Footprints of Cryptocurrency: A Bibliometric Review

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ABSTRACT

The growing popularity, the exponentially expanding market size, and the volatility of Cryptocurrency are gaining the attention of all, whether it is investors, policymakers, miners, or academicians. So, this paper has used Bibliometric analysis to explore the existing works of literature in the area of Business, Finance, and Economics. We have reviewed and analysed 1344 articles extracted from the Web of Science core collection, Clarivate Analytics of the period from 2011 to mid-2022 using VOSviewer and Biblioshiny (Biblimetrix: R package) analytical tools. This paper has presented citations, publications, and the impact of sources, documents, authors, organizations, countries, etc., along with their relationships with the help of tables, charts, and network diagrams. The analysis shows exponential growth in the last 4-5 years. Bitcoin and Cryptocurrency (or Cryptocurrencies) are the most frequent keywords. With many ups and downs, cryptocurrency is maintaining its pace with a gradual increase in its acceptability worldwide.

Keywords: Cryptocurrency, Bitcoin, Bibliometric analysis, Biblioshiny, VOSviewer
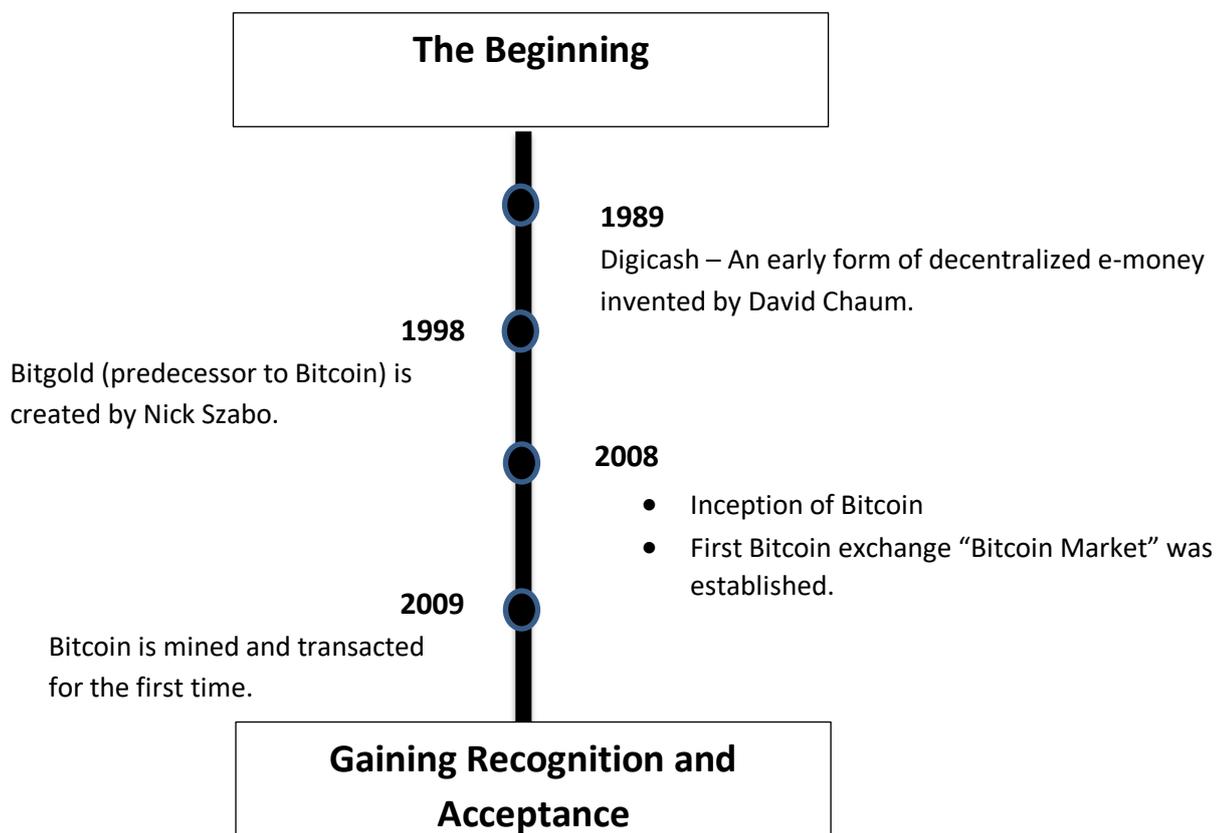
JEL Classification

INTRODUCTION

In the world of digitization, everything is going digital. The currency is also taking a digital face. Cryptocurrency also is the result of this digitization race. Cryptocurrency is a type of decentralized digital currency which had presence for a long time but has come into the picture after the inception of Bitcoin in 2008, which was developed by a pseudonymous developer Satoshi Nakamoto. The first commercial transaction involving Bitcoin happened in 2010 (History of the Cryptocurrency market in India, 2021). After that, in 2011, other cryptocurrencies like Namecoin, Litecoin, etc. commonly known as Altcoin (Cryptocurrencies other than Bitcoin), started to emerge. In such a short span of a decade, cryptocurrency has exploded onto the scene and has grown at an ever-increasing rate.
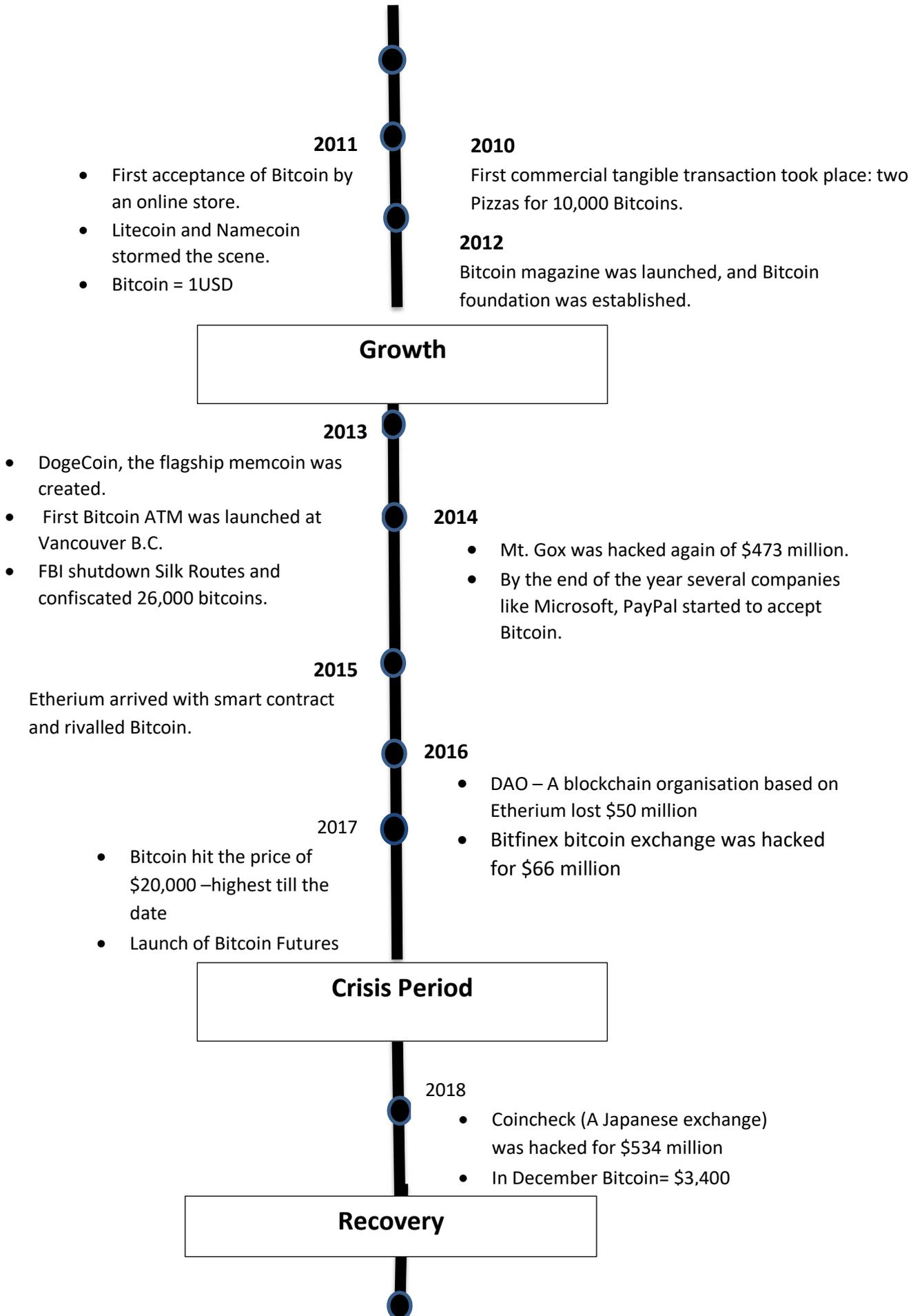
As the topic (cryptocurrency) has attracted investors, academicians, writers, etc. towards it because of its unique features. It is becoming impossible to keep up with everything being published due to the rapid increase in academic publications (Briner & Denyer, 2012). This really hampers the ability to accumulate knowledge and to actively collect evidence through the set of previous research works. Therefore, Literature Review studies are becoming crucial in synthesizing past research findings for effective use of the existing knowledge base, advancing a line of research and providing evidence-based insight into the practice of exercising and sustaining professional judgment and expertise (Rousseau, 2012). So, this paper has used one of the popular review techniques known as Bibliometric Analysis. Bibliometric analysis is the use of statistical methods to analyse the bibliometric publications data such as peer-reviewed journals, articles, books, conference proceedings,
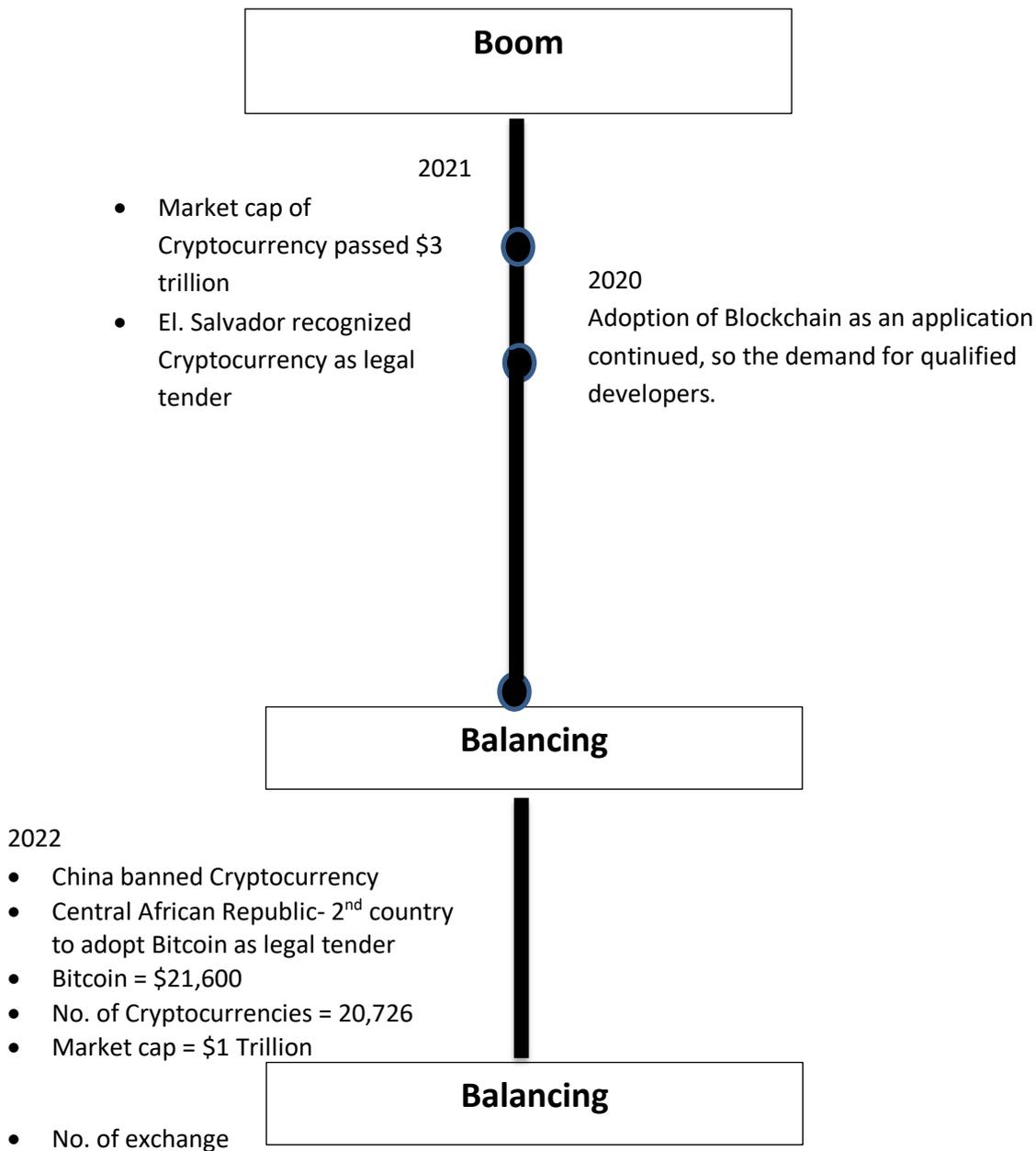
periodicals, reports and related documents. It is widely used to present the relations of research domains with quantitative methods (Ali et al., 2021)

