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SCIENTOMETRIC ANALYSIS OF CYBER SECURITY IN GLOBAL RESEARCH FROM SCOPUS DATABASE DURING THE PERIODS 2001-2020

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ABSTRACT

This study of scientometric analysis of cyber security research publications from Scopus Database during 2001-2020. A total number of 14190 research publications are contributed to cyber security. A maximum of 2718 (19.15%) research publications are contributed in the year 2019 and the highest value of citations of 14849(14.44%) in the year 2017. The relative growth rate is 2.94 in the year 2002 and 0.46 in the year 2020. At the same time, doubling time found that 0.24 in the year 2002 and 1.52 in the year 2020. A maximum of 33(6.88%) research publications are contributed by Kozik, R. United States, The authorship pattern a maximum of 3313 research publications are contributed by two authors. The average degree of collaboration is 0.79, the average Collaborative co-efficient is 0.44, the average collaborative index is 2.34, the average modified collaborative co-efficient is 2.34. The CAI for two, three, and more than three authorship contributions are increasing trend 1st block year to 2nd block year. A maximum of 629(19.88%) research publications are contributed by computer science lecture notes, including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics. The country of a maximum of 5195(41.37%) research publications are contributed by the United States. The time series analysis will be expected in the cyber security research publications in the year 2025 is around are equal to 1920, and the year 2030 is around are equal to 2525.

INTRODUCTION

In the early 1970s computer virus was first generated and it was noticed on ARPANET, the predecessor to the internet. The first computer worm was spread in the year 1988 and it draws the attention the social media. Viruses have developed and become a pandemic a quarter of a century later. In a very short span Viruses increased quickly and malware has become more difficult, later Cyber-attacks happen daily and are continuously changing. The attacks come in all shapes and sizes from computer worms to large data breaches. "Cyber-attacks have evolved from tiny hacks created by high-school students to state-sponsored attacks compromising presidential elections in the past quarter-century alone. While threats continue to develop, so does the defense against them. It's important to remember these past events in order to combat impending attacks. Milestone incidents are what made cybersecurity what it is today" (https://www. google.com /search?client=firefox-b-d&q=cyber +security + introduction. (Accessed on 27.07.2021) To avoid viruses from external threats and protect devices and networks Cyber Security was designed.

The employees of the Cyber Security professionals have to protect the client's confidential information, maintain employee productivity, and enhance their confidence in products and services. Cyber Security rotates around the business standard of confidentiality, honesty, and availability, or CIA. Confidentiality means data can be accessed only by authorized parties; honesty means information can be added, altered, or removed only by authorized users; and availability means the data must be available on-demand according to agreed-upon restrictions. "The main element of Cyber Security is the use of authentication mechanisms. For example, a user name identifies an account that a user wants to access, while a password is a mechanism that proves the user is who he claims to be" (https://www.varonis.com/blog/events-that-changed-cybersecurity. (Accessed on 27.07.2021)).

Scientometric Study: Scientometric is a genuinely interdisciplinary research field that extends almost all scientific areas. In addition, many extensive bibliometric studies of necessary science fields appeared during the last two decades. At present, the meaning of bibliometric turns out to be the science of measurement relating to documents. "The word measurement means the application of

mathematical and statistical techniques to find out the growth of document, scattering, or literature in various types of documents, publication of documents by an author, impact of document, and so on" Van Raan (1997). So that this paper aims to analyze the contribution of cyber security research publications from the Scopus Database during 2001-2020. According to Beck (1978) "Scientometrics is defined as the quantitative evaluation and inter-comparison of scientific activity, productivity, and progress". Bookstein (1995) defined "scientometrics as the science of measuring science. Scientometrics is also considered as a bibliometric measurement for evaluation of scientific development, social relevance and impact of the application of science and technology". Ingwerson and Christensen (1997) defined the term "informatics designates a recent extension of the traditional bibliometric analysis, also to cover non-scholarly communities in which information is produced, communicated and used".

Literature Review: Dhawan, *et al* (2021) examined the global cyber security research output (1998-2019) using the Scopus data and to discover basic trends and developments at the global level and individual level using bibliometric indicators. The cyber security research showed a 46.41% growth with an average citation impact of 5.05 citations per paper is nearly 15% of the total papers were funded by external agencies. The top 10 countries alone accounted for the output in the subject (76.52%). Among the top 10 countries, the United States leads this list with the highest publication productivity (43.75% of global output). Canada leads the world in terms of the relative citation index (1.47).

