Visualizing the Evolution and Knowledge Landscape of Adaptive Market Hypothesis (2004-2022): A Scientometric Analysis

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ABSTRACT

The purpose of the paper is to find the evolution of the 'Adaptive Market Hypothesis (AMH)' by bibliometric and scientometric analysis between the calendar years 2004 and 2022. We used a scientometric approach by taking 148 documents from the Scopus database. The study attempts to identify prominent authors, significant journals, most cited papers, countries, organizations, co-authorship network analysis map, inter-country evolution, and keyword occurrences in scholarly engagement. The analysis also uncovers the conceptual structure and thematic evolution of the topic. Biblioshiny and VOSviewer performed the tabular and visual mapping for the different scientometric dimensions. The study lays out an instant snapshot of the AMH knowledge domain.

Keywords: Adaptive Market Hypothesis, Bibliometric, Scientometric, Mapping

Introduction

In the past few decades, the Efficient Market Hypothesis (EMH) has been one of the most prominent notions. It proposes that market prices instantly and rationally integrate all available information. Nonetheless, the rising field of behavioural economics and finance has refuted this theory by suggesting that markets are driven by fear and greed rather than rationality. Andrew Lo, an MIT professor, proposed the Adaptive Market Hypothesis (AMH) concept in 2004, which reconciles market efficiency with behavioural alternatives by applying the principles of evolution to financial interactions. AMH is essentially an alternative economic theory that combines EMH with behavioural finance. The creator of this theory says that people are generally reasonable but can occasionally overreact during periods of greater market volatility. The theory asserts that people are motivated by their self-interests, make mistakes, and generally adapt and learn from them. In particular, the Adaptive Markets Hypothesis is a novel version of the EMH based on evolutionary concepts.

A fine amount of literature review regarding AMH would be insightful to analyze the literature scientometrics perspective. The crux of EMH is markets are efficient but ignore the investors' behavioural aspect, which is a fundamental block in the investor cognitive process and decision-making. The adaptive Market Hypothesis is vital as it combines traditional financial economics with behavioural models and favours their coexistence. as it is an emerging topic, it has been observed that no study has applied a scientometric approach to mapping the AMH research patterns. According to Boyack and Klavans (2010) co-citation is vital for the scientometrics method. Certain research areas by different scholars have been using the scientometric approach. However, there needs to be more attention towards the adaptive market hypothesis in this regard. It indicates a significant

opportunity for researchers in these domains to conduct bibliometric analysis on their scholarly work. Newly established scientometric approaches have been used in this study to facilitate the understanding of the adaptive market hypothesis domain, which may prove valuable for relevant researchers in the future.

The study also intends to trace and evaluate the evolution of the knowledge domain on AMH rather than resolving the controversy and criticism of the theory and field development. Since its inception in 2004, there has been a lot of discussion on AMH, accompanied by certain reservations that have been considered the building blocks of the theory. This scientometric study helps set the stage for future research by defining significant features of past research. The relevant stakeholders can trace the evolution of AMH research for practical implications. It would not only help in understanding the key aspects of the theory but also aim to make further improvements in the field. By analyzing the bibliometric data from 2004 to 2022, this work has added depth and enriched scholarly engagement on AMH by using scientific mapping analysis and bibliometric coupling. Bibliometric analysis has been conducted using the VOSviewer and Biblioshiny (R package) to create a conceptual structure map and three-field plot, along with a treemap and word cloud. Present a bibliometric analysis of the Adaptive Market Hypothesis using a scientometric approach in contribution to the existing literature.

Following the literature the paper deals with the methodology, data, and research design with an introduction to bibliometrics and scientometrics. The bibliometric and scientometric study results are presented in next section, followed by a discussion of the key findings and a visual representation of the investigation. Findings, limits, practical consequences, and directions for future research are discussed , followed by a conclusion

Objectives

The scientometric analysis intends to:
○ identify citation trends and publication frequency of AMH in the defined time period
○ evaluate the evolution of knowledge domain on AMH rather than resolving the controversy and criticism on the theory
○ frame historical research dimensions regarding AMH for future studies
○ facilitate the understanding of AMH domain for the relevant researchers in the future

Research Methodology

Introduction to Bibliometrics and Scientometrics

Bibliometric analysis is a statistical and mathematical technique used to analyze data from books, , peer-reviewed journal articles, periodicals, reviews, reports,conference proceedings, and related documents (Ellegaard and Wallin, 2015; Aria & Cuccurullo, (2017). The term was first coined by Pritchard in 1969 as a technique to measure, assess, compare, and rank publications, trace relationships and identify research trends (Kalantari *et al*., 2017; Majeed,& Ainin, 2021). Bibliometrics can be employed extensively in qualitative and quantitative research methodologies for analyzing the contents, references, citations, and authorship of publications.

Scientometrics is a sub-field of the bibliometrics' scientific domain which involves the quantification and evaluation of the impacts of science, technology, and innovations and the use of such measurements in policy and governance processes (Leydesdorff and

Milojević, 2015). Scientometric endeavors to estimate the impact of publications and their authors in influencing knowledge development. Furthermore, it provides an insight into the impact of scientific citations as a medium for scholarly communication, mapping of intellectual landscapes and production of focus indicators as used in the assessment of research performance and productivity (Bornmann and Leydesdorff, 2014).

Data Organization and Sampling

This research makes use of Scopus as *it focuses mainly business research*, a widely-used academic search database, to give readers an in-depth look into global research output in fields like management, accounting, business, and the social sciences more generally. Both bibliometric and scientometric analyses provide legitimate ways to learn about past research and anticipate future advancements in the field, making them useful for a wide range of purposes (Morant and Soriano, 2016). The reason behind using Scopus database is that it covers social sciences research.

The Scopus search engine was used to retrieve 148 documents pertaining to AMH research published between 2004 and 2022 for this investigation. An initial set of papers was chosen from all Scopus citations that had the phrase "Adaptive Market Hypothesis" in their titles. Given AMH's pervasive influence, I've amassed a body of research on the hormone from a variety of disciplines (i.e. Business, Economics, Econometrics and Finance, Decision Sciences, Management and Accounting, Social Sciences). In this investigation, we employed bibliometric indices such as authors, language, journals, nations, and areas of expertise. All told, the sample size is 148, all of which are either articles or reviews. The selection criteria used for the research documents are listed in Table 1.