Development

The idea of cryptocurrency begun to evolve in the late eighties. Digicash invented by David Chaum was an early form of decentralized e-money. Decentralization which became the central characteristics of the modern cryptocurrencies. After that there were many attempts to create cryptocurrencies and some of them got success too. Bitgold was one of them, which is regarded as predecessor to Bitcoin. The cryptocurrency idea got solidified after the inception of Bitcoin in 2008. Since 2010, cryptocurrency in the form of bitcoin stated its role playing in the commercial world with the historical transaction of two pizzas for 10,000 bitcoins. Other cryptocurrencies i.e., altcoins were continuously being created along with other related developments. Many cryptocurrency exchanges were created, and ATMs were installed to support its commercial transactions. Organisations to support its development and the magazines for promotion were also created. Cryptocurrency derivatives were also created to boost its trade by actual price discovery and future predictions. Everything was good with minor glitches in the form of hacks and policy makers' regulations and prohibitions. Growing acceptance by many major corporates and the increasing confidence among the investors pushed the Bitcoin price to, its highest till date of $20,00 per bitcoin. Very soon after the hike, rumours regarding the ban of cryptocurrency, were spreading very quickly. Initial coin offering and token sales were banned by many large companies like Facebook, Google, Twitter, etc. The largest cryptocurrency OTC market of Japan was hacked. And there were many instances of theft and losses were being reported. These negative incidences caused the demotivation among the investors, which resulted the crisis to take place in the early 2018. After the crisis extensive research and development works started to know the reason of the crisis and to find the way to improve the situation. Many corporates started to adopt Blockchain as an application. All these continued, which caused the improvement in the cryptocurrency market condition and pushed the demand of qualified developers and miners too. These types of developments revived the confidence of the investors so boldly that caused a boom in 2021, where Bitcoin price touched its all time high of $69,000 per coin. As every extreme has a limit, so evidenced in the case of cryptocurrency. After just some time of this big hike, in 2022 a big correction in the bitcoin price took place. There were many reasons behind it. Some of them are- Chinese ban over cryptocurrency, possible hikes in FED rate as hinted in Dec. 2021, stock market correction, panic selling, profit booking, etc.

The Beginning

1989
Digicash – An early form of decentralized e-money invented by David Chaum.

1998
Bitgold (predecessor to Bitcoin) is created by Nick Szabo.

2008
- Inception of Bitcoin
- First Bitcoin exchange "Bitcoin Market" was established.

2009
Bitcoin is mined and transacted for the first time.

Gaining Recognition and Acceptance

2011

- First acceptance of Bitcoin by an online store.
- Litecoin and Namecoin stormed the scene.
- Bitcoin = 1USD

2010

First commercial tangible transaction took place: two Pizzas for 10,000 Bitcoins.

2012

Bitcoin magazine was launched, and Bitcoin foundation was established.

Growth

2013

- DogeCoin, the flagship memcoin was created.
- First Bitcoin ATM was launched at Vancouver B.C.
- FBI shutdown Silk Routes and confiscated 26,000 bitcoins.

2014

- Mt. Gox was hacked again of $473 million.
- By the end of the year several companies like Microsoft, PayPal started to accept Bitcoin.

2015

Etherium arrived with smart contract and rivalled Bitcoin.

2016

- DAO – A blockchain organisation based on Etherium lost $50 million
- Bitfinex bitcoin exchange was hacked for $66 million

2017

- Bitcoin hit the price of $20,000 –highest till the date
- Launch of Bitcoin Futures

Crisis Period

2018

- Coincheck (A Japanese exchange) was hacked for $534 million
- In December Bitcoin= $3,400

Recovery

Figure 1: Timeline of Cryptocurrency

Regulations and Legal status

Seeing the cryptocurrencies' exponentially growing popularity and the probable threats attached to them, regulations regarding them have continuously been tightened.

Financial Action Task Force (FATF) has defined cryptocurrency-related services as virtual assets services providers (VASPs) and recommended that they have to be regulated with the same money laundering and know-your-customer (KYC) requirements as financial institutions (cryptocurrency, 2021)

Every country is trying to regulate cryptocurrencies. In this row, China moved a step ahead and banned financial institutions and payment companies from being able to provide cryptocurrency transactions-related services in 2018. Again in 2020, Chinese government declared all cryptocurrency transactions of any kind as illegal.

South Korea implemented new legislation regarding all digital asset managers, providers and exchanges to be registered with the Korea Financial Intelligence Unit to operate in South Korea. India too in 2018, issued circular banning banks and NBFCs from dealing in virtual currency and providing such services to people associated with them.

Although Supreme Court set aside this virtual ban on cryptocurrencies the policymakers are continuously trying to hinder the cryptocurrency growth in India.

So, they took digital currency gains in the purview of the high-income tax bracket and proposed to issue an official digital currency of its own to minimize the crypto flow in the country (cryptocurrency regulations in India: a brief history, 2020).

In the midst of the tightening of crypto regulations race, there are some countries also like El. Salvador and the South African Republic have recognized cryptocurrency as legal tender for unrestricted operations in the country (cryptocurrency, 2021)

METHODOLOGY

The present study employs the systematic methodological approach to ensure comprehensive coverage with reproducible results of the existing literature.

Systematic reviews aid in familiarizing with the present state of the art and in the identification of research gaps in that field (Tranfeld et al. 2003; Rousseau et al. 2008). The authors discuss the complete methodological process in the following sub-sections.

