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Scientometric Analysis of Metaverse Scientific Literature Appeared in Scopus Database: A Study

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Abstract: ***In this attempt, the authors have highlighted the Metaverse Literature that appeared in the Scopus Database, from 2006-2024, 4224 papers were published and received a total of 43990 citations. Initially, the publication rate was less, but from 2021 Metaverse literature has accelerated in its publication highest number of papers were published in the year 2024 as it is been publishing but the highest number of citations were observed in the year 2022 with 18511 citations. Maximum papers were found in the year 2022, but whereas in the case of authorship pattern, three authored papers are more in number with 880, in which single-authored papers 626 and the rest 3596 papers are considered as multi-authored papers. Authors have used more than 1700 different Channels of Communication to publish their research output but the highest number of papers are been published in the Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) with 122 (2.89%) papers. China is the leading country in publishing Metaverse literature with 919 (21.76%) papers, whereas India stands in the third position with 464 (10.98%) papers.***

Keywords: Metaverse, Scientometric Study, Bradford Law of Scattering, Authorship Pattern, Publication Productivity, Channels of Communication

1.Introduction

The **Metaverse** is an evolving, interconnected virtual world where physical and digital realities converge, enabling people to interact, socialize, play, work, and create within immersive environments. It is often described as a collective, shared, and persistent digital universe that goes beyond traditional virtual reality (VR) and augmented reality (AR), integrating various technologies like blockchain, AI, and immersive interfaces. The Metaverse is still in its early stages but has the potential to reshape numerous industries and create new social, economic, and cultural paradigms. As technology continues to evolve, especially with advancements in VR, AR, blockchain, and AI, the Metaverse is likely to become a more immersive, integrated, and ubiquitous part of daily life. However, realizing the full potential of the Metaverse will require addressing the challenges of privacy, security, ethics, and accessibility. The vision of the Metaverse is still unfolding, but it promises to be a transformative force in how we experience and interact with the digital world.

2.Review of Literature

Gadad, Raju. & Savanur, Kiran. (2018). Researchers attempted to analyze Prof. P.S. Narayanan's publications under the Scientometric framework, where authors scrutinized the data extracted from the Web of Science database. 89 publications authored by prolific authors by applying Scientometric indicators such as authorship pattern, and Channels of communication, which gives different dimensions for the Scientometric studies.

Shri Ram. And Paliwal, Nitin. (2014). Assessment of Bradford's law of scattering of Psoriasis Literature helps to understand the core journals in specific fields especially, this study gives thorough knowledge about Bradford's law and other modified models to test the same. With this attempt, authors have scrutinized more than 24000 publications, various indicators have been applied to verify the data. The study provides a pathway to easily understanding the applications and their procedure.

Borgohain, Dhruba Jyoti. And others (2021). Researchers have attempted to verify the data published in Information Science literature, and citations that are received by the Information Science literature are the prime focus of the research. In this attempt, researchers have given detailed notes on different models associated with Bradford's law of scattering. Leimkuhler Model to Bradford distributions is the main concern of the study.

Further different research publications have been analyzed to get some innovative ideas and implemented in this study.

Need for the Study:

The literature on the need for the Metaverse emphasizes its transformative potential in fields ranging from business and education to social interaction and entertainment. However, significant challenges remain, particularly in terms of ethics,

security, and access. Future research is required to address these challenges and to understand the societal impact of fully realized virtual environments. This literature study provides a framework for further exploration into the Metaverse's potential and its place in the evolving digital landscape.

3.Methodology

The present study emphasizes the scientific output published on Metaverse Literature; the reflective data was obtained from the Scopus Database by providing proper keywords in a detailed bibliographical format. Further, the data was scattered in MS Excel spreadsheets to prepare the required tables, and suitable graphs and charts were used to represent the data systematically. Researchers also applied Scientometric indicators to achieve set objectives. "Zotero reference management tool" has been used to account for the previously published literature on the Scientometric study.

Scope and Limitations:

An attempt is made to analyze the scientific literature published on Metaverse under the Scientometric framework; thus, the study is restricted to the data published on the above-said subject in the Scopus database, from 2006 to 2024.

