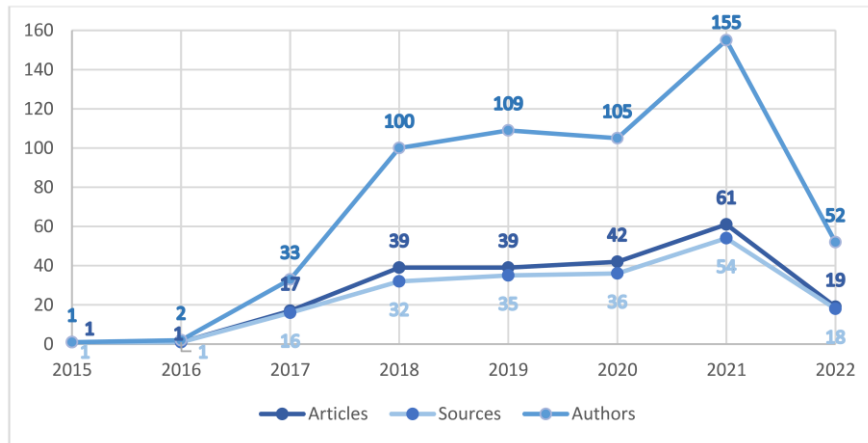
In this section, we present a descriptive analysis of the scientific literature of our corpus. This analysis studies the temporal evolution of the research and the relevance of its sig-

<sup>1</sup>We used the asterisk (\*) in the search as a wild card character to make our search simpler and more comprehensive, as it will track all possible forms of the used terms.

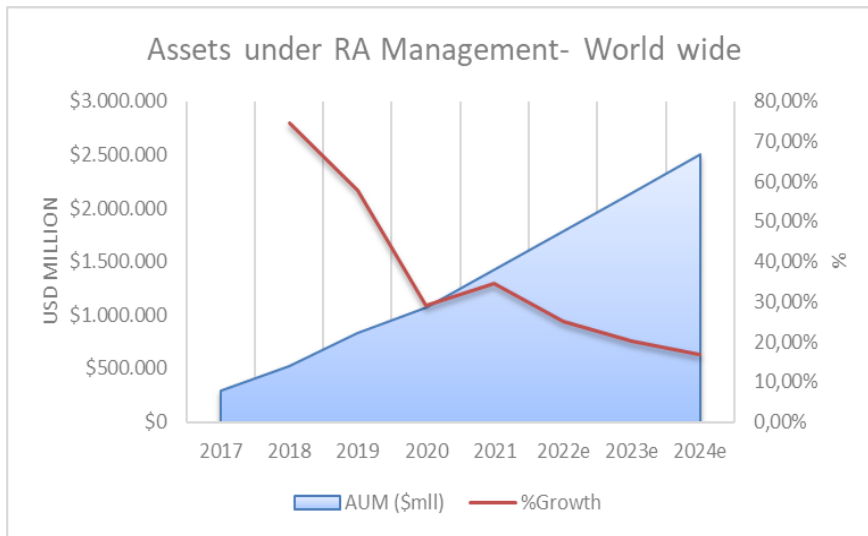
<sup>2</sup> Our corpus is available upon request.

**Table 2. Corpus Summary (2015:2022).**

Main Information of Merged Sources	Result	Document Type	Documents	%
Sources	170	Article	127	57.99%
Documents	219	Conference / Proceeding paper	64	29.22%
Authors	460	Book chapter / Book	13	5.94%
		Review / Review articles / Book Review	15	6.85%



**Fig. (2).** Annual evolution of publications, sources, and authors about RA until May 21, 2022.



**Fig. (3).** AUM growth (Source: elaboration from Statista.com).

nificant variables, such as sources, authors, and countries of publication. To determine the impact of each document, the most cited articles and authors were also examined. The analyses have been carried out using the functions *biblioAnalysis* and *bilbioshiny* of the R language packages.