Literature retrieval and selection (Data)

The present paper works with the bibliometric data extracted from Web of Science Core Collection (WoS), Clarivate Analytics. Web of Science database is the oldest and one of the largest databases with a wide range of academic resources in multiple disciplines.
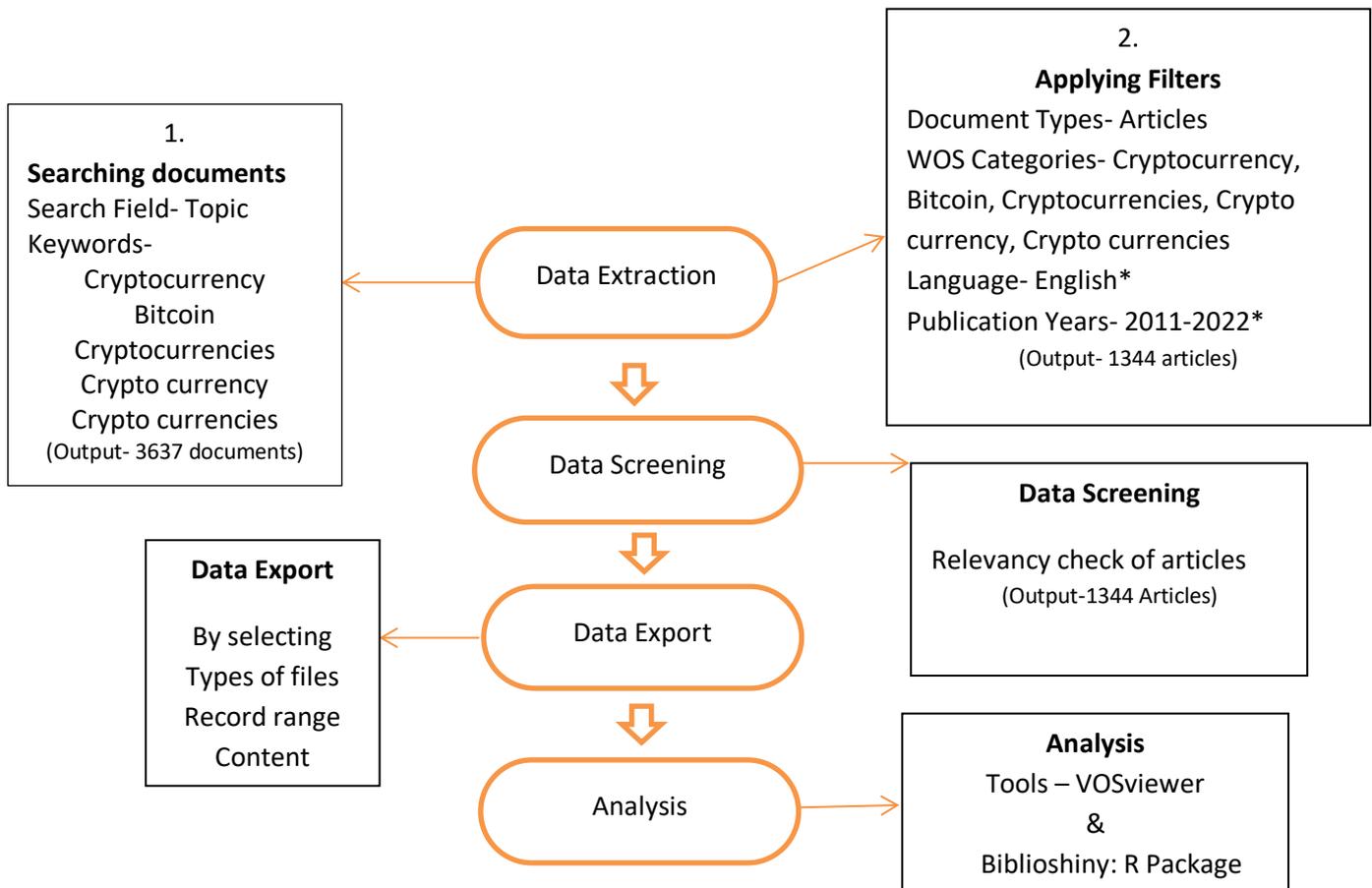
To avoid the chances of missing the research papers authors use different keywords, cryptocurrency, bitcoin, cryptocurrencies, crypto currency and crypto currencies with "or" operator. Asterisk (*) is not used because it covers some extra articles outside the purview of our interest i.e., cryptocurrency.

We use "Topic" search field which covers the title, abstract, author keywords and keywords plus which provides enhanced coverage of the relevant articles.

By considering the whole-time range of 2011 – mid-2022 without any filter we have found 3637 documents. After applying the filter "Articles" in Document types we found 3312 documents and by applying "Business, Business Finance, Economics, Management and Social Sciences Interdisciplinary" in Web of Science categories, found 1344 documents. Since all the documents available (1344) are in English language only, so we haven't used "Language "filter".

After that, we exported the bibliometric data of all the selected documents in "Plain Text file" by selecting "Full record and Cited references". The plain text file is selected because it is supported by both the bibliometric analytical tools "VOSviewer" and "Biblioshiny ".

Web of Science allows exporting a maximum of 500 records at one time. So, we have exported three times for all the records by selecting different ranges of records. Biblioshiny does not allow selecting multiple files while loading data on it. So, we make a consolidated file of all three plain text files by just copying and pasting the second and third files into the first one.

1.

Searching documents
Search Field- Topic
Keywords-
  Cryptocurrency
  Bitcoin
Cryptocurrencies
Crypto currency
Crypto currencies
(Output- 3637 documents)

2.
Applying Filters
Document Types- Articles
WOS Categories- Cryptocurrency,
Bitcoin, Cryptocurrencies, Crypto
currency, Crypto currencies
Language- English*
Publication Years- 2011-2022*
(Output- 1344 articles)

Data Extraction

Data Screening

Data Screening
Relevancy check of articles
(Output-1344 Articles)

Data Export
By selecting
Types of files
Record range
Content

Data Export

Analysis

Analysis
Tools – VOSviewer
&
Biblioshiny: R Package

*Selected all available

Figure 2- Data extraction and processing mechanism

Tools

This paper utilises two important and popular bibliometric analysis tools VOSviewer and Biblioshiny. VOSviewer is a freely available Java-based application developed by Van ECK and Waltman for analysing and visualising citation networks of scientific collections (Massimo Aria & Corrado Cuccurullo, 2017). Biblioshiny is a part of the "R" packages for bibliometric analysis. It is also available without any charges.

Results and Discussion

Descriptive Analysis

Description	Results
Timespan of study	2011:2022
Number of Sources (Journals, Books, etc.)	221
Number of Documents	1344
Annual Growth Rate % of documents	68.16
Document Average Age	1.68
Average citations per doc	24.54
References	31838

DOCUMENT CONTENTS	
Keywords Plus (ID)	1174
Author's Keywords (DE)	2843
AUTHORS	
Authors	2383
Authors of single-authored docs	195
AUTHORS COLLABORATION	
Single-authored docs	242
Co-Authors per Doc	2.75
International co-authorships %	43.45
Documents type	Articles only

Year	Annual production	Mean Total Citation per article	Mean Total Citation per year
2011	1	2.00	0.18
2012	0	0.00	0.00
2013	0	0.00	0.00
2014	2	6.50	0.81
2015	12	187.42	26.77
2016	17	149.00	24.83
2017	24	126.83	25.37
2018	79	85.28	21.32
2019	188	41.61	13.87
2020	257	25.14	12.57
2021	356	9.14	9.14
2022	304 *	2.24*	*

Table 1: Annual scientific production and citation

It is evident from the table 1 that the first article has published in 2011 and then shown stagnancy in production for a few years. But from 2015 there is exponential growth in the publication year after year which shows the pace of the growing popularity of Cryptocurrencies. It shows an annual growth rate of 68.16%.
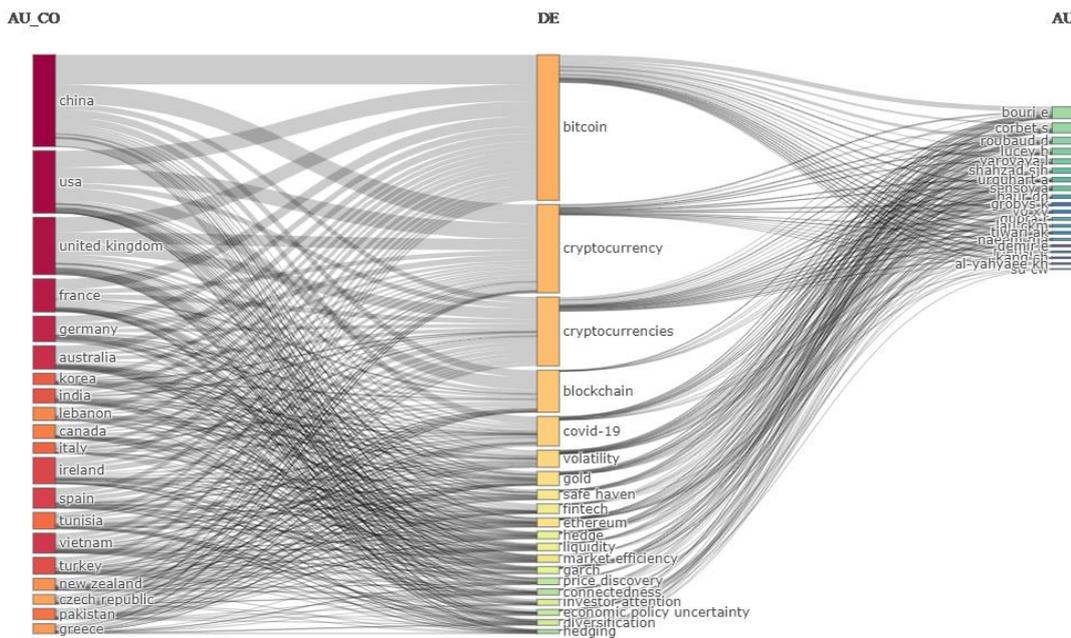
*AU CO- Author's country, DE- Author Keyword, AU- Author

Figure 3 – Three Field plot of authors, authors' countries and author keywords

Three Field plot is the diagrammatic representation of the relationship among the three terms. It helps in understanding the relationship among the terms along with the breadth and depth of the relationship. Fig.3 shows the three-field plot of Authors, Authors' country and Author Keywords. China has the biggest share among all the countries which is evident from the longest rectangle shown with China. It means China's scientific production related to cryptocurrency is maximum. Similarly, it can be interpreted that Bitcoin is the most frequently used Keyword and author Elie Bouri has the maximum number of articles in this field. The width of the links shows the proportion of the relationship shared by the pair. So, it can be concluded that China's maximum work in this field is related to Bitcoin which also covers the maximum number of articles on bitcoin. The most productive author Elie Bouri also has the maximum number of papers related to bitcoin. China has contributed to almost all the fields related to the given keywords that are implied from the direction of the links.