Table 1: Documents Selection Criteria

Sr.	Search Steps	Records
1.	All documents with the word "Adaptive Market Hypothesis" in the title	181
2.	Limit to Language: English	177
3.	Limit to Subject Area: Business, Economics, Econometrics and Finance, Decision Sciences, Management and Accounting, Social Sciences	153
4.	Limit to Document Type: Articles and Reviews	148
5.	Limit to Publication Stage: Final	148

Following Scopus query has been used for fetching the required data:

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TITLE-ABS-KEY ( "Adaptive Market Hypothesis" )  AND  ( LIMIT-TO
( LANGUAGE , "English" ) ) AND  ( LIMIT-TO ( SUBJAREA , "ECON" )  OR
LIMIT-TO ( SUBJAREA , "BUSI" )  OR  LIMIT-TO ( SUBJAREA , "SOCI" )  OR
LIMIT-TO ( SUBJAREA , "DECI" ) )  AND  ( LIMIT-TO ( PUBSTAGE ,
"final" ) )  AND  ( LIMIT-TO ( DOCTYPE , "ar" )  AND  ( LIMIT-TO
( DOCTYPE , "re" ) )
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Research Design

To find out the evolution of the research regarding Adaptive Market Hypothesis (AMH), a statistical historical analysis has been conducted. The reason being the theory was introduced by Lo(2004). The collected references across the aforementioned time frame

have allowed us to identify recurring themes related to AMH in the fields of business, , economics, accounting & finance, management . This allows us to see the big picture of the AMH field and how it has evolved over the past 16 years. We have used the statistical programme R with the Biblioshiny package and the VOSviewer science mapping programme to do this . These software packages facilitate a variety of investigations by combining various clustering and visualisation methods.

Data Analysis and Results
Main Information about Data

Table 2: Data Information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2004:2022
Sources (Journals, Books, etc.)	95
Documents	148
Annual Growth Rate %	16.24
Document Average Age	4.22
Average citations per doc	18.7
References	6985
DOCUMENT CONTENTS	
Keywords Plus (ID)	137
Author's Keywords (DE)	385
AUTHORS	
Authors	248
Authors of single-authored docs	23
AUTHORS COLLABORATION	
Single-authored docs	28
Co-Authors per Doc	2.39
International co-authorships %	24.32
DOCUMENT TYPES	
Article	143
Review	5

Table 2 summarizes the main information about data used for the analysis. The data reveals that that 148 documents have been taken from 95 journals for a time period from 2004 to 2022.

Author Citation and Co-citation Analysis

Figure 1 and Table 3 highlights top-ten authors in the research related to Adaptive Market Hypothesis. A detailed evaluation in the table shows that prominent authors are Urquhart A with 7 published articles followed by Khuntia S, Madhavan V, Muzindutsi P, and Pattanayak J.K with 6 published articles each. Hiremath G.S, Kim J.H, Lo A.W and Obalade A have also made some contribution with 5 published articles each. Lo A.W, who proposed the theory, is the author with maximum citations. Kim J.H and Urquhart A follow with 354 and 288 citations, respectively. Khuntia S, Pattanayak J.K and Hudson R. are also prominent authors with 139, 139, and 138 citations. Figure 1 presents the most productive authors and article publication yearly representing by node-size.

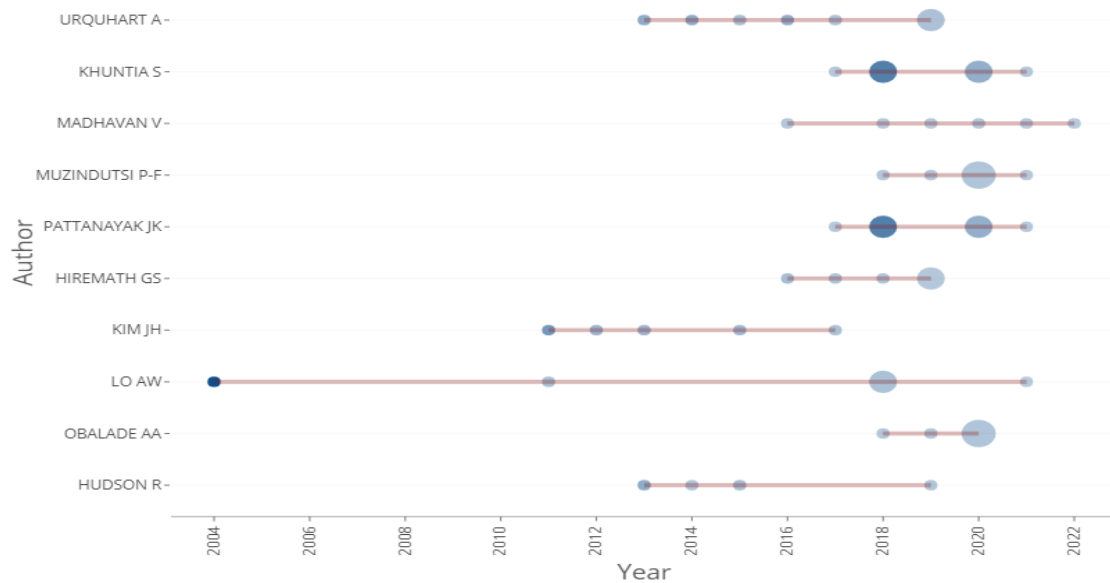**Figure 1: Prominent Authors of AMH Research**

Table 3: Top 10 authors in AMH Research

Author	Article	R	Citation	R	Cit./Article	R
Urquhart A.	7	1	288	3	41.14	3
Khuntia S.	6	2	139	4	23.17	5
Madhavan V.	6	3	14	8	2.33	9
Muzindutsi P.-F.	6	4	13	9	2.17	10
Pattanayak J.K.	6	5	139	5	23.17	6
Hiremath G.S.	5	6	48	7	9.60	7
Kim J.H.	5	7	354	2	70.80	2
Lo A.W.	5	8	753	1	150.60	1
Obalade A.A.	5	9	13	10	2.60	8
Hudson R.	4	10	138	6	34.50	4

Author co-citation analysis has been used for some time as a great method for uncovering the underlying logic of a research topic, but it is based on simple co-citation counting, which ignores the citations' actual contents. Figure 2a and 2b represents the co-citation author network visualization and citation network density visualization, which have been developed through VOSviewer.