Kavitha *et al* **(2018**) analyzed the research output on Solar cell research publications fromthe Scopus database during 1978 – 2017 with 150201 publications. Out of that, 4430 (2.95%) publications were open-source publications and 145771(97.5%) publications were from the source. The study identified that 55% of articles appeared last six years during the study A maximum of 15113(10.06%) publications are published in the year 2017. 14 countries are contributed more than 2750 publications and 96377(64.17%) papers were published by Journal.

Kumar (2014) analyzes scientometric study on digital literacy research publications from library information science and technology abstracts (LISTA) during 1997-2011 with 137 articles. Out of that 53.28% of articles focus significantly on digital literacy. Academy journals and periodicals are published 69. of 34%of articles in the field of digital literacy. Triple authorship pattern was 35.04% publications and 35-40 age group authors are published number of 39.42% articles. U.K. (27.01%) and U.S.A. (24.82%) were published more numbers of articles. International journal of information and library review published a maximum of 8.03% of articles.

Sudhakar and Thanuskodi (2018) analyzed the scientometric analysis of Marine Pollution Bulletin Journal research publications from 2008 to 2017 with 5416 publications. The maximum number of 905(16.71%) publications were contributed in 2017. This study identified RGR had been decreased from 0.63 to 0.18 while doubling time has been increased from 1.10 to 3.85. The degree of collaboration was 0.94, indicating its dominance of multiple authors' contributions. Liu J. was the top-ranked author with 49 articles. The United States contributes a maximum number of 910 (12.06%) publications.

Dhanya and Raja (2017) examined the Indian research output of industrial pollution indexed in the Web of Science database with 805 publications during 2007-2016, which received 9699citations. Kumar A and Kumar R are the most productive authors with 13 (1.6%). The most productive journal is Environmental Monitoring and Assessment, with 103 (12.8%) publications, and the maximum of articles was published in 2016 with 113(14%) publications.

The relative Growth Rate was 0.16 in 2016, and Doubling Time was 4.58 in 2016.

Ravichandran and Vivekanandhan (2021) examine the Scientometric analysis of wastewater management research publications during 2010-2019 from the Scopus database. The study identified that a maximum of 2842(14.31%) research publications with 19857 citations contributed in 2019. Ngo, H.H contributed a maximum of 101(0.51%) research publications, maximum of 19355 articles were contributed by joint authors, and the average degree of collaboration was 0.97. Maximum of 2102(10.58%) research publications are contributed in Bioresource technology, ministry of education, china with 863(22.32%) research publication and China has contributed the maximum of 5919(29.80%) research publications

Ravichandran and Vivekanandhan (2021) analyzed the wireless sensor network research output in India during 2010-2019 from the SCOPUS database with 11775. This study identified that the maximum number of 2058(17.48%) publications are contributed in 2019, and the compound annual growth rate was 5.44. This study determined that the relative growth rate decreased, and the doubling time increased. The average degree of collaboration was 0.96, and CAI decreased trend for more than three authors from 1st block year (106.71) to 2nd block year (97.39).

Objectives

- To identify the year wise growth of publications with citations
- To analysis the relative growth rate and doubling time
- To determine the top 10 authors contribution
- To analysis the authorship pattern and degree of collaboration
- To analysis the collaborative co-efficient and collaborative index
- To examine the co-authorship index
- To identify the top 20 journals, and country's contributions.
- To analyze the time series analysis.

Scope and Coverage of this Study: We have performed this study for the coverage period of 20 years (2001 to 2020). We have focused on the scholarly literature directly related to the term 'cyber security which is indexed in the Scopus database.

Research Methodology: The cyber security research publications are identified using the Scopus multidisciplinary online database from 2011 to 2020 using the following search keyword: (TITLE-ABS-KEY ("Cyber Security") AND PUBYEAR > 2000 AND PUBYEAR < 2021) the data was collected for this study is 16.07.2021. The collected data were analyzed using a micro soft excel worksheet.

Data Analysis and Interpretations

Citations per Publication (CPP): CPP has been broadly used in the scientometric assessment to stabilize the variation in volumes of literature published by the different institutions/countries, etc. (Bharvi and Khaiser (2016) and Sandhya (2016). From this study, CPP has been used to assess the impact of Pollution Control research publications for the years, countries, institutes, and authors for the below-mentioned formula

$$P = \frac{\text{Total Citations of a Country or Institution}}{\text{Total of Publications}}$$

Year-wise growth of publications: Table 1 shows theyear-wise growth of Cyber Securityresearch publications during the ten-year study period between 2001 and 2020 with 14190 research publications and 102752 citations. From the study, it is identified that the maximum of 2718 (19.15%) research publications are contributed in the year 2019, followed by 2483 (17.50%) publications in the year 2020, and 2022 (14.25%) publications in the year 2018. The average research publication per year is 709.5. During the ten-year study, it is identified that a total number of14190 publications are received 102752 citations.