Source Analysis

Table 2 Most relevant Sources

Sr. No.	Sources	Articles
1.	FINANCE RESEARCH LETTERS	250
2.	ECONOMICS LETTERS	74
3.	RESEARCH IN INTERNATIONAL BUSINESS AND FINANCE	71

4.	INTERNATIONAL REVIEW OF FINANCIAL ANALYSIS	58
5.	APPLIED ECONOMICS LETTERS	48
6.	NORTH AMERICAN JOURNAL OF ECONOMICS AND FINANCE	45
7.	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	38
8.	APPLIED ECONOMICS	36
9.	FINANCIAL INNOVATION	34
10.	JOURNAL OF INTERNATIONAL FINANCIAL MARKETS INSTITUTIONS & MONEY	30

Table 2 represents the list of the top 10 sources of articles in the selected field. Out of 221 sources of publications, the top 10 journals have published a total of 684 documents which is approximately 51% of the total publications of 1344. Only Finance Research Letters has published 18.6% of the total documents in this area.
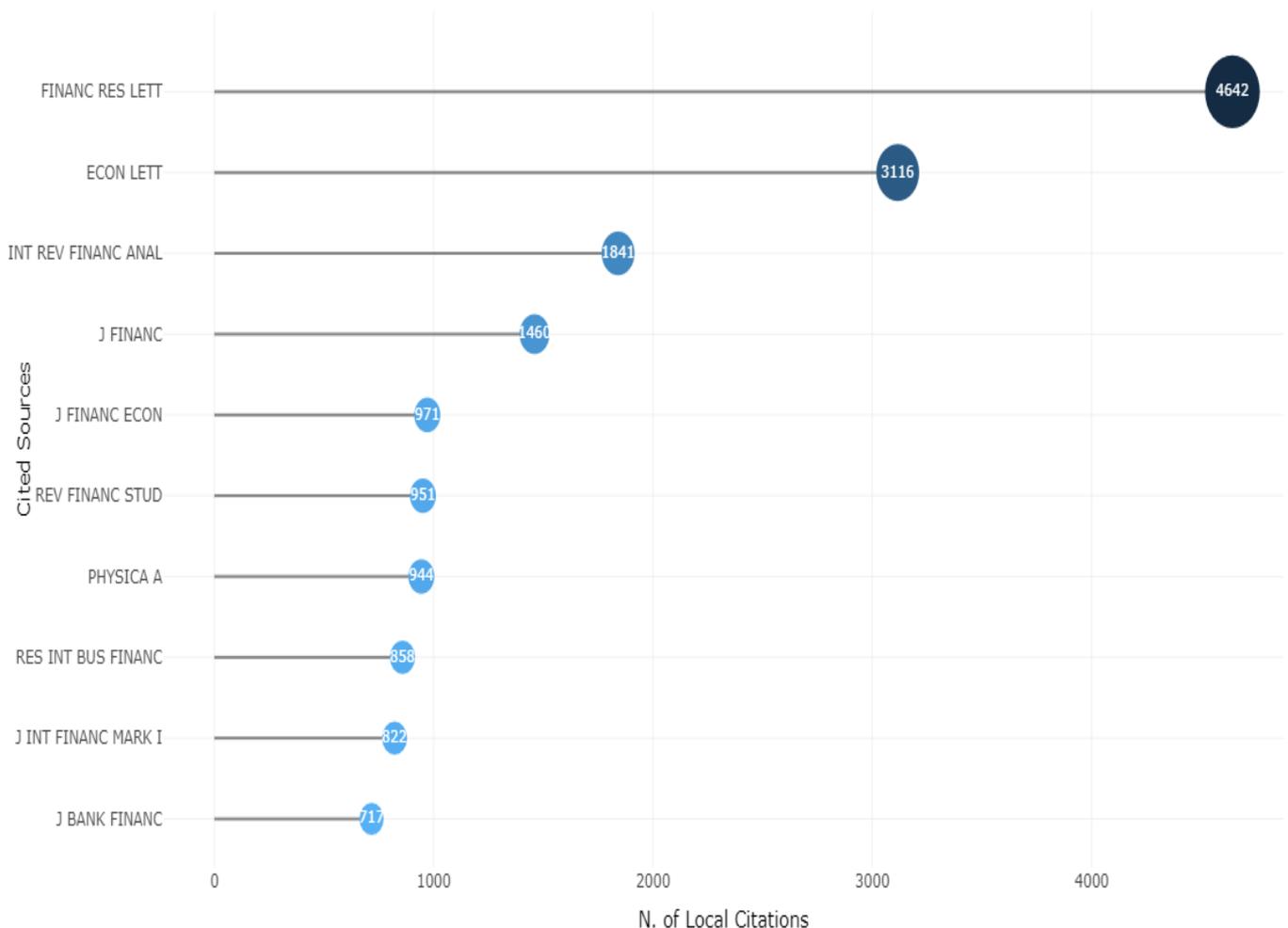
Figure 4- Most Local Cited Sources

Citations are counted in two ways one is Global and the other is Local. A local citation is the number of times a document is cited by others within the selected group of documents. For here the group of 1344 articles is considered for the local citations.

On the other hand, Global citation is the number of times a document is cited by any of the other documents in the Document repository or Database. In this paper, whole Web of Science database documents is considered for the Global citations. Finance Research Letters is positioned at the top in terms of both local as well as global citations (Total citations). Others in the row are Economics Letters, International Review of Financial Analysis, etc. which are shown in Figure 4 and Table 3.

Table 3 Source Impact

Element	H index	G index	M index	TC	NP	PY start
FINANCE RESEARCH LETTERS	47	84	6.714	8077	197	2016
ECONOMICS LETTERS	32	67	4	5282	67	2015
INTERNATIONAL REVIEW OF FINANCIAL ANALYSIS	21	49	3	2413	53	2016
RESEARCH IN INTERNATIONAL BUSINESS AND FINANCE	20	37	3.333	1485	61	2017
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	16	28	2.667	817	31	2017
JOURNAL OF INTERNATIONAL FINANCIAL MARKETS INSTITUTIONS & MONEY	13	24	1.625	1137	24	2015
NORTH AMERICAN JOURNAL OF ECONOMICS AND FINANCE	12	19	3	415	38	2019
QUARTERLY REVIEW OF ECONOMICS AND FINANCE	12	24	2.4	602	24	2018
APPLIED ECONOMICS	11	32		1059	32	
APPLIED ECONOMICS LETTERS	11	23		550	32	

*There is difference between the number of publications and the total number of articles of sources because of the presence of early access articles (It cannot be ignored because its number is 104 (more than 8%) that is significant for the review paper)
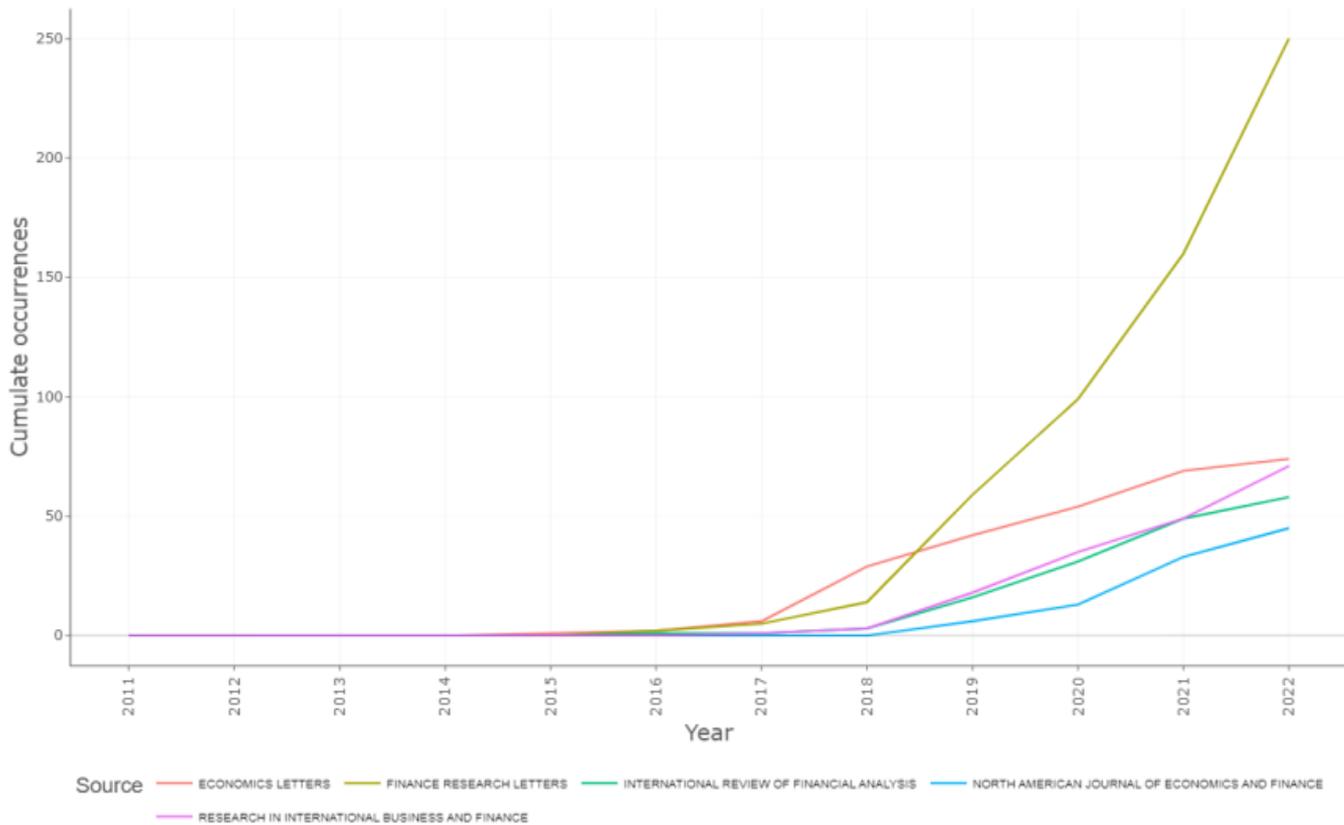
Source Dynamics

Figure 5 – Source Dynamics

Forbes is the oldest source producing the first article in 2011. After that Island Studies Journal published 2nd article after a long duration of about 3 years. After that, several sources started coming into the picture. Figure 5 has shown a chart of the source dynamics of top articles... Most of the sources are showing a sudden upward bend from 2018. It is because of the Cryptocurrency crisis that happened in 2018. The eagerness of knowing the reality behind the crisis and the prospects of Cryptocurrencies led to the production of a large number of articles. Finance Research Letters is showing much higher growth relative to the others in the chart. It started publishing in this field in 2016 and got momentum very quickly by publishing a huge number of articles related to the field. This is clearly visible through its steeply sloped graph. If we look at the source impact Finance Research Letters topped once again topped in the list with attractive figures in all H, G and M indices. "Economics Letters" and "International Review of Financial Analysis" are standing at second and third positions in the list.