Objectives:

The study emphasizes Metaverse literature by applying Scientometrics indicators, hence the following objectives are set for the study:

1. To distinguish Year-wise Distribution of Papers and Citations Metaverse Literature;
2. To know the Authorship Pattern in Metaverse Literature;
3. To find out the Different Channels of Communication Used to Publish Metaverse Literature;
4. To realize Top Countries Contributing to Publishing Metaverse Literature;
5. To understand the Language-wise Distribution of Metaverse Literature;
6. To categorize Different types of Data used to Publish Metaverse Literature and
7. To test the application of Bradford's Law of scattering

Table 1: Year-wise Distribution of Papers and Citations Metaverse Literature

Year-wise Distribution of Papers and Citations Metaverse Literature					
Year	**No. of Papers**	**%**	**Citations**	**%**	**Citation/ Paper**
2006	1	0.02	9	0.02	9.00
2007	2	0.05	14	0.03	7.00
2008	3	0.07	194	0.44	64.67
2009	2	0.05	5	0.01	2.50
2010	12	0.28	169	0.38	14.08
2011	8	0.19	134	0.30	16.75
2012	9	0.21	78	0.18	8.67
2013	5	0.12	123	0.28	24.60
2014	4	0.09	79	0.18	19.75
2015	3	0.07	124	0.28	41.33
2016	4	0.09	9	0.02	2.25
2017	2	0.05	224	0.51	112.00
2018	5	0.12	172	0.39	34.40
2019	2	0.05	23	0.05	11.50
2020	7	0.17	442	1.00	63.14
2021	31	0.73	1944	4.42	62.71
2022	670	15.86	18511	42.08	27.63
2023	1710	40.48	17416	39.59	10.18
2024	1744	41.29	4320	9.82	2.48
Total	**4224**	**100.00**	**43990**	**100.00**	**10.41**