Figure 2a: Co-Citation-Author Network Visualization

Figure 2a: Co-Citation-Author Network Visualization

Figure 2b: Citation-Author Density Visualization

Figure 2b: Citation-Author Density Visualization

Analysis by Year

Although research on the Adaptive Market Hypothesis began in 2004, there were few published articles until 2014. Since 2015, the number of studies has increased, and research on AMH has increased significantly since 2019 onward. Figure 3a depicts the evolution of annual advancement, and after 2018 a large increase may be noted. Figure 3b's trend of citations demonstrates that the biggest number of citations occurred in 2004, the year in which the adaptive market hypothesis emerged.

Figure 3a: Annual Scientific Production
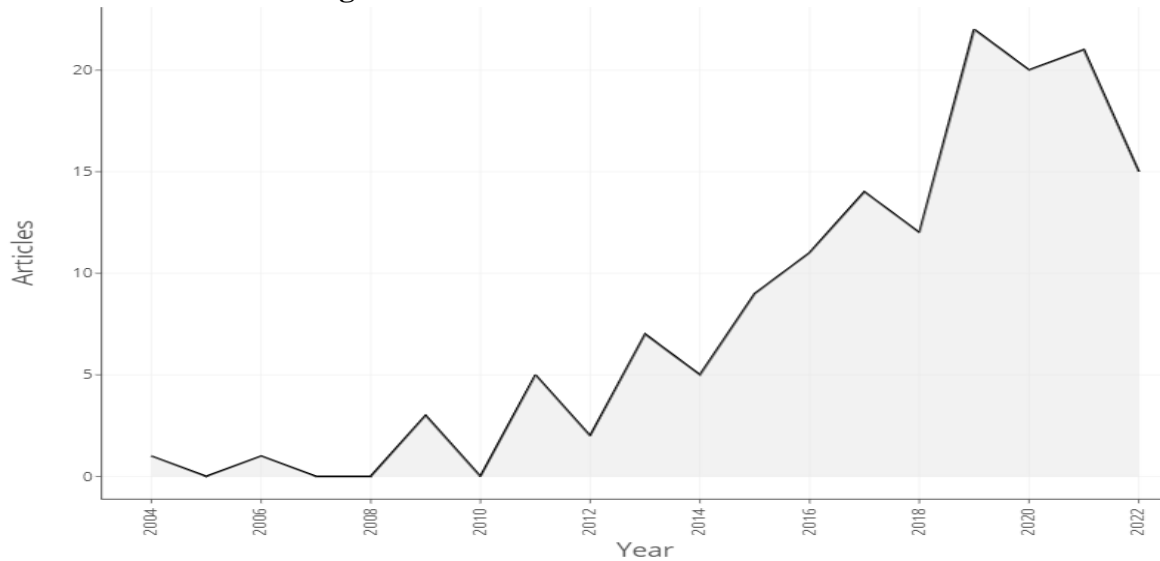
Figure 3b: Average citations per year
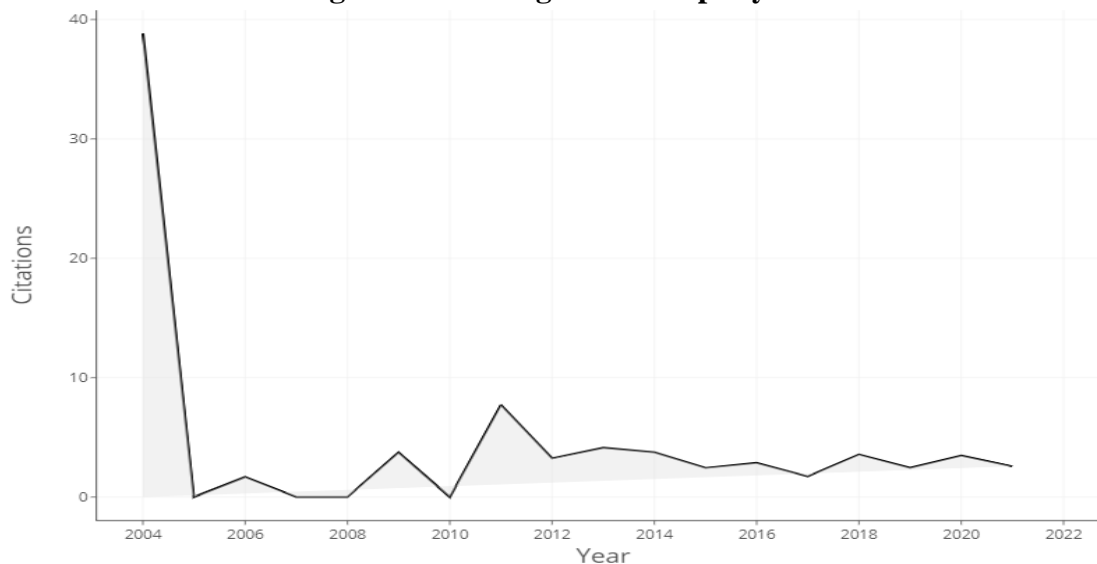
Analysis by Source/Journal

One of the important aspects of bibliometric analysis is to identify the top journals and their overall productivity in the relevant research field. Figure 4a reflects the number of articles published by top ten journals from the Scopus database. Figure 4b visualized the density

map of the contributions made for the research on AMH by different journals. Figure 4a and Table 5 show that Finance Research Letters is the most dynamic and important journal in AMH research, publishing 9 articles in total, followed by International Review of Financial Analysis with 7 articles of significance, and finally, Research in International Business and Finance with 5 articles of significance. Similarly, mapping density map provide approximate same results shown by Figure 4b. As far number of citations are concerned, International Review of Financial Analysis is leading the list.