Table 1. Year-wise growth of publications and Citations

S.No	Year	No of Publication	%	Citation	%	Cited	%	Uncited	%	CPP
1	2001	6	0.04	58	0.06	4	0.04	2	0.04	9.67
2	2002	13	0.09	788	0.77	5	0.05	8	0.16	60.62
3	2003	25	0.18	371	0.36	15	0.16	10	0.20	14.84
4	2004	35	0.25	282	0.27	19	0.21	16	0.32	8.06
5	2005	62	0.44	470	0.46	31	0.34	31	0.62	7.58
6	2006	94	0.66	1100	1.07	57	0.62	37	0.75	11.70
7	2007	91	0.64	868	0.84	55	0.60	36	0.72	9.54
8	2008	113	0.80	796	0.77	67	0.73	46	0.93	7.04
9	2009	177	1.25	1909	1.86	117	1.27	60	1.21	10.79
10	2010	257	1.81	3735	3.63	173	1.88	84	1.69	14.53
11	2011	369	2.60	4123	4.01	267	2.89	102	2.05	11.17
12	2012	470	3.31	7082	6.89	321	3.48	149	3.00	15.07
13	2013	639	4.50	8762	8.52	463	5.02	176	3.54	13.71
14	2014	697	4.91	7384	7.18	488	5.29	209	4.21	10.59
15	2015	984	6.93	10025	9.75	706	7.65	278	5.60	10.19
16	2016	1295	9.13	11251	10.94	976	10.58	319	6.42	8.69
17	2017	1640	11.56	14849	14.44	1260	13.66	380	7.65	9.05
18	2018	2022	14.25	12846	12.49	1442	15.63	580	11.68	6.35
19	2019	2718	19.15	11611	11.29	1750	18.97	968	19.49	4.27
20	2020	2483	17.50	4442	4.32	1008	10.93	1475	29.70	1.79
	Total	14190	100.00	102752	99.90	9224	100.00	4966	100.00	

Table 2. and Relative Growth Rate and Doubling Time of Research Publications

S.No	Years	No of Publications	Cum	W_1	W_2	$RGR=(W_2-W_1)$	$Dt=(0.693/RGR)$
1	2001	6	6		1.79		
2	2002	13	19		2.94	2.94	0.24
3	2003	25	44	1.79	3.78	1.99	0.35
4	2004	35	79	2.94	4.37	1.43	0.49
5	2005	62	141	3.78	4.95	1.16	0.60
6	2006	94	235	4.37	5.46	1.09	0.64
7	2007	91	326	4.95	5.79	0.84	0.83
8	2008	113	439	5.46	6.08	0.62	1.11
9	2009	177	616	5.79	6.42	0.64	1.09
10	2010	257	873	6.08	6.77	0.69	1.01
11	2011	369	1242	6.42	7.12	0.70	0.99
12	2012	470	1712	6.77	7.45	0.67	1.03
13	2013	639	2351	7.12	7.76	0.64	1.09
14	2014	697	3048	7.45	8.02	0.58	1.20
15	2015	984	4032	7.76	8.30	0.54	1.28
16	2016	1295	5327	8.02	8.58	0.56	1.24
17	2017	1640	6967	8.30	8.85	0.55	1.27
18	2018	2022	8989	8.58	9.10	0.52	1.32
19	2019	2718	11707	8.85	9.37	0.52	1.34
20	2020	2483	14190	9.10	9.56	0.46	1.52