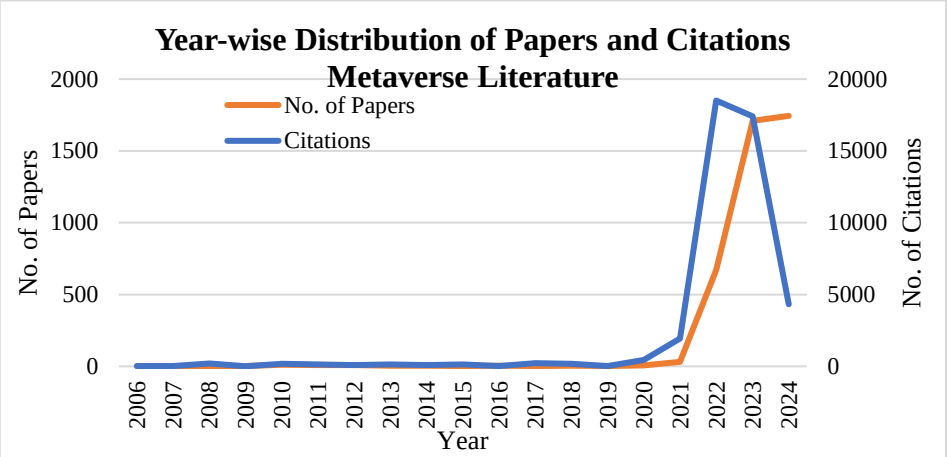

Figure 1: Year-wise Distribution of Papers and Citations Metaverse Literature

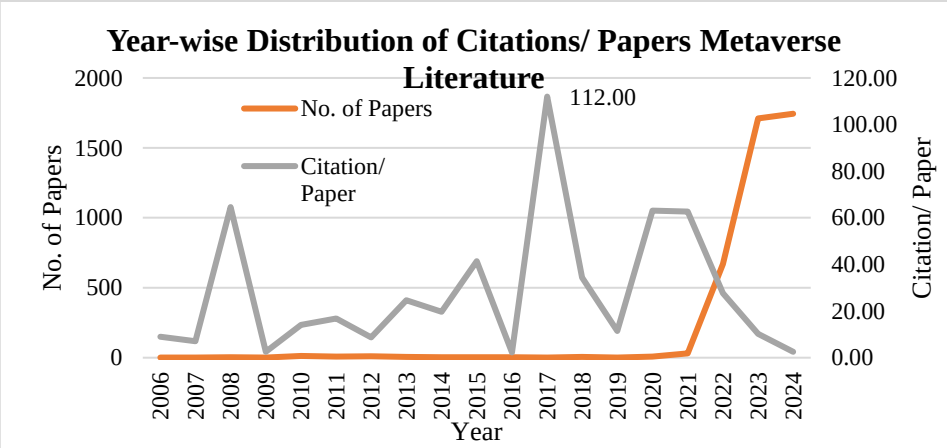

Figure 2: Year-wise Distribution of Citations/ Papers Metaverse Literature

Table No. 1 represents the Year-wise distribution of Papers in Metaverse Literature The number of papers increases significantly starting in 2022, with the highest count in 2024 (1744 papers). Citations peaked in 2022 (18,511), and 2023 also saw many citations (17,416). Despite the high number of papers, citations in 2024 were lower (4,320). The citation per paper ratio was highest in 2017 (112.00), which suggests a smaller number of papers with high citation impact. It significantly decreased in 2024 (2.48), indicating that while more papers were published, their citation impact per paper is lower. Overall, the data indicates a substantial increase in the number of papers in recent years, but the citation per paper ratio has decreased over time, especially in 2024.

Table 2: Authorship Pattern in Metaverse Literature

Year	Authorship Pattern in Metaverse Literature											MP	Total
	Single *	2*	3*	4*	5*	6*	7*	8*	9*	10*	More than 10 Authors		
2006	1										0	0	1
2007	1	1									0	1	2
2008	1		2								0	2	3
2009		1			1						0	2	2
2010	5	2	2	2	1						0	7	12
2011		4	1	1		2					0	8	8
2012	4	1	2	1				1			0	5	9
2013		3	2								0	5	5
2014	1			1		2					0	3	4
2015		2						1			0	3	3
2016	2			1		1					0	2	4
2017	1	1									0	1	2
2018	2	1	1	1							0	3	5
2019	2										0	0	2
2020	3	1	1	1						1	0	4	7
2021	7	13	5	2	2	1		1			0	24	31
2022	134	131	153	87	81	43	20	5	10		6	536	670
2023	264	332	359	251	173	169	70	32	18	19	23	1446	1710
2024	198	335	352	304	225	156	76	40	16	15	27	1546	1744
Total	**626**	**828**	**880**	**652**	**483**	**374**	**166**	**80**	**44**	**35**	**56**	**3598**	**4224**