Figure 4a: Top journal with the research on AMH
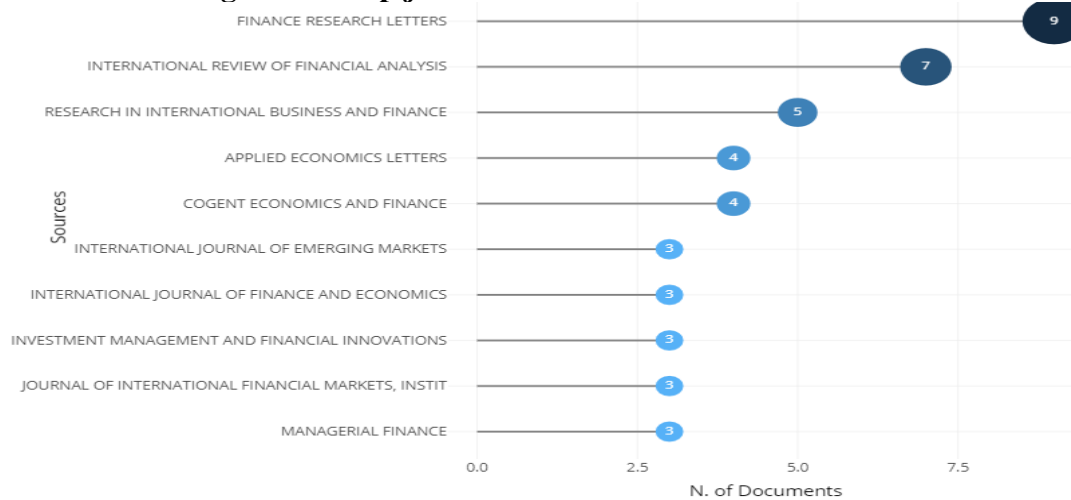
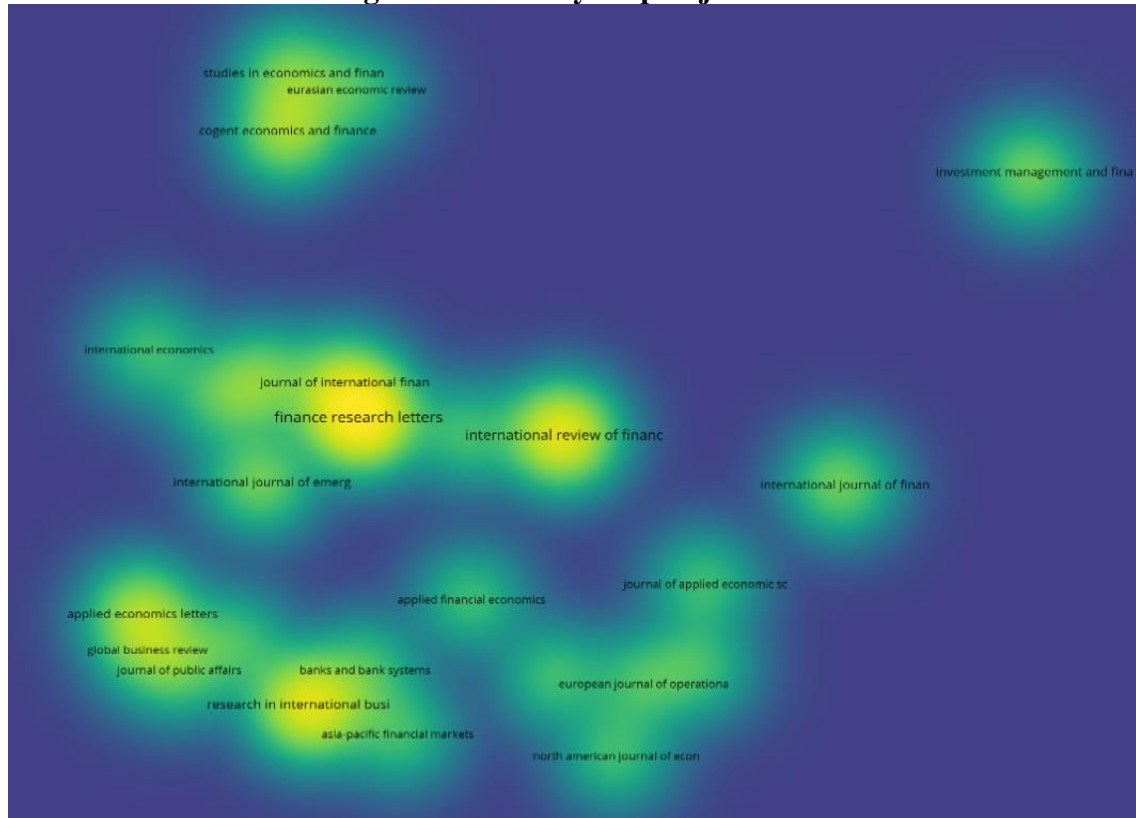
Figure 4b: Density map of journals

Table 5 - Top 10 journals with most publications in research on AMH

| Source	Articles	R	Citations	R	Cit./Art.	R
Finance Research Letters	9	1	189	2	21.00	3
International Review of Financial Analysis	7	2	332	1	47.43	1
Research in International Business and Finance	5	3	76	3	15.20	5
Applied Economics Letters	4	4	15	6	3.75	8
Cogent Economics and Finance	4	5	14	7	3.50	9
International Journal of Emerging Markets	3	6	12	8	4.00	6
International Journal of Finance and Economics	3	7	12	9	4.00	7
Investment Management and Financial Innovations	3	8	30	5	10.00	4
Journal of International Financial Markets, Institutions and Money	3	9	67	4	22.33	2
Managerial Finance	3	10	9	10	3.00	10

Analysis by Country

According to the report, India is the most productive nation to have published 28 Adaptive Market Hypothesis research articles between 2004 and 2022. It is followed by the United Kingdom with 26 articles, the United States with 21, South Africa with a close margin of 18 articles, Australia with 11, Malaysia with 10, and China with 9 articles. Each of France, Iran, Japan, Mexico, Pakistan, Spain, and Romania contributes four articles.