Table 3. Top 10 Authors Contributions in Cyber Security Research Publications

S.No	Author	Publication	%	Citation	%	CPP	h-index	RCI
1	Kozik, R.	33	6.88	258	2.76	7.82	9	0.40
2	Choo, K.K.R.	31	6.46	337	3.60	10.87	9	0.56
3	Wang, L.	31	6.46	451	4.82	14.55	9	0.75
4	Choraś, M.	30	6.25	217	2.32	7.23	9	0.37
5	Ekstedt, M.	30	6.25	409	4.37	13.63	10	0.70
6	Govindarasu, M.	24	5.00	1690	18.06	70.42	14	3.61
7	Ishii, H.	24	5.00	555	5.93	23.13	13	1.19
8	Straub, J.	24	5.00	74	0.79	3.08	6	0.16
9	Soman, K.P.	23	4.79	572	6.11	24.87	8	1.28
10	Hariri, S.	22	4.58	243	2.60	11.05	7	0.57
11	Thuraisingham, B.	22	4.58	219	2.34	9.95	8	0.51
12	Hahn, A.	21	4.38	1316	14.06	62.67	11	3.21
13	Janicke, H.	21	4.38	315	3.37	15.00	8	0.77
14	Joshi, A.	21	4.38	321	3.43	15.29	8	0.78
15	Liu, C.C.	21	4.38	931	9.95	44.33	14	2.27
16	Weiss, J.	21	4.38	72	0.77	3.43	4	0.18
17	Zhu, Q.	21	4.38	275	2.94	13.10	8	0.67
18	Liu, P.	20	4.17	323	3.45	16.15	7	0.83
19	Morris, T.	20	4.17	487	5.20	24.35	11	1.25
20	Sun, W.	20	4.17	294	3.14	14.70	7	0.75
	Total	480	100.00	9359	100.00			

Out of that maximum of 14849(14.44%), citations are received 1640 publications in the year 2017. Followed by 12846 citations are received 2022 publications in the year 2018. From the study, out of 14190 publications, 9224 research publications are cited publicationsand 4966 publications are uncited publications. The maximum of citation per paper is 60.62 in the year 2002, followed by CPP is 15.07 in the year 2012 andthe average citation per paper is 12.27

Relative Growth Rate of Publications: The relative growth of publications was analyzed using the two parameters, namely Relative Growth Rate and Doubling time, which was originated by Mahapatra (1985)[20]. RGR is a measure to study the number of articles in a period.

It is calculated as

$$R(a) = \frac{(W2 - W1)}{(T2 - T1)}$$

Whereas

R (a) = RGR = the mean relative growth rate over the particular period of interval
W_1 = the logarithm of the beginning number of publications/pages
W_2= the logarithm of ending number of publications/pages after a specific period of interval
$T_2 - T_1$ = the unit difference between the beginning and the ending time.

Doubling Time: The doubling time is the time taken for the doubling of the number of records actually published within a specified period. The doubling time is calculated from the relative growth rate and the natural logarithm number is used, the difference has a value of 0.693. Thus the corresponding doubling time can be calculated by the following formula,

$$Dt = \frac{0.693}{R(a)}$$

Relative Growth Rate and Doubling Time of Research Publications: The relative growth rate and the doubling time (Dt) were calculated and the results are presented in Table 2. From the study, it is identified that the relative growth rate is 2.94 in the year 2002 and 0.46 in the year 2020. This study confirmed that the relative growth rate is decreasing trend. At the same time doubling time found that 0.24 in the year 2002 and 1.52 in the year 2020 and it is confirmed that doubling time is an increasing trend.

H-Index: Hirsch (2005) proposed the h-index is one of the alternatives into the standard bibliometric indicators for the single scientists, it is defined as in the table A scientist has index h if h of his or her Np papers have at least h citations each and other papers (Np – h) have ≤ citations each.

Table - various methods of *h*-index

Model	Equation	Description
Hirsch	$h = \sqrt{(C / a)}$	C = Total Citations; a = Constant

Relative Citation Index (RCI): Relative citation index (RCI) was developed by the Institute of Scientific Information (now Thomson Reuters, USA) and examine the impact of different countries and institutions in the field of Pollution Control research publications. The scientific impact of leading countries was examined by using two relative indicators, namely citations per paper (CPP) and relative citations index (RCI). Citations per paper (CPP) is a relative indicator computed as the average number of citations per paper. It has been broadly used inbibliometric studies as it normalizes a large difference in the volumes of publications among most productive countries, institutions, and authors. To measure both influence and visibility of a country research global wise, the following formula has been used by Bharvi Dutt and Khaiser Nikam (2016)[22]

$$RCI = \frac{\text{A Country share of the World Citations}}{\text{A Country share of the World Publications}}$$

RCI = 1 indicates that a country's citation rate is equal to the world citation rate
RCI > 1 indicates that a country's citation rate is greater than the world citation rate
RCI < 1 indicate that a country's citation rate is lower than the world citation rate

Top 10 Authors Contributions in Cyber Security Research Publications: Table 3 identified the top ten author's contributions in cyber security research publications from the Scopus database for the selected twenty-year study period. From the study, it is identified that, the maximum of 33(6.88%) research publications are contributed by Kozik, R.United States,and this publicationis received 258(2.76%) citations, CPP is 7.82, h-index is 9, and RCI value is 0.40. Followed by Choo, K.K.R.from the United kingdomwith 31(6.46%) research publications and it is received by 337(3.60%) citations, CPP is 10.87, h-index, is 9, and RCI value is 0.56.thethird-ranking author is Wang, L.from India with 31(6.66%) research publications, 451(4.82%) citations, CPP is 14.55, h-index is 9, and RCI value is 0.75.