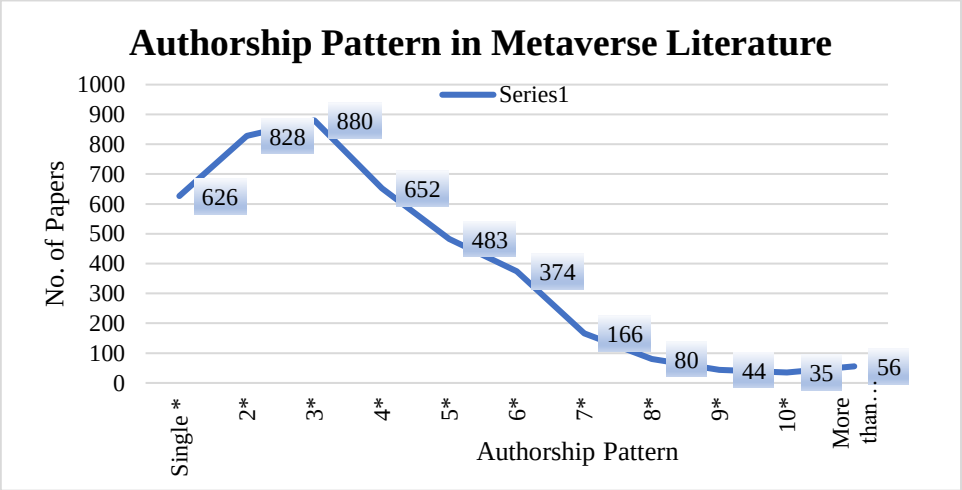

Figure 3: Authorship Pattern in Metaverse Literature

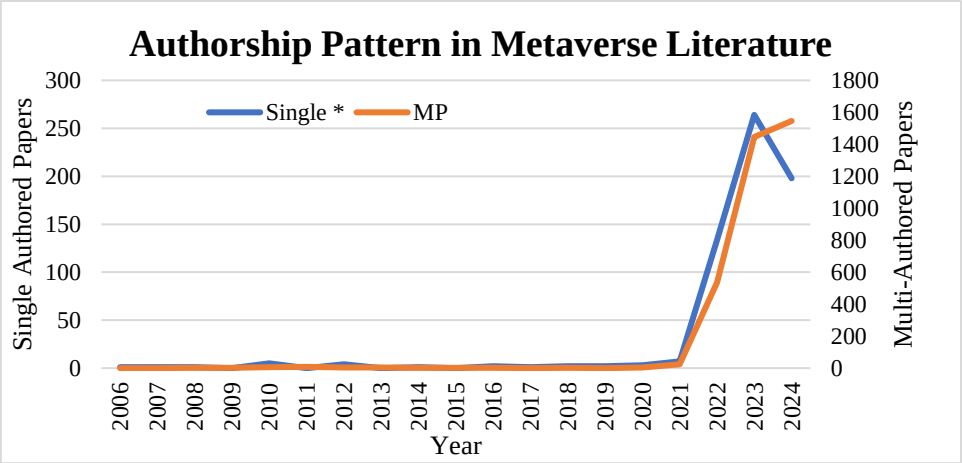

Figure 4: Authorship Pattern in Metaverse Literature

The table No. 2 shows the distribution of authorship patterns in Metaverse literature from 2006 to 2024. The rows represent different years, while the columns break down the number of publications by the number of authors involved. There has been a significant increase in the number of publications from 2006 to 2024. Publications with a single author were more frequent in the early years, but multi-author collaborations have become increasingly common, especially in recent years. From 2021 onwards, there has been a notable rise in publications with more than 10 authors, reflecting larger collaborative efforts. In 2023 and 2024, these large collaborations saw significant numbers, totalling 23 and 27, respectively. In the earlier years (2006–2010), single authorship was dominant. Starting around 2011–2012, multi-author publications (especially 2-4 authors) began to increase. By 2021, publications with 2–3 authors were the most common, and collaborations involving 4–10 authors grew significantly, particularly in 2022 and 2023. This data reflects a trend toward increasingly collaborative research in the Metaverse field, particularly in recent years, with a shift from single authorship to larger teams.

Table 3: Different Channels of Communication Used to Publish Metaverse Literature

Different Channels of Communication Used to Publish Metaverse Literature					
S. No.	**Channels of Communication**	**Total**	**%**	**FPY**	**LPY**
1	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	122	2.89	2007	2024
2	ACM International Conference Proceeding Series	91	2.15	2018	2024
3	Lecture Notes in Networks and Systems	71	1.68	2023	2024
4	Proceedings - 2023 IEEE International Conference on Metaverse Computing, Networking and Applications, MetaCom 2023	69	1.63	2023	2023
5	IEEE Access	56	1.33	2021	2024
6	Communications in Computer and Information Science	42	0.99	2022	2024
7	Sustainability (Switzerland)	41	0.97	2021	2024
8	Studies in Big Data	40	0.95	2023	2024
9	Journal of Metaverse	36	0.85	2021	2024
10	Electronics (Switzerland)	35	0.83	2022	2024
11	IEEE Journal on Selected Areas in Communications	33	0.78	2023	2024
12	Linguistic and Philosophical Investigations	32	0.76	2022	2023