**3.1. Evolution of the Documents and Journals**

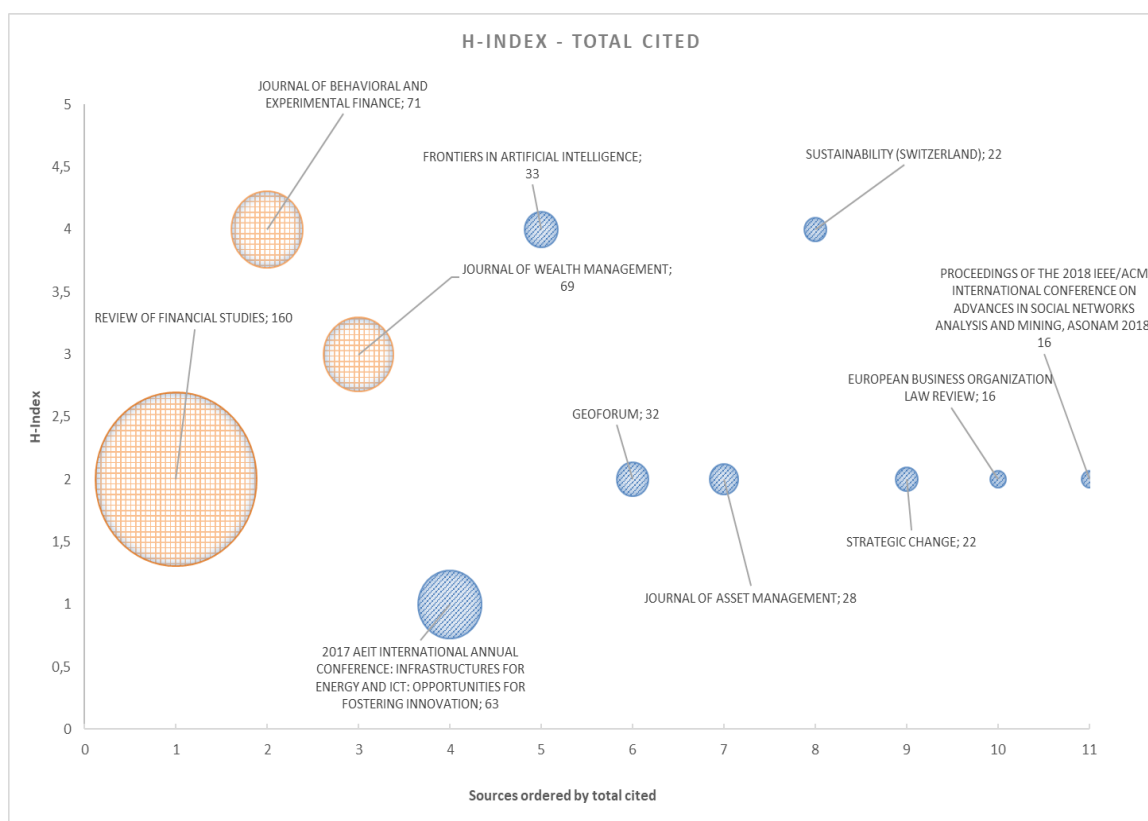
Fig. (2) summarizes the evolution of the number of research documents published on the topic ‘Robo Advi\*’. The first document studied was written by Chew (2015), an article published in *FORTUNA* journal. In 2017, scientific interest in RA began to grow, with 33 authors investigating the subject in 17 articles. However, it was in 2018 that this growth

in interest was consolidated, with a notable increase in the number of authors (100) and articles (39), a trend which continues today. During the period 2019-2021, the average number of publications was 47, and the average number of authors was 123. Additionally, interest from publishers has also clearly grown, as the number of sources publishing RA articles has tripled since 2017. In the first five months of 2022, we have observed more documents, sources, and authors than in all of 2017 (see Fig. 2).

When comparing scientific production with the evolution of assets under management (AUM) in RA platforms (see Fig. 3), the increase in research interest since 2018 is consistent with the increase in RA business.

**Table 3. Publication Sources with Three or More Papers.**

Sources	Articles	%
Journal of Behavioral and Experimental Finance	7	3.18%
Frontiers in Artificial Intelligence	6	2.73%
Sustainability	6	2.73%
Journal of Wealth Management	5	2.27%
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	5	2.27%
Jusletter it	3	1.36%
Lectures Notes in Networks and Systems	3	1.36%
Risks	3	1.36%
TOTAL	38	17.27%



**Fig. (4).** Relevance of the sources.

Table 3 lists publication sources according to their number of items (for publications with three or more items per source). In the analyzed period, the sources in Table 3 have published 19.73% of the total articles, *Journal of Behavioral and Experimental Finance*, *Frontiers in Artificial Intelligence*, and *Sustainability* highlighted. Table 3 also reveals a special interest in this topic among researchers in business finance, management, economics, and computer science.