Authorship Pattern in Cyber Security Research Publications: Table 4 identified theyear-wise authorship pattern in the field of cyber securityresearch during the twenty-year study period. From the study, it is identified that, out of 14190 research publications, 3041 research publications are contributed by single authors and the remaining 11149 research publications are multi-author's contributions. From the multi -author's publications, a maximum of 3313 research publications are contributed by two authors, followed by 3143 publications are contributed bythree authors, 2166 publications are four authors. During the ten-year study period, more than five authors have contributed 1296 publications.

Degree of Collaborationin Cyber Security Research Publications: The degree of collaboration is the relationship between single author and multi-author contributions. The degree of collaboration is calculated by the Subramanian (1983) formula and used by Vivekanandhan (2016), Sivasamy (2020).

$$DC = \frac{Nm}{(Nm + Ns)}$$

Where DC = Degree of Collaboration
N_m = Number of Multi-authored publications
N_s = Number of single-authored publications
In the present study, Nm = 11149, Ns= 3041

So that the degree of collaboration is =11149/ (3041+11149) = 0.79
Table 5 shows the degree of collaboration in cyber securityresearch publications for the ten-year studies period. From this study, it is identified that the degree of collaboration is between 0.17 in the year 2001 and 0.84 in the year 2020. The average degree of collaboration is 0.79. From this study, it is identified that the majority of cyber securityresearch publications are contributed by collaborative authors.

Collaborative of Co-efficient (CC): The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by Ajiferuke, *et al.* (1988)

$$CC = 1 - \left[\sum_{j=0}^{k} \left(\frac{1}{j} \right) \times Fj/N \right]$$

Whereas,
Fj = Number of publications with j author papers
N = Total number of the research publications and
k = the greatest number of authors/papers in the given field

Table 4. Authorship Pattern in Cyber Security Research Publications

Years	1	2	3	4	5	>5	Total
				Authorship Pattern			
2001	5	0	1	0	0	0	6
2002	12	0	1	0	0	0	13
2003	14	2	5	2	1	1	25
2004	23	5	5	2	0	0	35
2005	38	15	3	3	2	1	62
2006	29	29	17	12	2	5	94
2007	43	13	11	14	6	4	91
2008	54	25	15	12	2	5	113
2009	71	42	32	17	9	6	177
2010	73	59	53	29	22	21	257
2011	125	83	70	53	12	26	369
2012	150	126	89	53	20	32	470
2013	210	134	140	74	44	37	639
2014	196	164	151	91	54	40	696
2015	268	262	191	115	74	74	984
2016	286	315	291	189	112	101	1294
2017	326	398	375	262	132	147	1640
2018	339	488	477	331	201	186	2022
2019	387	622	664	443	286	316	2718
2020	392	531	552	464	252	294	2485
Total	3041	3313	3143	2166	1231	1296	14190
%	21.43	23.35	22.15	15.26	8.68	9.13	100.00

Table 5. Degree of Collaboration inCyber Security Research Publications

Years	Single Author Publications NS	Multi-Author Publications NM	Total Author Publications	Degree of CollaborationDC=NM/Ns+Nm)
2001	5	1	6	0.17
2002	12	1	13	0.08
2003	14	11	25	0.44
2004	23	12	35	0.34
2005	38	24	62	0.39
2006	29	65	94	0.69
2007	43	48	91	0.53
2008	54	59	113	0.52
2009	71	106	177	0.60
2010	73	184	257	0.72
2011	125	244	369	0.66
2012	150	320	470	0.68
2013	210	429	639	0.67
2014	196	500	696	0.72
2015	268	716	984	0.73
2016	286	1008	1294	0.78
2017	326	1314	1640	0.80
2018	339	1683	2022	0.83
2019	387	2331	2718	0.86
2020	392	2093	2485	0.84
Total	3041	11149	14190	0.79

Table 6. Collaboration Index and Collaborative of Co-efficient of Cyber Security research