13	Applied Sciences (Switzerland)	30	0.71	2021	2024
14	Review of Contemporary Philosophy	25	0.59	2022	2023
15	International Journal of Human-Computer Interaction	24	0.57	2023	2024
16	Springer Proceedings in Business and Economics	24	0.57	2022	2024
17	IEEE Transactions on Consumer Electronics	23	0.54	2023	2024
18	Technological Forecasting and Social Change	23	0.54	2008	2024
19	Procedia Computer Science	22	0.52	2014	2024
20	IEEE Internet of Things Journal	21	0.50	2023	2024
21	Journal of Retailing and Consumer Services	21	0.50	2023	2024
22	2023 International Conference on Intelligent Metaverse Technologies and Applications, iMETA 2023	20	0.47	2023	2023
23	CEUR Workshop Proceedings	20	0.47	2018	2024
24	Computers in Human Behavior	20	0.47	2022	2024
25	Heliyon	20	0.47	2022	2024
26	IEEE Transactions on Learning Technologies	20	0.47	2022	2024
27	Conference on Human Factors in Computing Systems - Proceedings	19	0.45	2022	2024
28	Future Internet	19	0.45	2022	2024
29	Applied Soft Computing	18	0.43	2023	2024
30	International Journal of Contemporary Hospitality Management	18	0.43	2023	2024
31	Internet Research	18	0.43	2023	2024
32	Proceedings of SPIE - The International Society for Optical Engineering	18	0.43	2022	2024
33	Proceedings of the Annual Hawaii International Conference on System Sciences	18	0.43	2023	2024
34	IEEE Network	17	0.40	2023	2024
35	IEEE Transactions on Systems, Man, and Cybernetics: Systems	17	0.40	2023	2024
36	Studies in Computational Intelligence	17	0.40	2022	2024
37	Education and Information Technologies	16	0.38	2023	2024
38	Cyberpsychology, Behavior, and Social Networking	15	0.36	2022	2024
39	Sensors	14	0.33	2021	2024
40	Smart Innovation, Systems and Technologies	14	0.33	2023	2024
41	IFIP Advances in Information and Communication Technology	13	0.31	2021	2024
42	Information Technology and Tourism	13	0.31	2023	2024
43	Critical Arts	12	0.28	2023	2024
44	Digest of Technical Papers - SID International Symposium	12	0.28	2022	2024
45	Frontiers in Psychology	12	0.28	2022	2024
46	IEEE International Conference on Communications	12	0.28	2022	2024
47	International Conference on ICT Convergence	12	0.28	2021	2024
48	Library Hi Tech News	12	0.28	2022	2024
49	Metaverse Communication and Computing Networks: Applications, Technologies, and Approaches	12	0.28	2023	2023
50	Proceedings - IEEE Global Communications Conference, GLOBECOM	12	0.28	2022	2023
51	Psychology and Marketing	12	0.28	2022	2024
52	IEEE Transactions on Mobile Computing	11	0.26	2024	2024
53	Information (Switzerland)	11	0.26	2022	2024
54	Journal of Global Fashion Marketing	11	0.26	2024	2024
55	Studies in Systems, Decision and Control	11	0.26	2023	2024
56	10 Papers Published in 7 Difference Channels of Communication	70	1.66	2012	2024
57	9 Papers Published in 6 Difference Channels of Communication	54	1.28	2022	2024
58	8 Papers Published in 12 Difference Channels of Communication	96	2.27	2022	2024
59	7 Papers Published in 21 Difference Channels of Communication	147	3.48	2022	2024
60	6 Papers Published in 26 Difference Channels of Communication	156	3.69	2010	2024
61	5 Papers Published in 26 Difference Channels of Communication	130	3.08	2021	2024
62	4 Papers Published in 60 Difference Channels of Communication	240	5.68	2013	2024
63	3 Papers Published in 105 Difference Channels of Communication	315	7.46	2010	2024
64	2 Papers Published in 231 Difference Channels of Communication	462	10.94	2009	2024
65	Each Article Published in 1157 Different Channels of Communication	1157	27.39	2006	2024
	Total	**4224**	**100.00**		

The table Number 3 lists different channels of communication used to publish Metaverse literature, along with the number of papers published, their percentage share of total publications, and the years when the first and last publications occurred for each channel. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): 122 publications (2.89%) ACM International Conference Proceeding Series: 91 publications (2.15%) Lecture Notes in Networks and Systems: 71 publications (1.68%) Proceedings - 2023 IEEE International Conference on Metaverse Computing, Networking and Applications, Metacom 2023: 69 publications (1.63%) IEEE Access: 56 publications (1.33%).