Regarding the relevance of the sources (see Fig. 4), the *Review of Financial Studies* clearly stands out for its volume of citations, at 160. This journal is indexed in the first quartile of the Business, Finance (5/110) and Economics (22/376) JCR categories. Two articles from our corpus have been pub-

lished in this journal: Chen et al. (2019) and D’Acunto et al. (2019). In Chen et al. (2019), robo-advising was considered one of fintech’s most valuable innovations, while D’Acunto et al. (2019) examined the impact of robo-advertising tools on investors’ financial decision-making. The *AEIT 2017 International Annual Conference* obtains relevance from its citation in the article by Mannaro et al. (2017) on the use of the blockchain in several different fields, one of them RA. Occupying the first positions on the H-index are the *Journal of Behavioral and Experimental Finance*, *Frontiers in Artificial Intelligence*, and *Sustainability*. Yet, if we look solely at the number of citations, these journals rank second, fifth, and eighth, respectively.

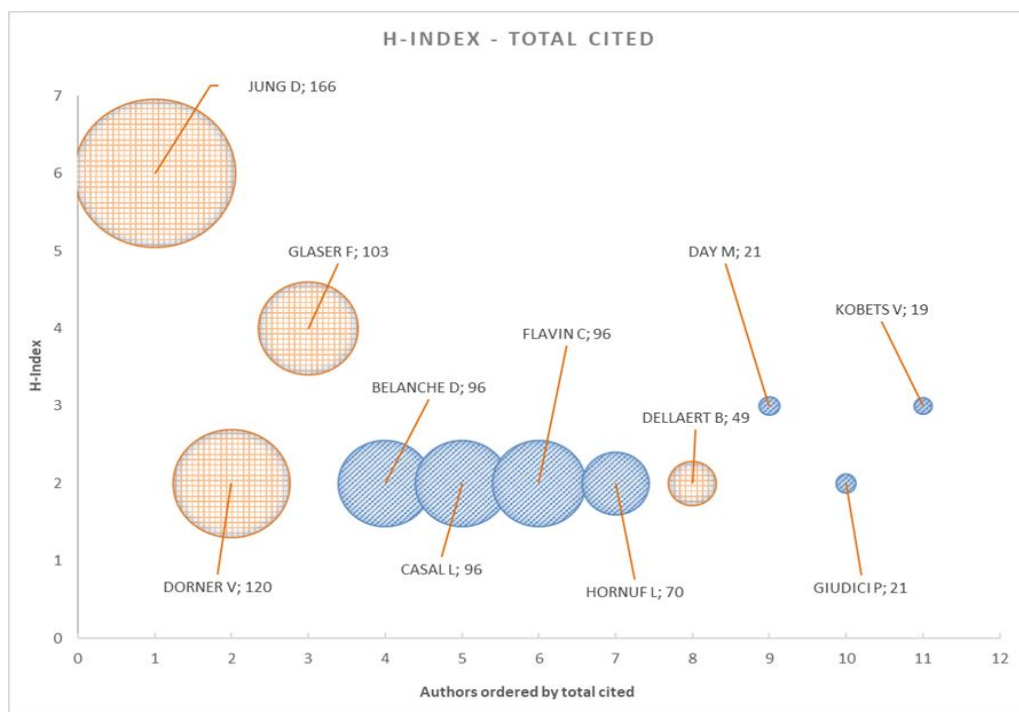


Fig. (5). Relevance of the authors.

### 3.2. Publication Activity: Authorship

Table 4 presents a summary of the productivity of the 460 authors of our corpus. The ratio between the total number of authors and the total number of documents is 2.1 (an author is counted only once). If author appearances are considered, then the average number of co-authors per document is 2.5. The Collaboration Index (CI) score of 2.45 represents the total authors of multiple-author articles, with respect to the total number of multi-authored articles (Elango and Rajendran, 2012; Koseoglu, 2016).

Table 4. Author Summary.