Year	1	2	3	4	5	>5	CC	CI	MCC
				Authorship Pattern					
2001	5	0	1	0	0	0	0.93	0.11	0.11
2002	12	0	1	0	0	0	0.05	1.15	1.25
2003	14	2	5	2	1	1	0.30	2.08	2.17
2004	23	5	5	2	0	0	0.21	1.60	1.65
2005	38	15	3	3	2	1	0.23	1.69	1.72
2006	29	29	17	12	2	5	0.43	2.40	2.43
2007	43	13	11	14	6	4	0.36	2.33	2.36
2008	54	25	15	12	2	5	0.33	2.10	2.12
2009	71	42	32	17	9	6	0.38	2.26	2.27
2010	73	59	53	29	22	21	0.47	2.73	2.74
2011	125	83	70	53	12	26	0.43	2.52	2.52
2012	150	126	89	53	20	32	0.44	2.50	2.50
2013	210	134	140	74	44	37	0.44	2.56	2.56
2014	196	164	151	91	54	40	0.47	2.66	2.66
2015	268	262	191	115	74	74	0.47	2.68	2.68
2016	286	315	291	189	112	101	0.52	2.87	2.87
2017	326	398	375	262	132	147	0.53	2.95	2.95
2018	339	488	477	331	201	186	0.56	3.06	3.06
2019	387	622	664	443	286	316	0.58	3.21	3.21
2020	392	531	552	464	252	294	0.57	3.22	3.22
Total	3041	3313	3143	2166	1231	1296			

Table 7. Co-Authorship Index in Cyber Security Research Publications Co- Authorship Index in Cyber Security Research Publications

10 year Block	Single Author	CAI	Two Author	CAI	Three Author	CAI	More than three Author	CAI	Total
2001-2010	362	193.49	190	93.22	143	73.95	178	61.65	873
2011-2020	2679	93.87	3123	100.44	3000	101.71	4515	102.51	13317
Total	3041		3313		3143		4693		14190

Table 8. Top 20 Journals contributions in Cyber Security research

S.No	Journals	No of Publications	%	Total Citation	%	CPP	h-index	RCI
1	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	629	19.88	2393	10.74	3.80	22	0.54
2	ACM International Conference Proceeding Series	447	14.13	1411	6.33	3.16	17	0.45
3	Advances In Intelligent Systems And Computing	297	9.39	649	2.91	2.19	10	0.31
4	Communications In Computer And Information Science	184	5.82	376	1.69	2.04	10	0.29
5	European Conference On Information Warfare And Security Eccws	158	4.99	199	0.89	1.26	5	0.18
6	IEEE Access	155	4.90	2334	10.47	15.06	22	2.14
7	IEEE Security And Privacy	144	4.55	1190	5.34	8.26	18	1.17
8	Ceur Workshop Proceedings	126	3.98	301	1.35	2.39	8	0.34
9	Computers And Security	120	3.79	3614	16.21	30.12	28	4.27
10	Proceedings Of SPIE The International Society For Optical Engineering	107	3.38	349	1.57	3.26	11	0.46
11	IFIP Advances In Information And Communication Technology	96	3.03	329	1.48	3.43	8	0.49
12	Computer Fraud And Security	89	2.81	215	0.96	2.42	8	0.34
13	Iet Conference Publications	86	2.72	218	0.98	2.53	8	0.36
14	Computer	85	2.69	1593	7.15	18.74	14	2.66
15	IEEE Power And Energy Society General Meeting	83	2.62	541	2.43	6.52	13	0.93
16	Proceedings Of The Annual Hawaii International Conference On System Sciences	79	2.50	695	3.12	8.80	9	1.25
17	IEEE Transactions On Smart Grid	76	2.40	4608	20.67	60.63	38	8.61
18	Proceedings IEEE Military Communications Conference MILCOM	73	2.31	460	2.06	6.30	12	0.89
19	Network Security	66	2.09	185	0.83	2.80	6	0.40
20	Procedia Computer Science	64	2.02	630	2.83	9.84	14	1.40
	Total	3164	100.00	22290	100.00			