**Table 6:** Top 15 countries (Number of articles and citations)

Country	Articles	R	Citations	R	Cit./Art.	R
India	28	1	231	5	8.25	10
United Kingdom	26	2	491	3	18.88	6
United States	21	3	1047	1	49.86	2
South Africa	18	4	44	10	2.44	14
Australia	11	5	640	2	58.18	1
Malaysia	10	6	447	4	44.70	3
China	9	7	120	7	13.33	7
France	4	8	123	6	30.75	4
Iran	4	9	50	9	12.50	8
Japan	4	10	87	8	21.75	5
Mexico	4	11	11	14	2.75	13
Pakistan	4	12	13	13	3.25	12
Romania	4	13	4	15	1.00	15
Spain	4	14	42	11	10.50	9
Ukraine	4	15	20	12	5.00	11

Figure 5a: Cluster of countries studying AMH
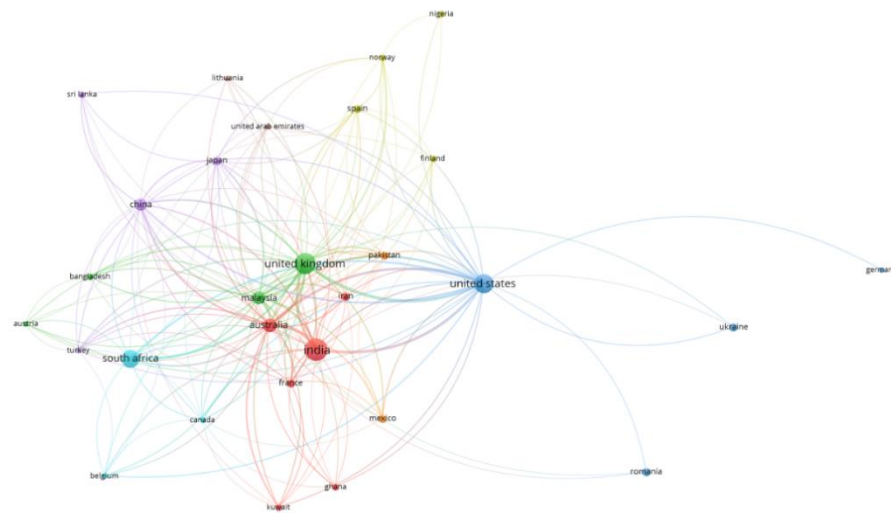
The Asian stock exchanges are considered as the special case studies, which is the reason behind the domination of India in AMH publications. United State of America, however, leads specifically with reference to the highest number of citations i.e., 1,047. Australia, UK, and Malaysia follow with 640, 491 and 447 citations, respectively. Figure 5a and 5b shows the cluster of countries studying adaptive market hypothesis and density visualization of countries' contributions in the field.

Figure 5b: Density visualization of countries
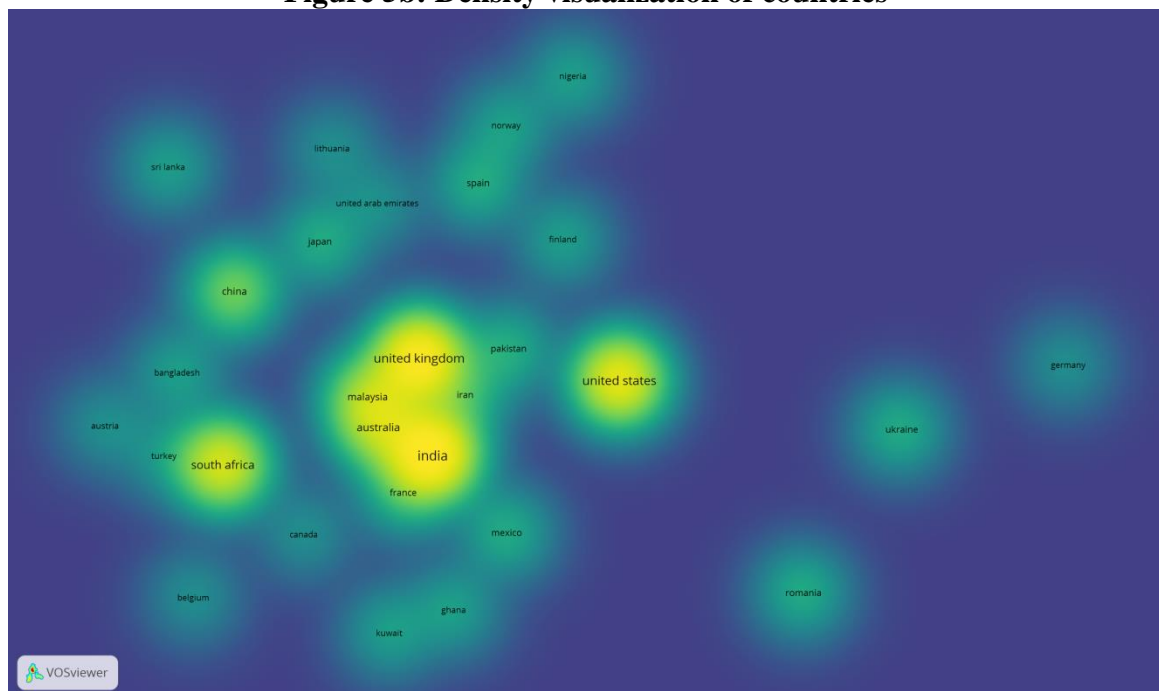
Analysis by Organizations

In the context of AMH research, University of Southampton has been identified as the leading organization with 12 articles, followed by University of Kwazulu-Natal with 10 articles and Indian Institute of Technology with 9 articles.

