Metrics To Mastery: A Roadmap For Innovative Technologies And Scientific Productivity

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ABSTRACT: *In today's fast-paced world of technological advancements and scientific breakthroughs, the pursuit of innovation and scientific productivity is both an aspiration and a necessity. As we traverse this transformative landscape, it becomes evident that "Metrics to Mastery" equips organizations to unlock the full potential of their research and development endeavors, foster innovation, and establish themselves as leaders in the dynamic technology and scientific productivity domain. This paper encapsulates the essence of this transformative journey, emphasizing the indispensable role of strategic metrics. "Metrics to Mastery" provides a structured approach to measure progress, evaluate performance, and make informed decisions rooted in data-driven insights. It empowers organizations to cultivate a culture of continuous improvement, where every action is guided by the compass of strategic metrics. In the present study, 13125 records were collected from the Web of Science database, and the period for the present study is from 1990 to 2021.*

Keywords: Technological Innovation, Technology Roadmap, Scientific Productivity, Scientometrics, Relative Growth Rate, Bradford Law, Innovation Culture

Received: 2 August 2023, Revised 5 September 2023, Accepted 23 September 2023

DOI: http://doi.org/10.6025/stm/2023/4/42-54

1. Introduction

In the contemporary landscape of technological evolution and scientific discovery, organizations are constantly in pursuit of the elusive goal of innovation and scientific productivity. These twin pillars not only drive progress but dictate competitiveness in an increasingly dynamic environment. This paper introduces a transformative framework, "Metrics to Mastery", which not only underscores the importance of strategic metrics but also provides a comprehensive roadmap for organizations to attain excellence. The metrics serve as the stepping stones to mastery, and organizations not only measure progress but also shape the future of technology and scientific excellence. Through an interdisciplinary lens, aiming to unearth novel metrics and methodologies that can better represent the diverse facets of scientific productivity and innovation to equip researchers, policymakers, and stakeholders with a more holistic understanding. Imagine a world where organizations not only measure progress but also shape the future. Picture a landscape where strategic metrics serve as the lighthouse, illuminating the way through the way through the darkest of innovation storms. This is the realm of "Metrics to Mastery", a transformative framework that transcends the ordinary and ushers organizations into a new era of innovation culture. Welcome to a landscape where innovation is not a distant dream but a tangible reality.

2. Methodology

Data was downloaded from Web of Science for „Technology Roadmap with all the terms in MeSH (Medical Subject Heading) with limits as "humans", 33 years during1989 to 2021". A total of 11500 records were obtained from the Web of Science database for this study. This study covers the measured most prolific authors, values of h, g, and m indexes for authors' impact, Degree of Collaboration for authors has also been discussed. An aggregate of 13125 records was downloaded and analyzed by using the R Programming (Biblioshiny), VoS Viewer, HistCite, and MSExcel as per the objects of the study.

3. Results and Discussions

Table 1. Details of Sample Data

S.No	Detail about the Sample	Observed values
1	Duration	1990-2021
2	Period of Time	32 Years
3	Total Records	13125
4	Total Number of Authors	110250
5	Unique Authors	53208
6	Total Number of Journals	3496
7	Document Types	18
8	Languages	10
9	Words	20085
10	Countries	150
11	Institutions	11410
12	Institutions with subdivisions	31026
13	Total Cited Reference	490740
14	Total Global Citation	289757

Table 1 explains the sample details of Technology Roadmap research publications obtained from the Web of Science database. The time span for the present study is from 1990 to 2021. In the present study, 13125 records were collected from the database, it has 110250 contributing authors, 3496 total journals, 18 types of documents, 10 types of languages, 150 countries from various continents, and 11410 institutions respectively.