Table 10. Country wise Contributions in Cyber Security research

S.No	Country	No of Publication	%	Citations	%	CPP	H- Index	RCI
1	United States	5195	41.37	52684	46.66	10.14	88	1.13
2	United Kingdom	1150	9.16	9450	8.37	8.22	43	0.91
3	China	953	7.59	10127	8.97	10.63	50	1.18
4	India	837	6.67	4385	3.88	5.24	29	0.58
5	Australia	497	3.96	5672	5.02	11.41	33	1.27
6	Italy	451	3.59	3657	3.24	8.11	29	0.90
7	Germany	391	3.11	1835	1.63	4.69	19	0.52
8	Canada	385	3.07	4469	3.96	11.61	34	1.29
9	Japan	317	2.52	2154	1.91	6.79	22	0.76
10	South Korea	305	2.43	3165	2.80	10.38	25	1.15
11	France	281	2.24	2092	1.85	7.44	20	0.83
12	Russian Federation	265	2.11	927	0.82	3.50	14	0.39
13	Spain	244	1.94	1910	1.69	7.83	23	0.87
14	South Africa	217	1.73	1282	1.14	5.91	13	0.66
15	Norway	194	1.54	1438	1.27	7.41	16	0.82
16	Malaysia	187	1.49	1194	1.06	6.39	16	0.71
17	Sweden	182	1.45	2838	2.51	15.59	25	1.73
18	Saudi Arabia	178	1.42	1330	1.18	7.47	20	0.83
19	Netherlands	165	1.31	1466	1.30	8.88	19	0.99
20	Poland	163	1.30	829	0.73	5.09	14	0.57
	Total	12557	100.00	112904	100.00			

Table 11. Time Series Analysis of Cyber Security research

S.No	Years	Count(Y)	X	X^2	XY
1	2001	6	-10	100	-60
2	2002	13	-9	81	-117
3	2003	25	-8	64	-200
4	2004	35	-7	49	-245
5	2005	62	-6	36	-372
6	2006	94	-5	25	-470
7	2007	91	-4	16	-364
8	2008	113	-3	9	-339
9	2009	177	-2	4	-354
10	2010	257	-1	1	-257
11	2011	369	1	1	369
12	2012	470	2	4	940
13	2013	639	3	9	1917
14	2014	697	4	16	2788
15	2015	984	5	25	4920
16	2016	1295	6	36	7770
17	2017	1640	7	49	11480
18	2018	2022	8	64	16176
19	2019	2718	9	81	24462
20	2020	2483	10	100	24830
	Total	14190		770	92874

Collaboration Index (CI): The simple indicator is presently employed in the publications to the collaboration index among the co-authors, which is to be understood nearly as the mean number of authors per paper are suggested by Ajiferuke, *et al.*(1988)

$$CI = \frac{\sum_{j=1}^{k} jfj}{N}$$

Here

J - The number of co-authored papers appearing in a discipline
N - The total number of publications in the field over the same time period of interval and
k - The highest number of authors per paper in the same time field.

Modified Collaboration Coefficient: The modified collaboration coefficient (MCC) counted by the formula which is suggested by (Savanur and Srikanth, 2010)

Which is given below:

Where,

$$MCC = \frac{N}{N-1}\left[1 - \frac{\sum_{j=1}^{k} jfj}{N}\right]$$

j = the number authors in an article i.e. 1, 2, 3......
Fj = the number of j authored articles
N = the total number of articles published in a year, and
A = the total number of authors per article

Collaboration Index and Collaborative of Co-efficient of Cyber Security research: It is observed from Table 6, the collaborative coefficient is calculated and presented during the ten-year study period for cyber securityresearch publications. It is observed from the table highest collaboration coefficient is 0.93 in the year 2021 and lowest CC is 0.05 in the year 2002, and theaverage CC is 0.44. The collaboration index observed from table 6 the maximum collaboration Index is 3.22 in the year 2020, a minimum of 0.11 in the year 2001, and the average CI is 2.34. The modified collaboration coefficient observed from table 6 a maximum is 3.22 in the year 2020, a minimum of 0.11 in the year 2011, and the average MCC is 2.34.

Co-Authorship Index: The co-authorshipindex (CAI) is obtained by calculating proportionately the publications by single, two,and multi-authored papers (Garg & Padhi, 1999).[28]

$$CAI = \frac{N_{ij}/N_{io}}{N_{oj}/N_{oo}} X 100$$

Where,

Nij = Number of papers having authors in block i
Nio = Total output of block i
Noj = Number of papers having j authors for all blocks.
Noo = Total number of papers for all authors and all blocks

CAI=100 indicates that a countries co-authorships effort for a particular type of Authorship correspondents to the world average. CAI>100 reflects higher than average co-authorship effort and CAI<100 shows lower than average Co-authorship effort for a given type of authorship pattern. For calculating the co-authorship index for authors, years have been replaced into block years. For this study, the authors have been classified into two blocks (ie.2010-2014 and 2015-2019) Vs**.**single, two, three authors, and more than 3 authors.