Table 4 Most Relevant Authors

Authors	No. of Documents	Percentage
BOURI E	48	3.57
CORBET S	32	2.38
ROUBAUD D	27	2.00
LUCEY B	22	1.64
YAROVAYA L	22	1.64
SENSOY A	18	1.34
SHAHZAD SJH	18	1.34
URQUHART A	18	1.34
GUPTA R	16	1.19
NAEEM MA	16	1.19

Table 5 Most Local Cited Authors

Author	Local Citations
BOURI E	1727
ROUBAUD D	1621
LUCEY B	1019
CORBET S	968
URQUHART A	868
GUPTA R	639
DYHRBERG AH	569
YAROVAYA L	561
MOLNAR P	522
LAU CKM	471

Table 4 displays the list of the top 10 most productive authors in the field. These ten authors have cumulatively produced 237 documents out of 1344, which is 17.63 % of the total. Elie Bouri is at the top of the list with 48 (3.57%) documents. Corbet S. and Roubaud D. stand at the second and third positions in the list. If we talk about the citations that are displayed in table 5 and table 6. Bouri E. is at the first position in terms of Local as well as Total citations. It means he is the most cited authors among the selected articles as well as in the overall WOS Database for the selected field. Roubaud D. holds the second position in terms of local and total citations.

Table 6 Authors' Impact

Element	h_index	g_index	m_index	TC	NP	PY_start
BOURI E	26	46		3349	46	2017
ROUBAUD D	24	27	4	3115	27	2017
CORBET S	20	30	4	1974	30	2018
LUCEY B	16	20	3.2	1942	20	2018
GUPTA R	13	15	2.167	1258	15	2017
SENSOY A	12	16	3	528	16	2019
URQUHART A	12	17	1.714	1472	17	2016
SHAHZAD SJH	11	16	2.75	788	16	2019
TIWARI AK	11	12	1.833	724	12	2017
KATSIAMPA P	10	11		897	11	

Impact is calculated on the basis of different factors in which number of publications, total citation, ranks in different indices are important. Here three indices are considered that are H index, G index and M index. Jorge E. Hirsch, a physicist at UCSD suggested H-index in 2005. H index is the number at which the number of papers is equal to the citations counted after arranging all the papers of concerned author in descending order of citations. It is widely used index. But it does not consider the quality of papers, number of authors, position of authors in the author's list etc. It is independent of duration of academic's career.

Because of this, relatively new author with same productivity is assigned with lower h-index. To overcome this limitation, M index or m-quotient is suggested. M index weighs the period of academic endeavour to reduce the

biasness in favour of authors with longer careers. M quotient = h- index / number of years since the first published paper of the author. G index is a variant of h-index which considers the evolution of the most cited papers over time. It is the largest number or rank 'g' of the paper after arranging all the papers of the concerned author in descending order of citations at which first g papers together have at least g^2 citations. G index always exists for any set of papers and is unique in nature.

Table 6 shows the Author's impact of top 10 Articles. Bouri E. is at the first position with highest numbers in all the parameters i.e., indices, citation and number of publications. He started his publication in this field in 2017 with the productivity of 8 documents per year.
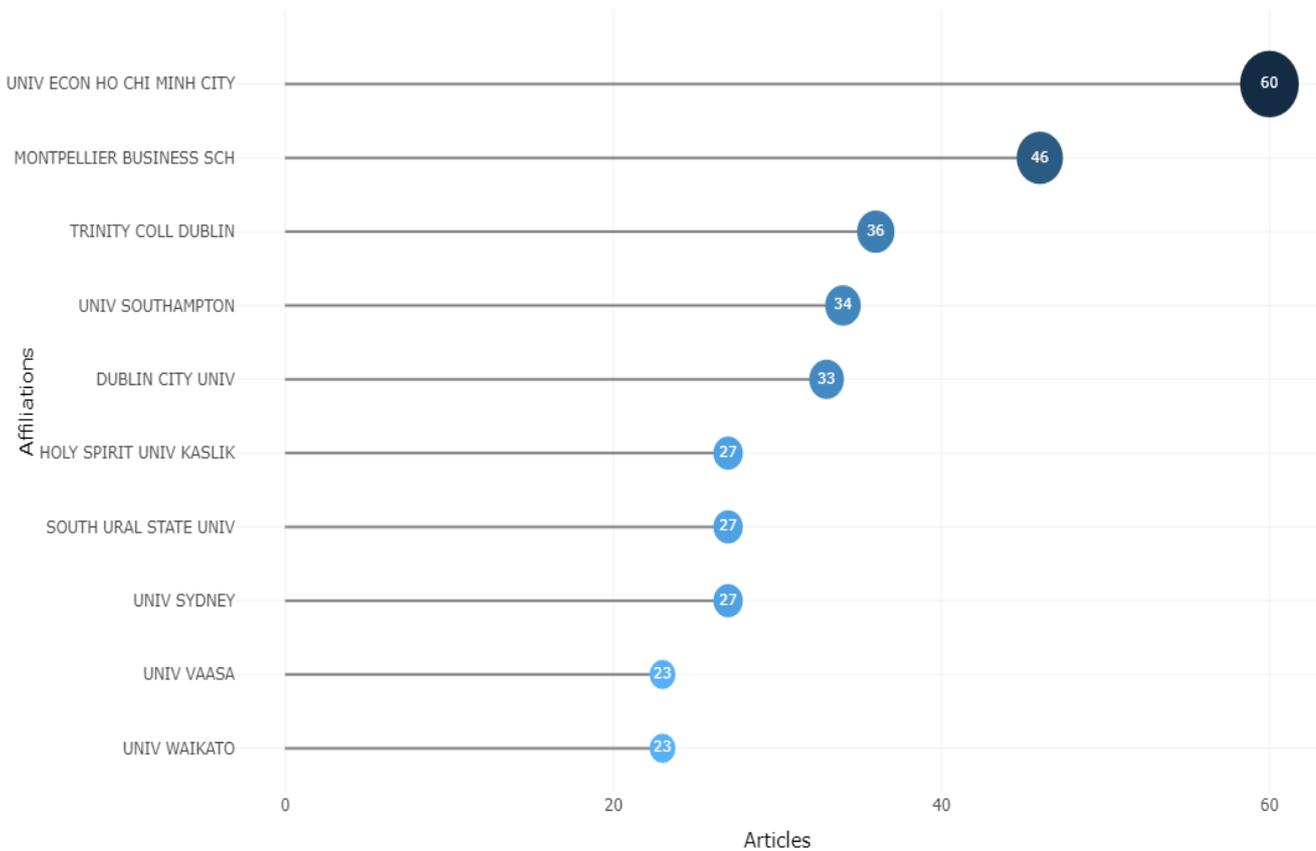
Figure 6 – Most relevant affiliations (according to authors)

Figure 6 shows the top 10 affiliations i.e., related institutions, universities or any other organisations, out of 1270. The picture shows the total production of all the authors related to the affiliations. These 10 affiliations have 336 articles which constitutes one fourth of the total articles of 1344. University of Economics Ho Chi Minh City is at the top of the list with the maximum production of 60 articles i.e., 4.46% of the total. It has started it production just three years ago in 2019 in this field and with its continuously increasing production; it has reached at the top of the list. Other organizations performing well in the field are Montpellier Business School, France, Trinity College, Dublin etc.

Countries' Scientific Production

Table 7

Region	Frequency
CHINA	568
USA	375

UK	294
FRANCE	160
GERMANY	118
AUSTRALIA	114
VIETNAM	103
SPAIN	100
IRELAND	97
TURKEY	77

Table 7 shows the top 10 countries in terms of scientific production. China is positioned at the top with 568 articles and USA is following it with 375 articles. From the countries given in the table Australia has started its publication in 2014 ahead of all other countries. China's scientific production in the field started in 2016, which is relatively later than that of many others. But its active involvement mainly from 2020, made it to reach to the top of the list.

Corresponding Author is the author which acts as the contact person for the publication house for any information or other work regarding the document for which he is designated as corresponding author. He is treated very important for the document. One reason behind it is that first author which is the largest contributor to the document, is designated as corresponding author.

Table 8 displays top ten countries in terms of articles related to the corresponding authors of that country. In this list too, China is at the top of the list with 236 articles which constitutes 17.6% of the total production. In these articles 150 are wholly produced by China and 86 articles have contributions of other countries' authors too. It also shows its good collaboration with other countries in terms of scientific production in this area. USA and UK hold second and third positions in both the list of countries' scientific production in terms of total articles as well as corresponding author's country.