Authors Main Data	Number
Authors	460
Author appearances	558
Authors of single-authored documents	56
Authors of multi-authored documents	404
Single-authored documents	58
Documents per author	0.485
Authors per document	2.1
Co-authors per document	2.5
Collaboration Index	2.45

As Table 5 shows, production is concentrated in the top authors (those with three or more papers), who comprise 25.45% of the total number of published pieces. Their production was concentrated in the years 2018, 2019, and 2021, with peak productivity in 2018.

Table 5. Top authors with Three or More Papers According to the Number of Articles.

Authors	#2018	# 2019	#2020	#2021	Total
A. Bhatia			1	5	6
D. Jung	4	2			6
A. Chandani			1	4	5
V. Kobets	3	1	1		5
F. Glaser	2	2			4
B. Berger		3			3
M. Y. Day	2	1			3
O. Ivanov	2	1			3
K. Lee	2	1			3
Q. Liu	3				3
M. Mehta				3	3
O. Snihovyi	2	1			3
D. Streich		1	1	1	3
J. Xue	3				3
J. Yin	3				3
Total	26	13	4	13	56

Fig. (5) presents the most influential authors based on the number of times their RA-based articles were cited, as the number of citations is generally considered a recognition of the importance and quality of the research (Shan and Wang, 2018). Dominik Jung (H-index = 6; Total cited =166) is an

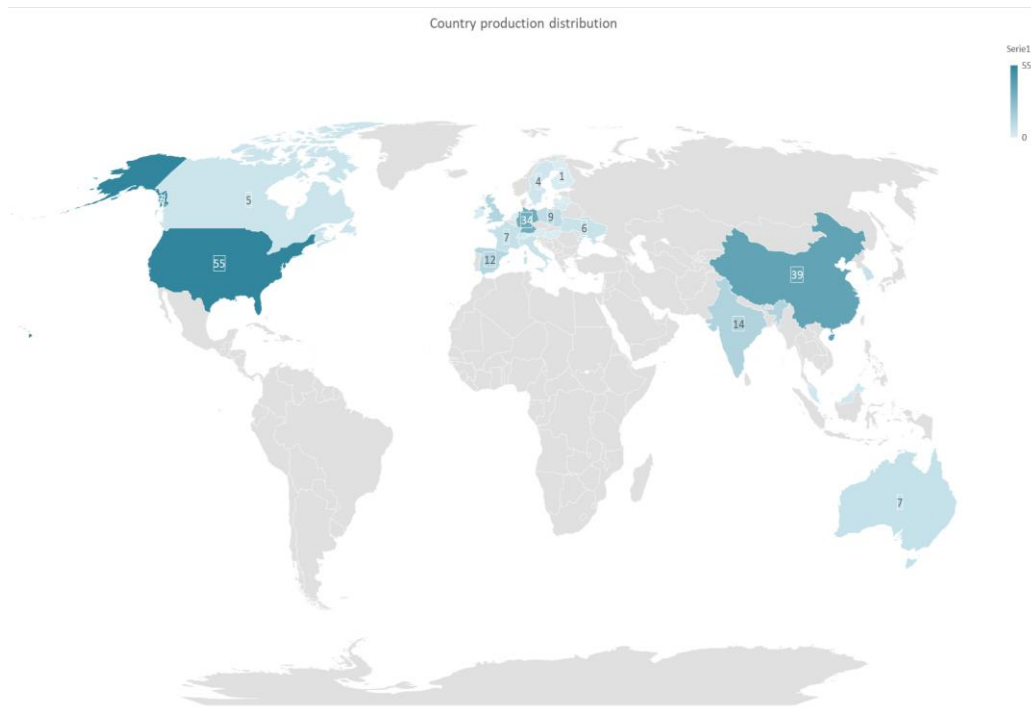


Fig. (6). Geographic relevance by authors.