Table 4: Top Countries Publishing Metaverse Literature

Top Countries Publishing Metaverse Literature			
S. No.	**Countries**	**No. of Papers**	**%**
1	China	919	21.76
2	United States	532	12.59
3	India	464	10.98
4	South Korea	455	10.77
5	United Kingdom	335	7.93
6	Italy	238	5.63
7	United Arab Emirates	173	4.10
8	Turkey	170	4.02
9	Canada	159	3.76
10	Australia	155	3.67
11	Germany	149	3.53
12	Spain	147	3.48
13	Singapore	143	3.39
14	Malaysia	136	3.22
15	Japan	126	2.98
16	Taiwan	113	2.68
17	Hong Kong	110	2.60
18	Saudi Arabia	106	2.51
19	Indonesia	103	2.44
20	France	82	1.94
21	Undefined	72	1.70
22	Thailand	67	1.59
23	Finland	64	1.52
24	Portugal	59	1.40
25	Jordan	59	1.40
26	Greece	58	1.37
27	Romania	57	1.35
28	Brazil	56	1.33
29	Pakistan	55	1.30
30	Qatar	53	1.25
31	Iraq	51	1.21
32	Lebanon	49	1.16
33	Switzerland	46	1.09
34	Czech Republic	45	1.07
35	Ireland	44	1.04
36	Viet Nam	43	1.02
37	South Africa	42	0.99
38	Netherlands	42	0.99
39	Macao	40	0.95
40	Sweden	39	0.92
41	Egypt	37	0.88
42	Slovakia	36	0.85
43	Norway	34	0.80
44	Iran	30	0.71
45	Mexico	29	0.69
46	Poland	25	0.59
47	Cyprus	25	0.59
48	Austria	23	0.54
49	New Zealand	22	0.52
50	Denmark	22	0.52

The table number 4 lists the top countries publishing Metaverse literature based on the number of papers published, along with the percentage share of total publications for each country. The dataset lists countries that contributed significantly to Metaverse research, with China leading in publications, followed by major contributors like the United States and India. Countries like the United Arab Emirates (4.10%) and Turkey (4.02%) show notable contributions as well. Publications are spread across diverse regions, with contributions from both Western (e.g., United States, United Kingdom) and Eastern (e.g., China, South Korea, India) countries. This indicates a global interest in Metaverse-related research, with a strong presence from Asian countries, as well as significant contributions from the United States and Europe.

Table 5: Language-wise Distribution of Metaverse Literature

Language-wise Distribution of Metaverse Literature			
S. No.	**Language**	**No. of Papers**	**%**
1	English	4036	95.55
2	Chinese	90	2.13
3	Spanish	45	1.07
4	Portuguese	11	0.26
5	Korean	10	0.24
6	Russian	8	0.19
7	Italian	7	0.17
8	German	5	0.12
9	Japanese	4	0.09
10	French	3	0.07
11	Turkish	2	0.05
12	catalan	1	0.02
13	Croatian	1	0.02
14	Czech	1	0.02
	Total	**4224**	**100.00**