Corresponding Author's Country

Table 8

Country	Articles	SCP	MCP	%age	MCP_Ratio
CHINA	236	150	86	17.6	0.364
USA	168	120	48	12.5	0.286
UNITED KINGDOM	133	70	63	9.9	0.474
AUSTRALIA	52	32	20	3.9	0.385
FRANCE	51	19	32	3.8	0.627
GERMANY	49	27	22	3.6	0.449
SPAIN	48	29	19	3.6	0.396
KOREA	41	23	18	3.1	0.439
IRELAND	38	5	33	2.8	0.868
ITALY	31	19	12	2.3	0.387

*SCP- Single Country Production, MCP- Multiple Country Production

Most Global Cited Documents

Figure 7 – Top ten Global cited documents

Figure 7 displays the top ten most global cited documents. It means the documents which have been referred the most by any other documents in the whole Database. The document DYHRBERG AH, 2016, FINANC RES LETT-a is at the top of the list with 565 citations. The title of the document **is** "Bitcoin, gold and the dollar – A GARCH volatility analysis". This paper has explored the financial capabilities of Bitcoin using GARCH models. It has evaluated the relationship of Bitcoin with gold and Dollar and has shown how Bitcoin can be used in risk management by the investors. Second and the third position are occupied by BOHME R, 2015, J ECON PERSPECT and Urquhart A, 2016, Econ Lett. Former has explained the Bitcoin in terms of its technology, Economic implications and its governance throughout the globe, while the later has tested the efficiency of Bitcoin.

Most Frequent Words (Tree Map)

Figure 8- Tree Map of most frequent Words

Tree map is a method of visual representation displaying pecking order of data by using nested rectangles to represent the branches of a tree diagram. Each rectangle has an area proportional to the amount of data it represents. Different Colours are used to differentiate each data set. Fig. 8 represents the Tree Map of most frequent words of author's keyword filed. Map shows Bitcoin as the most frequent words among all the author's keywords. But Cryptocurrency and Cryptocurrencies which represent the same thing jointly represent the maximum frequency of 26% which is larger than that of Bitcoin. So practically speaking Cryptocurrency (along with its variant Cryptocurrencies) is the most frequent words followed by Bitcoin and blockchain.
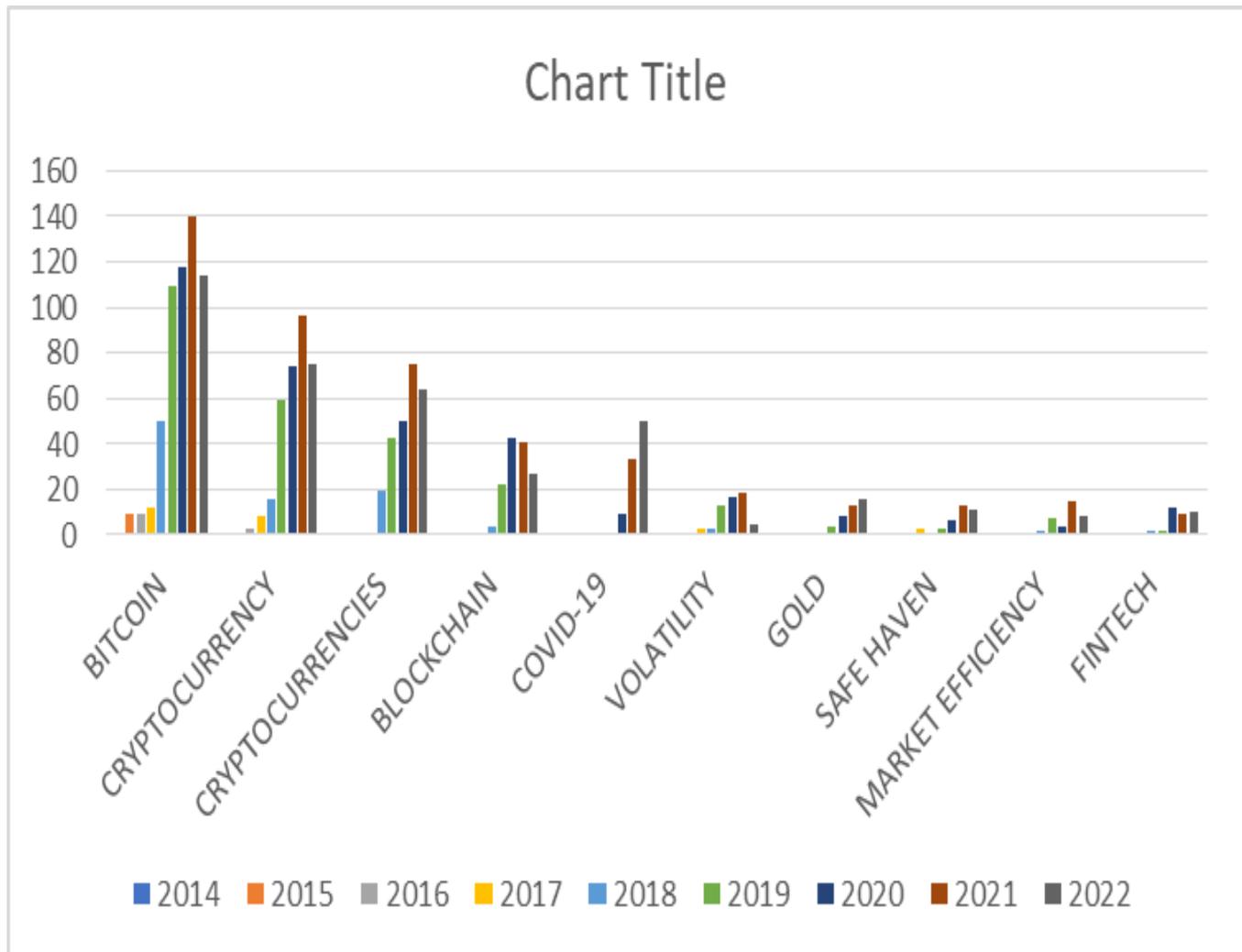
Figure 9- Word Dynamics

Word dynamics shows the progression of the word uses according to the time. Fig.9 shows the word dynamics of top ten most frequent words. It is clearly evident that the Bitcoin has earliest presence in the articles even before the word Cryptocurrency or Cryptocurrencies that started to appear from the year 2015 a year after than that of Bitcoin.

This shows the popularity of Cryptocurrency and its importance in the spread of Cryptocurrency. Words like Gold, volatility, safe haven, market efficiency, started to appear in the articles from 2015 and 2016 and have continuously increasing trends, which shows the interest of the academician towards the idea of Cryptocurrency as a financial asset and an investment option.

Words like Blockchain and Fintech have their appearance a little bit later from 2017, that was the time of increasing acceptance of Blockchain as a financial technology by many large companies. All these lead to adopt Cryptocurrency as an investment option by the investors, which is evident from the Cryptocurrency boom/ hike of 2017.
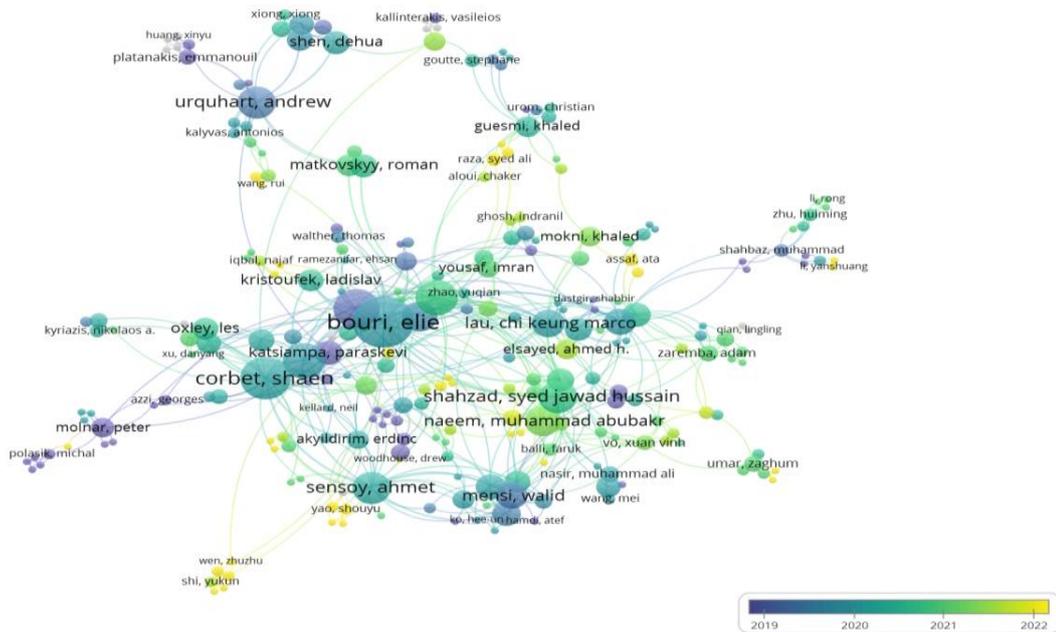
Co-authorship