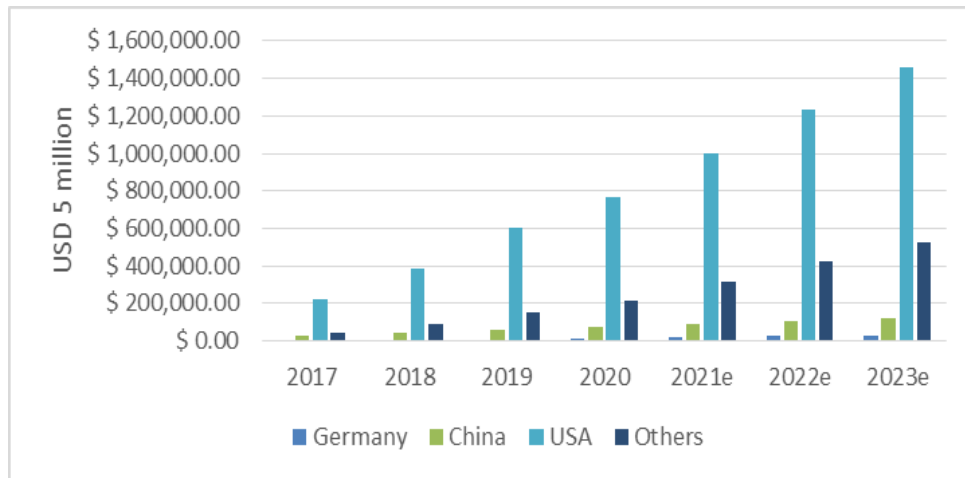


Fig. (7). Main countries by AUM (Source: Statista.com).

author whose impact stood out from the rest, both for their h-index and for the times they are cited. Jung is the co-author of 4 works in 2018, two of which were co-authored by Glaser. The second-highest number of citations belonged to Verena Dorner (H-index = 2; Total cited = 120), who also co-authored two articles with Jung in 2018. If we consider the H-index alone, Florian Glaser (H-index = 4; Total cited = 103) appeared second in the author rankings. All three authors belong to the same institution: The Karlsruher Institut für Technologie in Karlsruhe (Germany). If we look again at the H-index, two additional standouts were Min-Yuh Day (Tamkang University, Taiwan) and Vitali M. Kobets (Kherison State University, Ukraine).

Fig. (6) shows scientific research productivity statistics, ranked by author nationality. The United States is the most productive country, with 55 published papers, with China and Germany registering with 39 and 34 published papers,

respectively. The remainder of the countries have fewer than 15 published articles combined. Still, the geographical distribution of the papers shows that RA technology is generating interest around the world.

If we compare the geographical distributions of the productivity with the evolution of AUM under RA (see Fig. 7), the USA is again the country where the RA business has developed the most. This is logical, as most research in the field is carried out in the US. In China and Germany, business development related to RA has not yet reached AUM levels, like those in the USA, but their own levels of research production in RA stand out.

### 3.3. Analysis of Most Cited Research Documents

The total number of citations for each document reflects the attention and influence that each article has had in the scien-

tific community (Merigó et al., 2015). Table 6 displays a list of the twenty most-frequently cited documents. The relevance of the top 20 is highly concentrated in the first six papers, with more than 60 citations each. This degree of scholarly concentration is even higher than the degree observed in analyzing the authors' influence, and these top 20 documents

yielded 70.88% of the ensuing citations. The most cited paper, by Gomber et al. (2018), had accumulated 286 citations during the data analysis time frame. The second was Chen et al.'s (2019) study, with 104 citations. But Jung was once again the one who clearly dominated this list, with two papers in the top 20.