Table 7 shows that co-authorship Index values are calculated by block year period for cyber securityresearch publications for the selected twenty years study period. From the study, it is identified that CAI for two, three, and more than three authorship contributions are increasing trend and CAI for single authorship contributions are decreasing trendfrom 1st block year (2001-2010) to 2nd block year

(2011-2020). Table 8 identified the top twenty journals contributions in cyber security research publications from the Scopus database for the selected twenty-year study period. From the study, it is identified that the maximum of 629(19.88%) research publications are contributed by Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics,and his publications are received 2393(10.74%) citations, CPP is 3.80, h-index is 22, and RCI value is 0.54. Followed by ACM International Conference Proceeding Series with 447(14.13%) research publications and it is received by 1411(6.33%) citations, CPP is 3.16, h-index, is 17, and RCI value is 0.45. The third-rankingjournal is Advances in Intelligent Systems andcomputingwith 297(9.39%) research publications, 649(2.91%) citations, CPP is 2.19, h-index is 10, and RCI value is 0.31.

Table 10 identified the top twenty countries contributions in cyber security research publications from the Scopus database for the selected twenty-year study period. From the study, it is identified that a maximum of 5195(41.37%) research publications are contributed by theUnited States,and its publications are received 52684(46.66%) citations, CPP is 10.14, h-index is 88, and RCI value is 1.13. Followed by theUnited Kingdom,with 1150(9.16%) research publications and it is received by 9450(8.37%) citations, CPP is 8.22, h-index is 43, and RCI value is 0.91. Thethird-rankingcountry is China,with 953(7.59%) research publications, 10127(8.97%) citations, CPP is 10.63, h-index is 50, and RCI value is 1.18.

Time Series Analysis: Time series analysis reveals the estimated growth values are identified based on previous data. A straight–line equation is adapted to measure the future values based on previous data. Time series analysis used by Jeyshankar and Ramesh babu (2013). Table 11 shows that the time series analysis formula has been predicted for Cyber Securityresearch publications for the years 2025 and 2030

Straight Line Equation is

$Y = a +bx$

Here,

$\sum Y = 14190, \sum X^2 = 770, \sum XY = 92874$

a= $\sum Y/N = 14190/20 = 709.5 = 710$
b= $\sum XY/\sum X^2 = 92874/770 = 120.61 = 121$

Estimated publications in the year 2025 are when X=2025-2015=10

$Y = a +bx$

$= 710+ (121*10) = 710+1210 = 1920$

Estimated literature in 2030 is when X=2030-2015=15

$Y = a + bx$

$= 710 + (121*15) = 710 + 1815 = 2525$

The estimated growth based on a time series analysis statistical application will be expected in the Cyber Securityresearch publications in the year 2025 is around are equal to 1920 and the year 2030 is around are equal to 2525. So that time serious analysis conformed that the publications on Cyber Securityresearchare increasing trend.

Major Finding

- During the twenty-year study period a total numberof 14190 research publications is identified in cyber security research and a maximum of 2718 (19.15%) research publications are contributed in the year 2019 andthe highest value of citations of 14849(14.44%) in the year 2017.

- During the study relative growth rate is 2.94 in the year 2002 and 0.46 in the year 2020. At the same time doubling time found that 0.24 in the year 2002 and 1.52 in the year 2020 and it is confirmed that doubling time is an increasing trend.
- The study ofa maximum of 33(6.88%) research publications are contributed by Kozik, R. United States, the highest value of citations in 14849(14.44%) citations, and authorship pattern of a maximum of 3313 research publications are contributed by two authors.
- The average degree of collaborations is 0.79, average collaborative co-efficient is 0.44 and average collaborative index is 2.34, modified collaborative co-efficient is 2.34.The CAI for two, three, and more than three authorship contributions are increasing trend 1st block year to 2nd block year. At the same time, CAI for single authorship contributions is decreasing trend from 1st block year (2001-2010) to 2nd block year (2011-2020).
- During the maximum of 629(19.88%) research publications are contributed by Lecture notes in computer science including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics and his publications are received 2393(10.74%) citations, CPP is 3.80, h-index is 22, and RCI value is 0.54.
- During a maximum of 5195(41.37%) research publications are contributed by the United States and its publications are received 52684(46.66%) citations, CPP is 10.14, h-index is 88, and RCI value is 1.13.and the studies of time series analysis will be expected in the cyber security research publications in the year 2025 is around are equal to 1920 and the year 2030 is around are equal to 2525

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