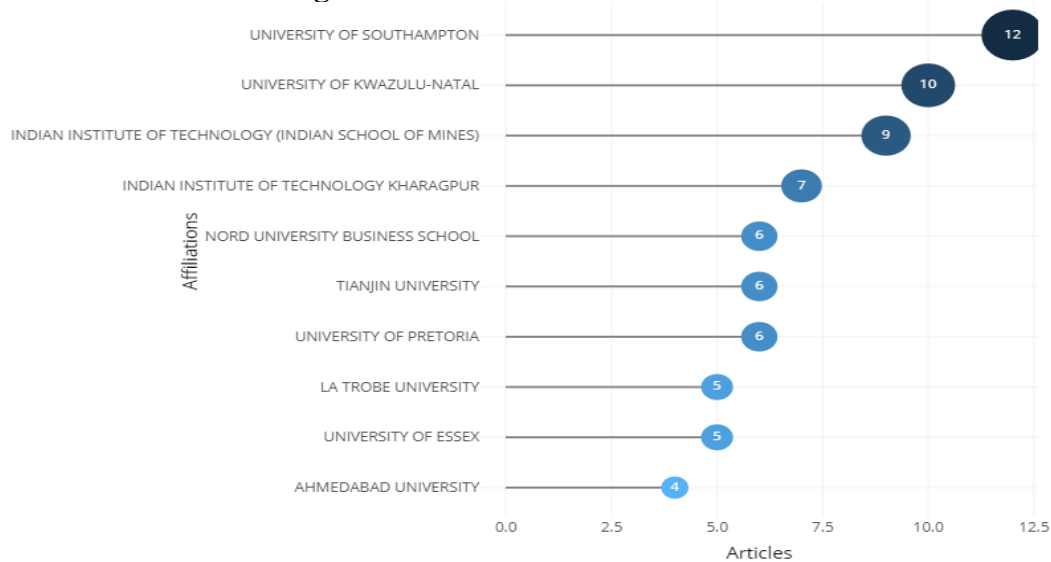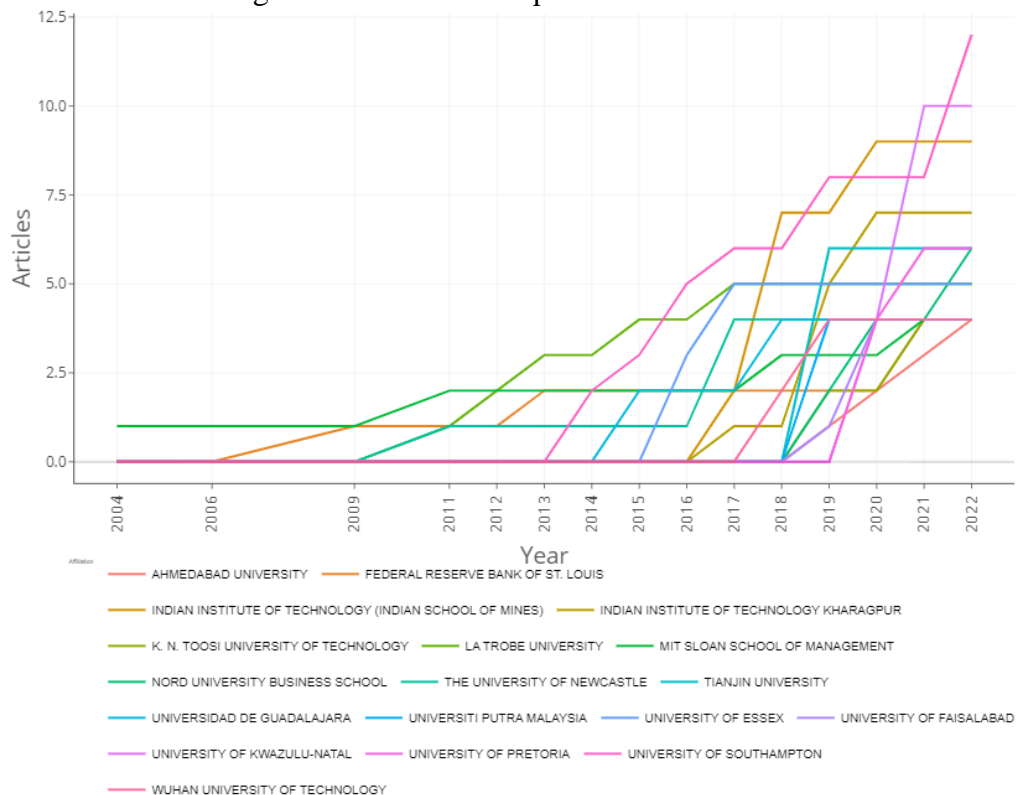**Figure 6a: Most relevant affiliations**

Figure 6a depicts the top ten most relevant affiliations dealing with the research on the theory of adaptive market hypothesis. Figure 6b reveals the affiliations' production in the research area over time.

Figure 6b: Affiliations' production over time

Keyword Co-occurrence Analysis

Analysis of keyword co-occurrence has been utilised in order to categorise developing themes in AMH research as well as the development of that study over time. It is essential and important for authors to assign the keywords, as the co-occurrence of keywords demonstrates the frequency with which they appear in publications. Figure 7a presents a comprehensive and high-level overview of the keyword co-occurrence study.

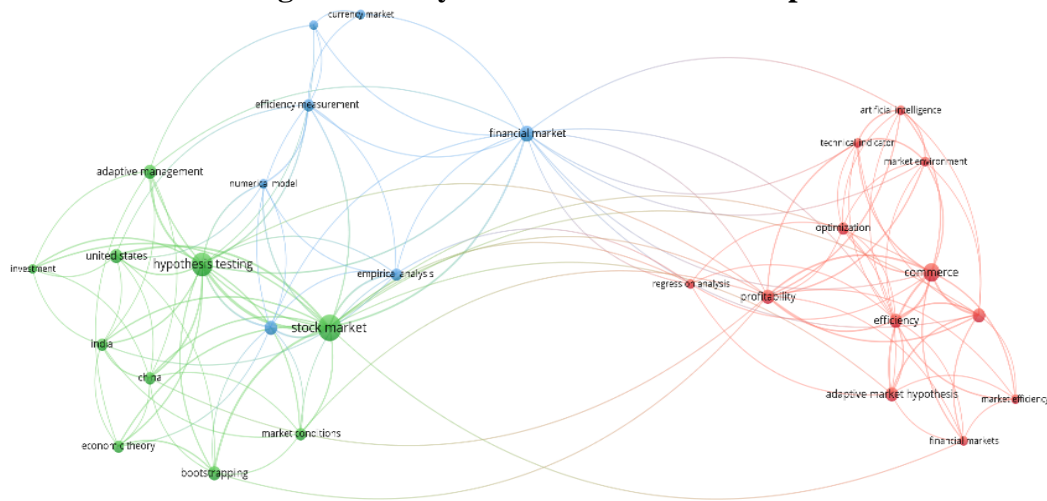**Figure 7a: Keywords co-occurrence map**