Figure 10- Overlay Visualization of Co-authorship - authors

Co-authorship means writing an article jointly by two or more authors. It can be analysed taking author, organisation and country as unit of analysis. Fig.10 shows the overlay visualization of Co-authorship by taking Authors as unit of analysis and Link Strength as weight. It shows that Elie Bouri, has the largest circular label, which shows that he has the highest link strength among all i.e. he has maximum number of documents authored with other authors. It is also clear from the colour of the bubble that most of his publications are around the year 2020. But he has also collaborations with some newer authors in the field, like xu, yahua. Bouri, ellie is followed by Corbett, shaen and roubaud, david. Roubaud, david who has maximum publications around 2019 is closely related to bouri, ellie because both are within the same cluster and labelled very closely.
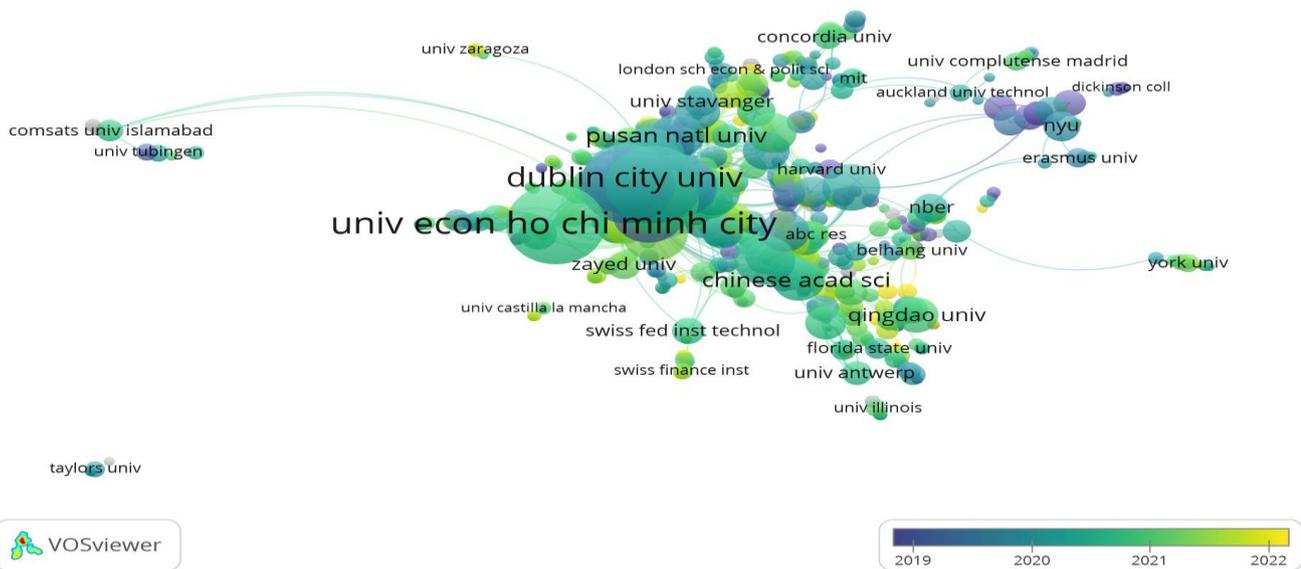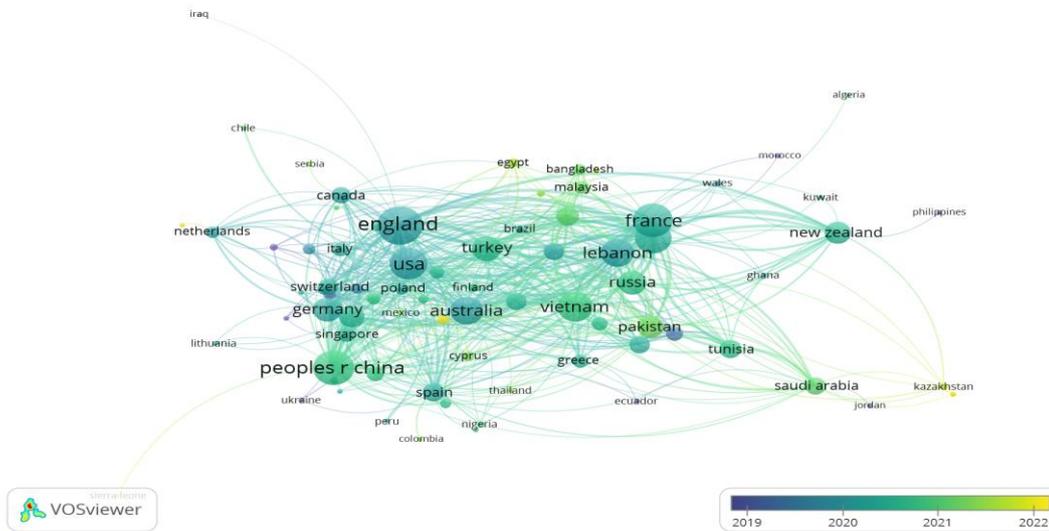

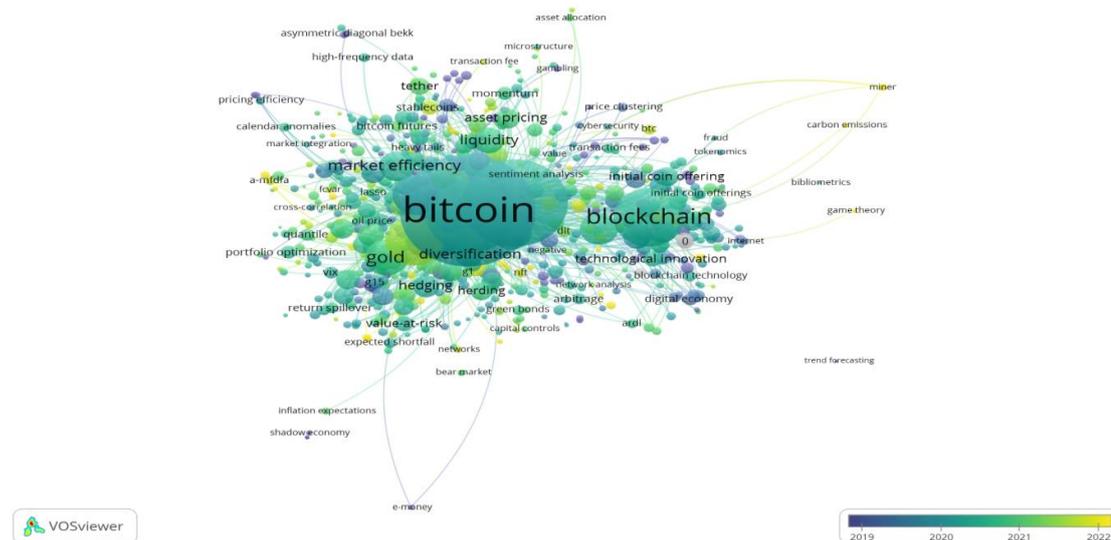**Figure 11- Overlay visualization of Co-authorship – Organisations**

Fig.11 displays the co-authorship taking organisation as the unit of analysis. It shows the organisation's collaboration through its authors for writing different documents. University of economics, Ho chi minh city is showing the highest co-authorship link strength with the highest 42 documents. Trinity college, Dublin and Montpellier business school, France are following university of Economics, Ho Chi Minh City. Trinity college, Dublin and university of economics Ho chi minh city have most of the documents of around 2021 but Montpellier business school, France has of around 2019. All these top three organisations have also good mutual co-authorship collaboration

Figure 12- Overlay visualization of co-authorship – countries

Fig.12 shows co-authorship overlay visualization taking country as the unit of analysis. This shows the link among the countries for writing documents jointly by the authors of the countries. England has the maximum co-authorship link strength with 200 documents which is lower than its follower Peoples republic china. France is at 3rd position. All three have average publication year of approximately 2020 but china has a little bit higher average publication year. Iceland which has average publication year of 2022 shows that it is very active in the recent years.

**Co-occurrence of Keywords**

Figure 13- Overlay visualization of co-occurrence of keywords

Co-occurrence of keywords indicates the frequency of occurrence a word together with other words. Fig.13 presents the overlay visualization of co-occurrence of Author's keywords taking total link strength as the weight. Author's keywords are the words used in the documents and indicated by the authors as important and key to understand the paper.

Author's keywords are selected for the visualization because these are really the important words because these are selected by the authors who have written the documents and know much better than any other about their articles. In the figure the software has displayed Bitcoin having maximum link strength for co-occurrence among all. After that Cryptocurrency/Cryptocurrencies (can be treated as one because both represent almost same thing) and Blockchain are positioned.

All these three top co-occurring words have average year of publication around 2020. Carbon emission, leverage effect, stable coin, analytical models, decentralized finance etc. are words co-occurring with these top occurring words in recent years. Also, these top keywords have co-occurrence with most of the other words.

Bibliographic coupling –document
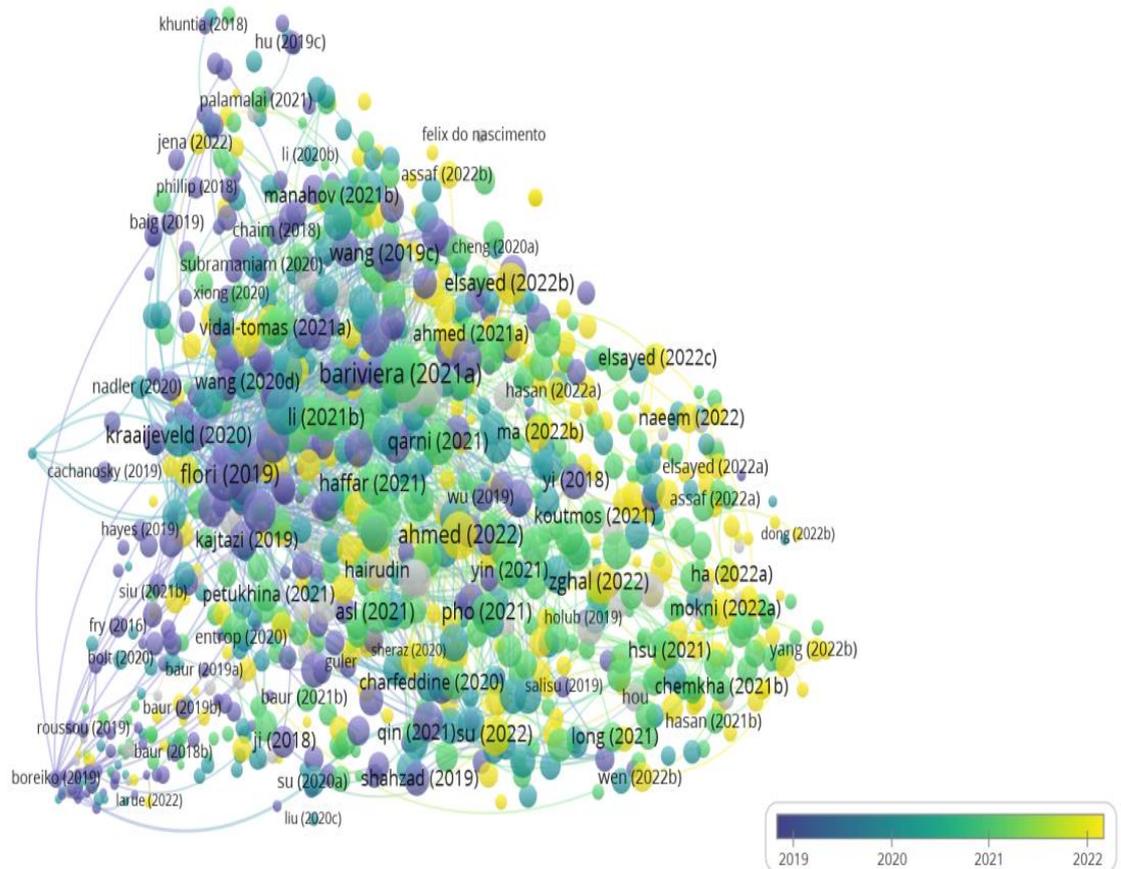
Figure 14- Overlay visualization of Bibliographic coupling of documents

Bibliographic coupling means the occurrence of the same reference in the bibliography or references of two documents. For the unit of analysis documents, sources, authors, organizations and countries can be considered. Fig.14 presents the overlay visualization of bibliographic coupling taking documents as the unit of analysis. The plots are drawn taking total link strength as weight.