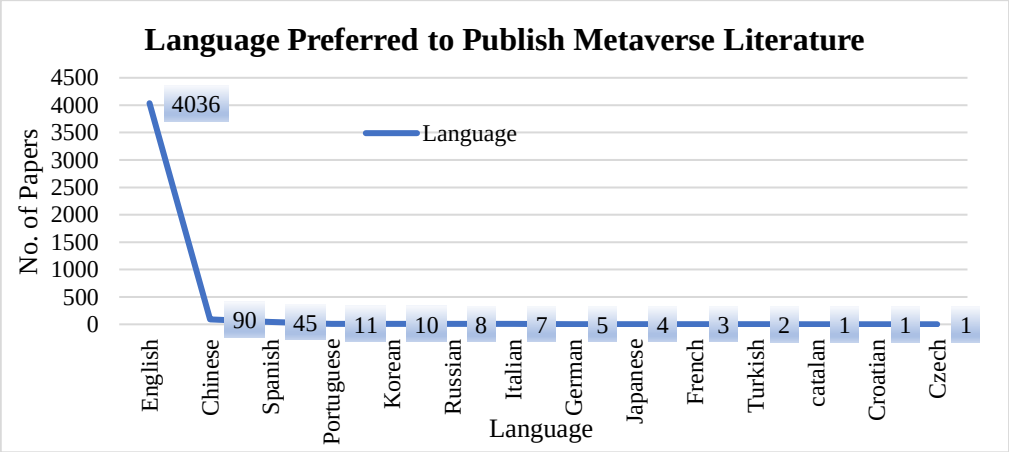

Figure 5: Language Distribution of Metaverse Literature

Table number 5 shows the distribution of papers published in various languages related to "Metaverse Literature." English is overwhelmingly the most common language in Metaverse literature, with 95.55% of the papers published in this language. Chinese is the second most common language (2.13%), followed by Spanish (1.07%). Other languages like Portuguese, Korean, Russian, and others make up a very small percentage of the total. Languages such as Catalan, Croatian, and Czech contribute only marginally to the overall count, each with just 1 paper (0.02%). This distribution highlights the global focus on Metaverse literature and underscores English's dominance in scholarly discussions on this topic.

Table 6: Different types of Data used to Publish Metaverse Literature

Different types of Data used to Publish Metaverse Literature						
S. No.	**Different Types of Data**	**Total No. of Papers**	**%**	**Total No. of Citations**	**%**	**Citation/ Item**
1	Article	2124	50.28	31381	71.34	14.77
2	Conference paper	1560	36.93	6370	14.48	4.08
3	Review	235	5.56	4645	10.56	19.77
4	Book chapter	214	5.07	314	0.71	1.47
5	Editorial	25	0.59	496	1.13	19.84
6	Note	23	0.54	314	0.71	13.65
7	Book	17	0.40	53	0.12	3.12
8	Short survey	13	0.31	337	0.77	25.92
9	Letter	10	0.24	75	0.17	7.50
10	Data paper	2	0.05	2	0.00	1.00
11	Retracted	1	0.02	3	0.01	3.00
	Total	**4224**	**100.00**	**43990**	**100.00**	**10.41**