**Table 6. The Twenty Most Cited Research Documents in RA.**

Tittle	First Author	Source	Year	Total Citations	% Total
On the Fintech Revolution: Interpreting the Forces of Innovation Disruption and Transformation in Financial Services	P. Gomper	Journal of Management Information Systems	2018	286	17.31
How Valuable is Fintech Innovation?	M.A. Chen	Review of Financial Studies	2019	104	6.30
Artificial Intelligence in FinTech: understanding robo-advisors adoption among customers	D. Belanche	Industrial Management and Data Systems	2019	89	5.39
Robo-Advisory: Digitalization and Automation of Financial Advisory	D. Jung	Business and Information Systems Engineering	2018	65	3.93
Crypto-Trading: Blockchain-oriented energy market	K. Mannaro	2017 AEIT International Annual Conference	2017	63	3.81
FinTech in Germany	G. Dorfleitner	FinTech in Germany (Book)	2017	63	3.81
The Promises and Pitfalls of Robo-Advising	F. D'Acunto	Review of Financial Studies	2019	56	3.39
Designing a robo-advisor for risk-averse, low-budget consumers	D. Jung	Electronic Markets	2018	55	3.33
Algorithmic Government: Automating Public Services and Supporting Civil Servants in using Data Science Technologies	Z. Engin	The Computer Journal.	2019	53	3.21
Fintech and the innovation trilemma	C. Brummer	Georgetown Law Journal	2019	44	2.66
Robo Advisors Algorithmic Trading and Investment Management. Wonders of Fourth Industrial Revolution in Financial Markets	R. Tao	Technological Forecasting and Social Change	2021	42	2.54
Regulating robo advice across the financial services industry	T. Baker	Iowa Law Review	2018	40	2.42
Robo-advisors and wealth management	K. Phoon	Journal of Alternative Investments	2018	32	1.94
Asset Management as a Digital Platform Industry: A Global Financial Network Perspective	D. Haberly	Geoforum	2019	30	1.82
Individualization of robo-advice	M. Faloon	Journal of Wealth Management	2017	29	1.76
Robo Advisors: quantitative methods inside the robots	M. Beketov	Journal of Asset Management	2018	26	1.57
Robo Advisory and Its Potential in Addressing the Behavioral Biases of Investors a Qualitative Study in Indian Context	A. Bhatia	Journal of Behavioral and Experimental Finance	2020	25	1.51
Roboadvisors a Substitute for Human Financial Advice	L. Brenner	Journal of Behavioral and Experimental Finance	2020	25	1.51
New Tech V New Deal Fintech As a Systemic Phenomenon	ST. Omarova	Yale Journal on Regulation	2019	22	1.33
To Advise, or Not to Advise – How Robo-Advisors Evaluate the Risk Preferences of Private Investors	M. Tertilt	Journal of Wealth Management	2018	22	1.33



	Sub-total top 20 documents	1171	70.88
	Total-citations (corpus)	1652	100

Note: References cited by other reference into the corpus.



Fig. (8). Wordcloud of author keywords.

3.4. Keywords Analysis

To identify the most notable concepts related to the search term ‘Robo Adv\*’, an analysis of the author keywords was performed. Fig. (8) shows the wordcloud obtained after excluding the search term itself. Concepts such as ‘fintech’, ‘artificial intelligence’, and ‘machine learning’ are mentioned in a large percentage of the works in our corpus. The wordcloud also highlights the presence of other concepts related to human aspects of RA, such as ‘financial advice’ and ‘trust’.

4. MAIN TOPICS OF RESEARCH IN OUR CORPUS

To study the main interest of RA-related research, we have reviewed the abstracts of the analyzed articles. In this phase of our work, we have considered the 196 articles of our data base that have abstracts<sup>3</sup>. The analysis of these abstracts, has allowed us to highlight three major themes that focus the RA academic research at present, namely (1) Low human factor related, which includes those concepts less related to the human factor such as Risk-Return calculation, asset selection, and all those cross-cutting topics related to RA implementation and the general methodologies applied in the development of RA; (2) High human factor related, dedicated to everything related to behavioral finance, the desires and characteristics of the investors, and those actions in which the human factor plays a major role; and (3) Compliance, including topics related to the regulatory aspects of RA.

Table 7 shows the volume of articles that are related, exclusively or not, to each topic. Interest in everything related to behavioral finance and actions highly related to the human factor has clearly grown in recent years. In fact, this is the most important research topic in our corpus, with 78 articles analyzing this topic in some way and 36 devoted exclusively to it.

Examining the articles that focus on a single theme, we find that theme 1, which encompasses those activities less related to human behavior, is analyzed by the second and third most cited work in our corpus, Chen et al. (2019) (104 citations) and Belanche et al. (2019) (89 citations). Technological in-

novations in the financial sector focus the work of Chen et al. (2019). They show that RA and Blockchain are the most valuable innovations, and that technological innovations are better appreciated if they have been made directly by financial firms than if they come from emerging non-finance firms. Belanche et al. (2019) focus on another aspect related to the acceptance of RA by customers. They conclude that financial institutions must design RA for a wide range of consumers. This implies that the marketing strategy must be tailored to the level of customer awareness of new technologies and to RA in particular.

Table 7. Number of Articles in Each Topic.