This visualization shows that bariviera (2021a). Flori (2019) and bedi (2020) are the top three documents which have maximum total link strength which show these are the most influential documents in terms of bibliographic coupling.
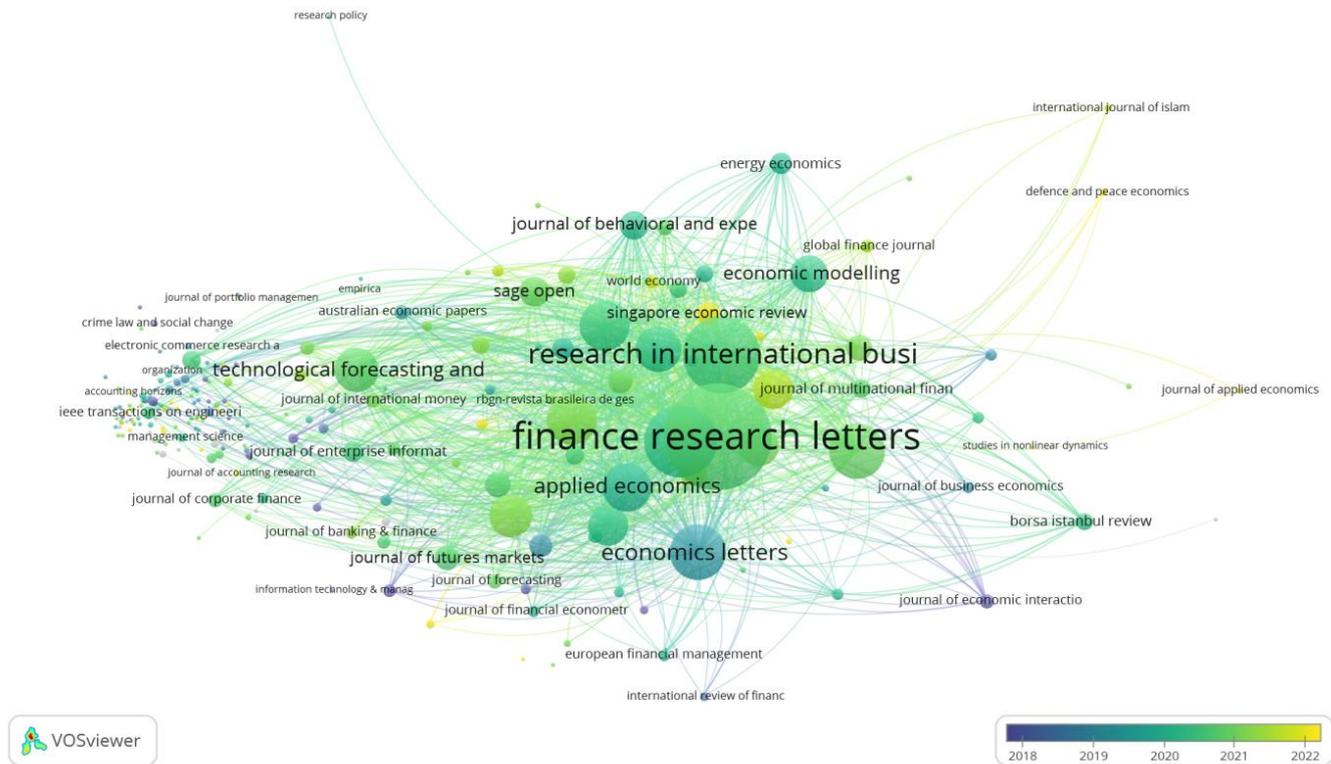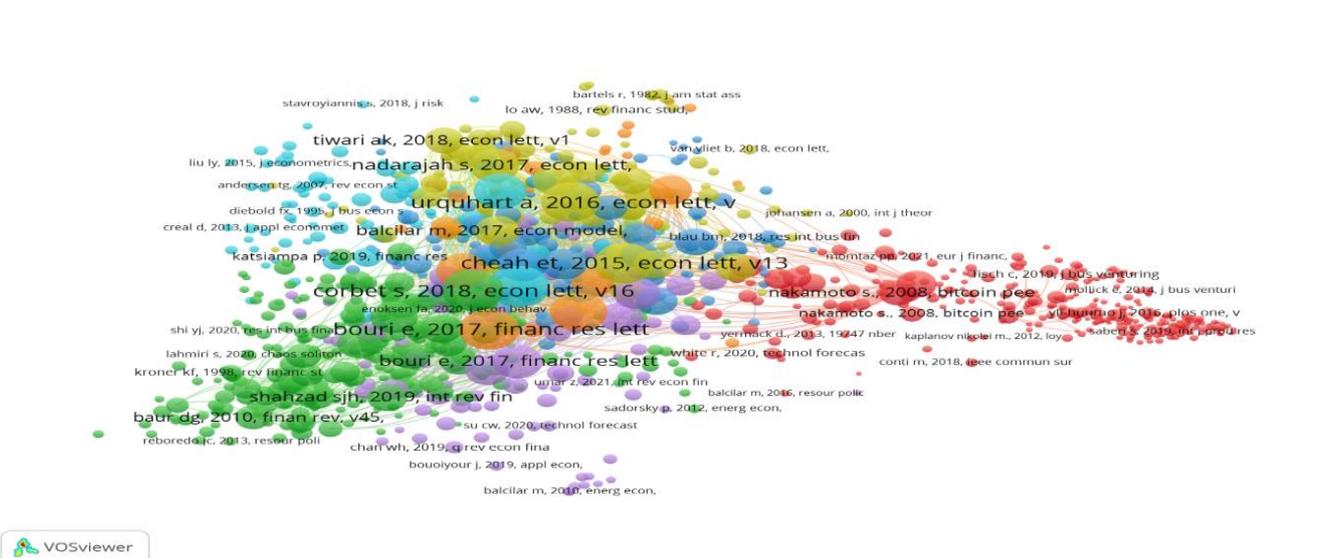
Figure 15- Overlay visualization of Bibliographic coupling of sources

Fig.15 shows the bibliographic coupling visualization taking sources as the unit of analysis. It shows the documents related to sources which are cited commonly by two documents and their frequency with weight in the form of total link strength. Finance research letters has the maximum total link strength which implies that its documents have maximum common bibliographic presence in two documents. Research in international business and finance and international review of financial analysis are the 2nd and 3rd in terms of total link strength for bibliographic coupling. All these sources have average year of publication is around 2020.5. This shows the presence of their maximum documents of around mid-2020.

Co-citation

Figure 16- Network diagram of co-citation of cited references

Co-citation means the presence of citations of two different documents together in a third document. It can be analysed taking cited references, authors and sources as the unit of analysis. Fig.16 shows the network visualization of co-citation taking cited references as the unit of analysis. Reference "corbet s, 2018, econ lett, v165, p28, doi 10.1016/j.econlet.2018.01.004" has maximum total link strength. This shows its maximum presence in pair with some other documents in the reference of the documents. There are seven clusters displayed by the software. This most influential cited reference is in second largest cluster2 with other 241 documents.

Figure 17- Network diagram of co-citation of authors

Fig.17 shows the network visualization of co-citation analysis with author as unit of analysis. It shows that Elie Bouri has the maximum total link strength followed by corbet,s and baur,dg. Top 1000 authors are classified into five clusters according to the similarity of their works.

Figure 18- Network diagram of co-citation of sources

Fig.18 displays co-citation analysis of sources. According to this Finance research letters has maximum total link strength along with the maximum citations. Economic letters and international review of financial analysis are at the second and the third positions in terms of total link strength. This shows the articles of these sources have maximum presence in the bibliography of the documents coupled with other documents. Top 1000 most influential sources according to the co-citation link strength are classified into five clusters. All the top three sources are among the top three clusters which contain maximum number of sources.

CONCLUSION

Our analysis shows that there were early trials of Cryptocurrencies before the inception of Bitcoin. But after the emergence of Bitcoin in 2008, the concept got solidified and appealing. The first document in this area appeared in 2011 in Forbes. There is a continuous increase in the literature, mainly in the last five years. A very high annual growth rate of documents of 68.16% is observed. Most of the works are done related to Bitcoin. Finance Research Letters is the most impactful source. It has the highest local and global citations. China is the leader in scientific production in the field, despite obstructive actions by the Chinese government. University of Economics Ho Chi Minh City has emerged as the most relevant affiliation with the highest number of documents. The number of countries participating in this field is increasing, but the contribution of many of them is very insignificant. The detailed insights of the study will be helpful for academicians and researchers in finding out about cryptocurrency and the related areas that are investigated, and in deciding which area to focus on for further studies.

This study is **delimited** to the data available in the Web of Science database only. So, further research can be done by considering the other databases like Scopus, Google Scholar, etc., individually or in a combined form. As this study has reflected, most of the research revolves around bitcoin, blockchain, market efficiency, cyber fraud hedging, etc., and there are some areas that are unexplored or very little explored. So, future research can delve into those less studied areas like return spillover, pricing efficiency, market integration, sustainability, blockchain governance, etc.

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