Figure 7b displays a word cloud that was generated using the R software, while Figure 7 displays a word tree map. Word clouds, often called tag clouds, are visual representations of the frequency with which a certain term is used. A bigger number of occurrences of the word with the higher frequency will be seen on the grid, and the inverse will also be true. The sudden increase in the use of keywords is illustrative of developing trends in research. Some of high-frequency keywords include adaptive management, market efficiency, prediction, empirical analysis, financial market, efficiency measurement and efficient market hypothesis. The word cloud shows that there has also been some work on AMH specifically with reference to COVID-19.

Figure 7b: Word cloud

Figure 8: The word Tree-Map

Tree-map analysis plays a vital role in identifying the fascinating research areas and ascertain the gaps on AMH research because the researchers keep on inserting multiple keywords frequently. Figure 8 exhibits a tree-map by exhibiting data as nested rectangles depicting the notable keywords used in the articles relevant to the theory. We provide an

illustrated natural-language-based word-grouping hierarchy of data sets relevant to AMH studies while the size axis and the colour scheme show the connection and significance, respectively. The tree diagram emphasises the clustering of keywords that may represent the AMH, whereas the tree diagram emphasises the clustering of keywords that may stand for the AHM.

Conceptual Structure Mapping

The conceptual structure map connected with AMH research conducted over the course of 19 years is depicted in Figure 9, with the two distinct clusters represented by the colours red and blue respectively. In other words, it is possible to say that the ensuing conceptual structure map divides the intellectual structure of AMH research into two distinct clusters. This is something that can be asserted because the map was created. The majority of the keywords were kept by the cluster that was coloured red (e.g., adaptive market hypothesis, market efficiency, commerce, efficiency). It seems that issues like the efficient market hypothesis and profitability are included in the second cluster, which is blue and is the smallest of the three. A limited number of researchers have looked at the issues that are covered in this grouping of themes. The words have been put together using the K-means clustering technique, with the emphasis being placed on the regularity of the terms. The K-means clustering method is a technique that is utilised for the purpose of clustering analysis, particularly in the fields of data mining and statistics. Its purpose is to divide a group of observations into a number of distinct groups (k). The similarity and closeness in the distribution illustrates how successful the conceptual structure diagram of the bibliographical data frame is. [Citation needed] The data indicate, on the whole, that the adaptive market hypothesis cluster has exerted a preponderant amount of influence over AMH research.

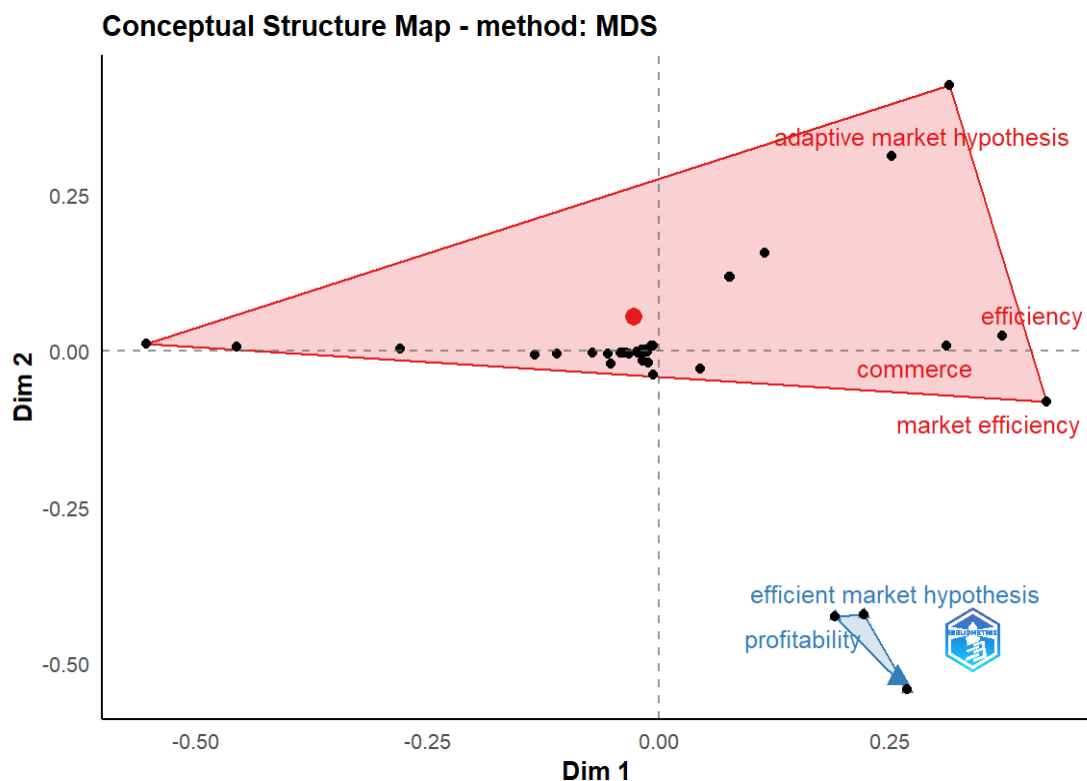**Figure 9: Conceptual Structure Mapping**