	T1	T2	T3
<b>Number of Articles</b>			
<b>2016</b>	1		
<b>2017</b>	12	5	3
<b>2018</b>	30	11	7
<b>2019</b>	35	13	5
<b>2020</b>	28	13	8
<b>2021</b>	56	28	2
<b>2022</b>	11	8	3
<b>Total</b>	<b>143</b>	<b>78</b>	<b>28</b>
<b>Number of Articles Exclusively Dedicated to One Topic</b>			
<b>2016</b>	1		
<b>2017</b>	8	2	1
<b>2018</b>	14	3	5
<b>2019</b>	31	4	2
<b>2020</b>	19	7	5
<b>2021</b>	54	16	1
<b>2022</b>	6	4	2
<b>Total</b>	<b>92</b>	<b>36</b>	<b>16</b>

<sup>3</sup> This corpus is available upon request.



The second topic focuses on issues where the human factor is more important. The papers by Bhatia et al. (2020) and Brenner and Meyll (2020) are the most relevant in number of citations, with 25 citations each. The first one studies whether RA can accurately understand the risk profile of investors, while the second focuses on the advantage of RA for investors concerned about conflicts of interest that may occur in human financial advice.

All aspects related to RA regulation cover our third topic: compliance. Baker and Dellaert (2018), with 40 citations, and Lee (2020), with 12, are the most cited papers on this

topic. The first paper identifies the key questions regulators should be able to answer about RA, and the capabilities regulators should develop to answer those questions. The second one focuses on the legal and regulatory framework that will need to be developed with the introduction of artificial intelligence (AI) into financial services markets.

## 5. RECENT RESEARCH TRENDS

To determine the most recent research trends, we have extracted the main objective of the articles in our initial corpus published in 2022 (see Table 8).

**Table 8. Recent Research Trends in RA.**

First Author	Main Objective (DOI)
A. Alekseenko	Identified the main challenges connected with robo-advising services and proposed key principles of establishing the legal framework for them. (10.1007/978-3-030-87687-6_19)
M. Anshari	Assessed the concept of digital twins as a new wave of intelligent financial advisors, especially their role in supporting the personalization and customization of financial technology (FinTech) services and management. (10.3390/jrfm15040163)
A.C. Brunen	Studied the preferences of sustainable consumers when faced with an all-or-nothing decision between a conventional portfolio and a sustainable one, managed by a digital financial advisor. (10.1016/j.jbankfin.2021.106314)
R. Caballero Fernández	Compared the performance of an investment portfolio chosen by expert analysts against one that uses strategies similar to those of RA. (10.1007/978-3-030-94485-8_13)
M. Chhatwani	Examined whether robo-advisory increases retirement worry based on agency and rational choice theory. (10.1108/MF-05-2021-0195)
C. Flavián	Studied how clients' technological literacy affects their acceptance of robo-advisor. (10.1108/JOSM-10-2020-0378)
S. Fritz-Morgenthal	Provided practical advice for establishing a risk-based governance and testing framework. Discussed the use of recent technologies, approaches, and platforms to support the establishment of responsible, reliable, accountable, explainable, auditable, and manageable Artificial Intelligence or Machine Learning. (10.3389/frai.2022.779799)
R.H. Huang	Critically assessed the regulation of robo-advisors in the US, UK, Singapore, China, and Hong Kong. (10.1080/14735970.2021.2012884)
Z. Li	Proposed a new model of portfolio selection with mental accounts. (10.1016/j.cor.2022.105801)
X. Liu	Analyzed the risk assessment and regulation algorithms of robo-advisory service platforms from three perspectives: platform, corporate, and investor characteristics. Explored the construction of a robo-advisory service platform risk prediction model, based on the machine learning perspective. (10.1155/2022/9903364)
R. Manrai	Investigated investors' perceptions of artificial intelligence, robo-advice services, and the behavioral factors influencing investors' intention to adopt them. (10.1057/s41264-021-00134-9)
D.M. Piehlmaier	Studied consumer behaviour relating to better positioning of the robo-advisor. (10.1186/s40854-021-00324-3)
S. Shan	Assessed the performance of robo funds, taking into account their investment exposure to carbon-emitting enterprises. (10.1016/j.techfore.2022.121694)
S.C. Tsai	Explored the current practical use of an AI robo-advisor algorithmic technique. (10.3390/asi5010015)
B. Von Walter	Examined whether consumers' lay beliefs about artificial intelligence (AI) influence the adoption of algorithmic advice. (10.1007/s11002-021-09589-1)
M.N. Wexler	Explored the implications for the sociology of professions influenced by robo-advice, as a first example of successfully programmed algorithmic knowledge managed by artificial intelligence. (10.1108/IJSSP-09-2021-0245)
K.W. Zheng	Examined the main drivers of intentions to adopt robo-advisors, explaining the robo-advisor adoption process among Malaysian retail investors. (10.1007/978-3-030-82616-1_54)