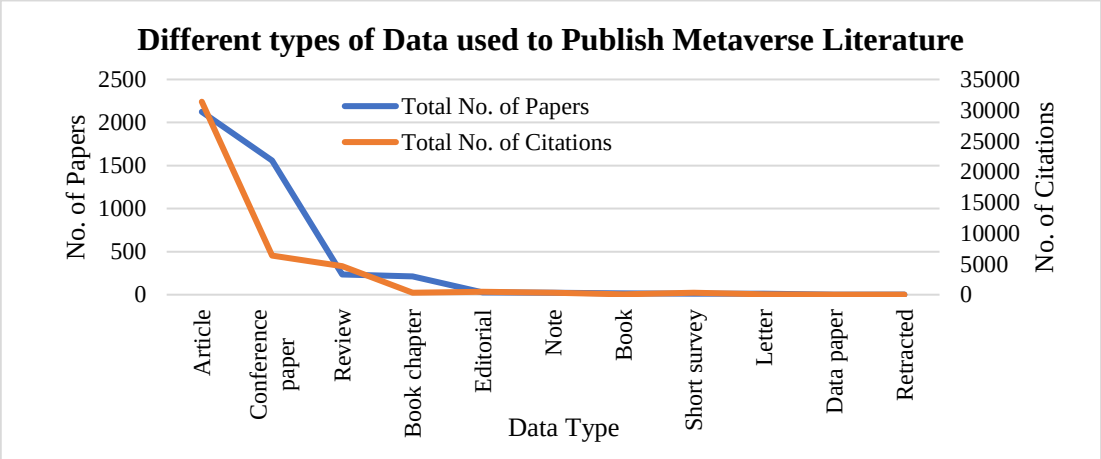

Figure 6: Different types of data Used to Publish Metaverse Literature

The table you provided shows the different types of data used in Metaverse literature, alongside their respective number of papers, citations, and citation/item ratio. The majority of the papers published are articles (50.28%), followed by conference papers (36.93%). Articles also have the highest total number of citations (71.34%). Among the different types, Review papers have the highest citation per item (19.77), followed by Editorials (19.84). This suggests that although fewer review papers are published, they receive significantly more attention and citations. Despite making up a large portion of the publications (36.93%), conference papers have a relatively lower citation rate per item (4.08). Types like Data papers (0.05%), Books (0.40%), and Letters (0.24%) contribute very little to the overall number of papers but do have some citations. There is a very small number of retracted papers (0.02%), with a moderate citation rate (3.00), indicating limited but some academic attention before retraction. Articles and conference papers dominate Metaverse literature in terms of both quantity and citations. Review papers, while fewer, enjoy significantly higher citation rates, suggesting they are highly influential. Other types like books, notes, and retracted papers contribute only marginally to the total body of literature.

Table 7: Bradford's Law of Scattering

Bradford's Law of Scattering			
Zones	**Journals**	**Papers**	**Bradford's Multiplier**
I	41	705	
II	189	709	4.61
III	641	709	3.39
Total	**871**	**2123**	**Avg. 4**

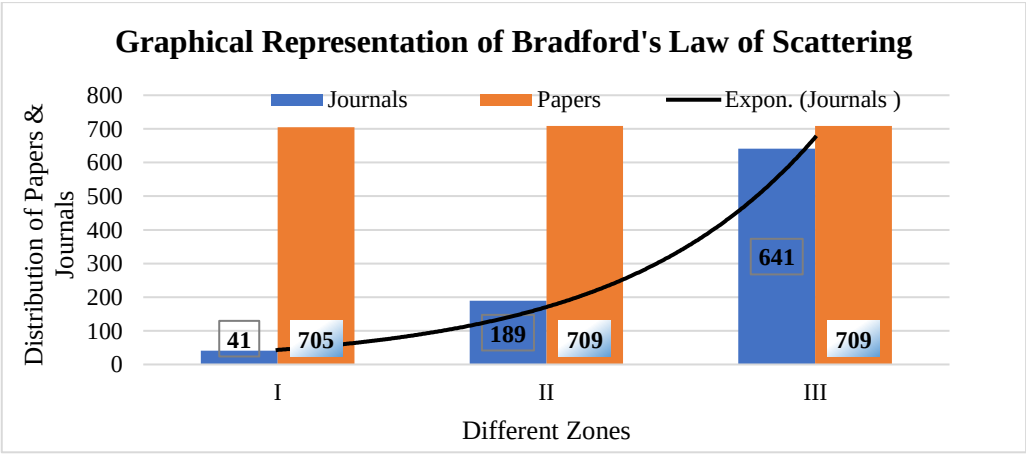

Figure 7: Graphical Representation of Bradford's Law of Scattering

Bradford's Law of Scattering is a principle used in bibliometrics to describe how articles or papers on a given subject are distributed among journals. The law suggests that journals can be grouped into three zones based on the number of articles they publish on a specific topic, with a diminishing return of articles as you move from one zone to the next. In other words, a small number of journals account for the majority of papers, while a larger number of journals contribute fewer papers. As per the data represented in the Graph, is further tested with the formula *n: n1: n2* as suggested by Bradford. Where 41: (41×4): (41×4^2) further simplified as 41: 164: 656= 861.

Percentage of Error = $\frac{861-871}{871}$×100 = -1.14,

hence the Percentage of Error is negative and negligible thus the Metaverse literature fits into Bradford's law of Scattering very well.

4.Conclusion

Metaverse literature is an interdisciplinary and rapidly developing area of study. While English-language articles and conference papers dominate, review papers and other less frequent formats also play a critical role in shaping the field's intellectual landscape. The field's future will likely be shaped by ongoing technological advancements, academic inquiry, and the evolving nature of virtual worlds and digital interactions. As the Metaverse continues to expand, so too will the scope and impact of its associated literature.

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