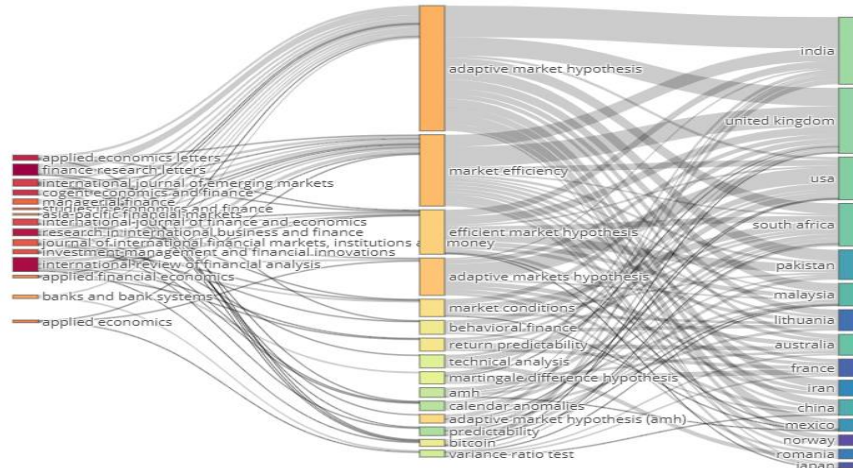**Figure 10: Three-field plot (Sankey Diagram)**

Figure 10 is a three-field map, also called a Sankey diagram, that has been used to analyse the "flow" between the original (on the left), primary (in the middle), and target (right) countries (right side). The three-field plot illustrates the general direction of flow between three or more variables. In a three-field plot, the sizes of the boxes and the thicknesses of the connecting arrows reflect the values and amounts depicted (Soundararajan et al. 2014). The three-field plot displays the theme designated by the keyword with the highest degree.

Figure 11: Thematic evolution
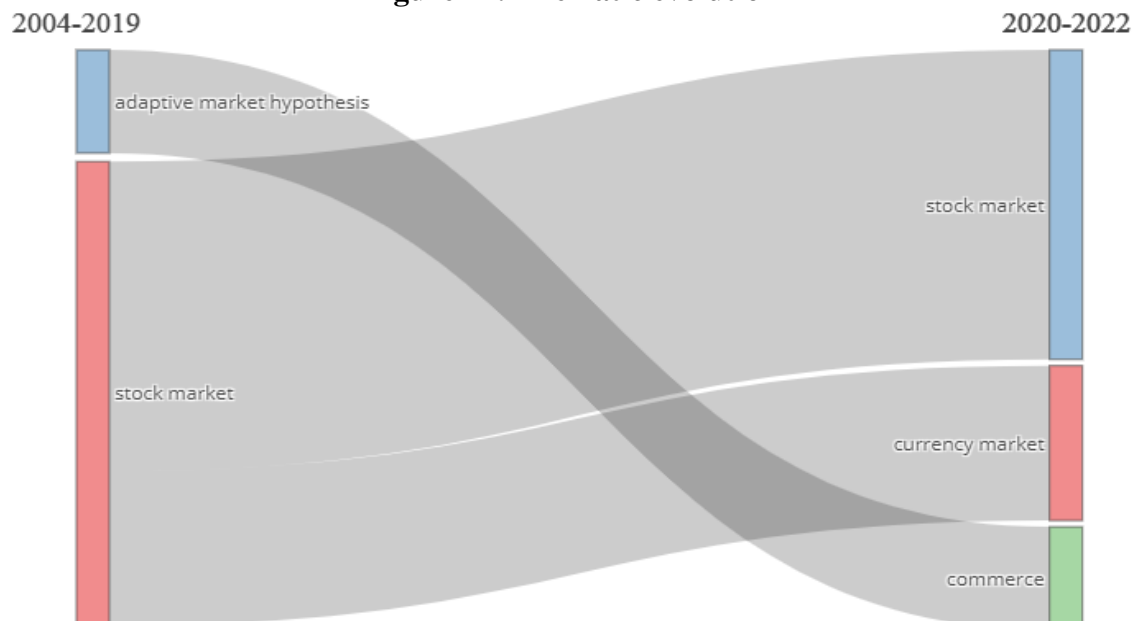
Thematic evolution has also been presented in Figure 11, which reveals that there have been two main themes i.e., adaptive market hypothesis and stock market in the studies

relevant to AMH up to 2019. From 2020 to onwards, however, few more themes including currency market and commerce have also been taken as basic themes in the studies relevant to the theory.

Discussion

The bibliometric and scientometric analysis of the research on adaptive market hypothesis reflects that the research have been conducted into several disciplines with numerous notable journals and in different countries. From a scholarly perspective, this research can help experts in the field of AMH better understand the processes at play in personal finance. Scientific mapping and bibliometric analysis were used to visualise and track the development of the subject across time, identifying key authors, journals, institutions, and nations. The results of the study can offer significant implications for the assessment of research relevant to adaptive market hypothesis. Though a reasonable sample in AMH literature has been collected by utilizing the Scopus database, however, there are certain limitations. As the research articles and review papers have been considered for the study, so the future research may be conducted by considering all other types of documents with a different selection criterion in Scopus. The study conducted on research in AMH from 2004 to 2022 aims at offering a richness in the findings through raw data, hence employing an inductive approach. The primary focus of the study is to ascertain the evolution and landscape of adaptive market hypothesis.

Conclusion

In the recent time, academic and practitioner communities are paying noticeable attention towards the field of behavioral finance. The sociological backdrop of the debate on efficiency market hypothesis suggests that an alternative to the traditional approach might be necessary. In this context, the AMH attempts to counter the EMH theory with the argument made by behavioral economists. EMH states that the markets are rational and efficient while the behavioral economists and proponents of AMH suggest that they are irrational and inefficient. This study has been conducted to determine the development of research on adaptive market hypothesis. The application of bibliometric tools not only reveals improbable potential for investigating the research environment, but also provides the quantitative approach taken by the researchers. Bibliometric techniques and the scientometric method are widely used by scientists as the standard for data presentation and the creation of scientific maps. From the analysis, the information regarding key authors, significant journals, countries, and affiliations has been revealed. The conceptual structure of the AMH has been assessed through thematic clusters and thematic evolution. There are certain limitations as well with reference to the study. The database used for the study is Scopus while further studies may be conducting by including other databases including Dimensions, Web of Science etc. Summing up, this study is particularly relevant for researchers who are dedicated to work in the fields of market efficiency and behavioral finance.

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