As can be seen from the objectives of the works collected in Table 8, the latest works on RA have focused on the topics 1 (Low human factor) and 2 (High human factor) described in the previous section. Given that topic 1 is very cross-cutting

and covers a wide range of activities involved in the implementation of RA, it seems logical that this subject is among the most studied. Once the problems related to the implementation and development of the RA are deeply studied, it

seems that researchers focus on other aspects of RA more related to the human factor. So, during first months of 2022, special importance is given to aspects related to customer acceptance in the use of RA (see, for example, Zheng et al. 2022, Von Walter et al. 2022 or Phiehlmaier 2022). Other topic of interest is the importance of the Artificial Intelligence used in RA to be understandable, reliable, and trustworthy to the investors (Flavián et al. 2022, Fritz-Morgenthal et al. 2022). Finally, the legal aspects included in topic 3 (Compliance) are also still of interest (Alekseenko 2022, Huang et al. 2022).

## 6. CONCLUSIONS

In this article, the Scopus and WoS bibliographic databases were merged to expand the number of references analyzed and thus obtain more consistent results. Through a corpus of 219 RA studies published until May 21, 2022, the current study offers a state-of-the-art map on the subject of RA. First, we reviewed the publications in our dataset from a bibliometric point of view, an analysis showing that the number of publications tripled in 2018 compared to 2017. In terms of journal distribution, the *Journal of Behavioral and Experimental Finance* was ranked first, with 7 papers. *Frontiers in Artificial Intelligence and Sustainability* tied for second, with 6 documents each.

The results obtained answer the two research questions posed in the introduction to this paper. *How mature is the research on RA?* It can be concluded that research into RA is at an early stage, in line with the level of development of the business. In relation to research production, the field's low degree of maturity is reflected in the small number of research documents (219) in our corpus, also indicated by the fact that the first paper was published in 2015. In 2018, there was an important quantitative leap in research, as production tripled compared to the previous calendar year (2017). *Is there a concentration of research work?* There is considerable concentration within the extant research, in both authors and countries. D. Jung is the most productive author, and the USA is the country in which the most papers about RA have been published.

After reading the abstracts in our corpus, we set out to answer an additional question: *which are the central subjects inside the research?* We have found three main themes, those dealing with activities that do not involve human interaction, those focusing on activities that do involve human interaction, and finally those focusing on the legal aspects of the implementation and use of RAs.

As the first one covers very different topics such as the application of new quantitative algorithms related to the ability to estimate profitability and risks, interpretation of financial variables and objectives of optimization of investment portfolios and other cross-cutting aspects as the use of artificial intelligence or chatboxes to implement RA; it is the one with the largest number of papers. However, it is worth highlighting the interest that has been aroused over the last year in everything related to customer acceptance of RA, a subject that belongs to the second of the aforementioned topics.

Finally, this study is a valuable resource for researchers, as it summarises the current state of knowledge in the RA field.

At the same time, this paper's findings play a key role in the academic trends related to RA research, drawing clear guidelines for future researchers and practitioners in financial markets.

The main limitation of this type of literature review studies is that they are static and show the situation at a given time. As we have seen RA is a very novel field of research and the number of papers focusing on it is always increasing. We did our search in May 2022, and since then the number of articles has increased, which shows the enormous interest that the scientific and professional community has in the subject.

## AUTHORS' CONTRIBUTIONS

The first author contributed by retrieving literature, conducting data analysis, and writing the paper. The second and third author contributed by retrieving literature and writing the paper. All authors read and approved the final manuscript.

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## AVAILABILITY OF DATA AND MATERIALS

Data used in this paper were collected from Scopus and WoS.

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## COMPETING INTERESTS

The authors declare that they have no competing interests.

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