Table 2. Year-wise distribution of Technology Roadmap Research Output

S.No	Year	Articles	Cumulative	W1	W2	RGR	DT
1	1990	3	3	0	1.10	1.10	0.63
2	1991	11	14	1.10	2.64	1.54	0.45
3	1992	12	26	2.64	3.26	0.62	1.12
4	1993	17	43	3.26	3.76	0.50	1.38
5	1994	22	65	3.76	4.17	0.41	1.68
6	1995	25	90	4.17	4.50	0.33	2.13
7	1996	21	111	4.50	4.71	0.21	3.30
8	1997	27	138	4.71	4.93	0.22	3.18
9	1998	23	161	4.93	5.00	0.15	4.50
10	1999	46	207	5.08	5.33	0.25	2.76
11	2000	52	259	5.33	5.56	0.22	3.09
12	2001	53	312	5.56	5.74	0.19	3.72
13	2002	64	376	5.74	5.93	0.19	3.71
14	2003	61	437	5.93	6.08	0.15	4.61

15	2004	67	504	6.08	6.22	0.14	4.86
16	2005	95	599	6.22	6.40	0.17	4.01
17	2006	106	705	6.40	6.56	0.16	4.25
18	2007	105	810	6.56	6.70	0.14	4.99
19	2008	204	1014	6.70	6.92	0.22	3.09
20	2009	420	1434	6.92	7.27	0.35	2.00
21	2010	472	1906	7.27	7.55	0.28	2.44
22	2011	542	2448	7.55	7.80	0.25	2.77
23	2012	539	2987	7.80	8.00	0.20	3.48
24	2013	576	3563	8.00	8.18	0.18	3.93
25	2014	633	4196	8.18	8.34	0.16	4.24
26	2015	799	1995	8.34	8.52	0.17	3.93
27	2016	1213	6208	8.52	8.73	0.22	3.19
28	2017	1134	7342	8.73	8.90	0.17	4.13
29	2018	1301	8643	8.90	9.06	0.16	4.25
30	2019	1396	10039	9.06	9.21	0.15	4.63
31	2020	1536	11565	9.21	9.36	0.14	4.90
32	2021	1560	13125	9.36	9.48	0.13	5.48
Total		13125	84325	196.52	206.00	9.48	106.86

Table 2 explains the present study 1990 to 2021 scientists published 13125 articles worldwide on Technology Roadmap. Analysis of the data shows that the annual research output in the Technology Roadmap research increased throughout the period of study, with the highest number of 1560 (11.89%) publications in the year 2021, 1526 (11.63%) records were published in 2020, 1396 (10.64%) communications in 2019 and the least was in the year 1990 with 3 (0.03%) records. A steady growth in number of publications has been gradually increased from 2018 to 2021.

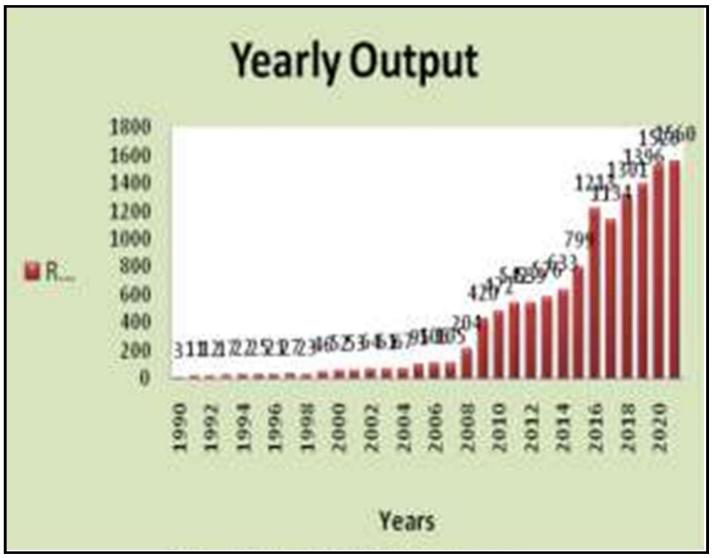

Figure 1. Yearly Publications

Table 3. Growth Ratio by Year-wise Analysis of Technology Roadmap Research

S.No	Year	Records	Growth Ratio
1	1990	3	-
2	1991	11	3.67
3	1992	12	1.09
4	1993	17	1.42
5	1994	22	1.29
6	1995	25	1.14
7	1996	21	0.84
8	1997	27	1.29
9	1998	23	0.85
10	1999	46	2.00
11	2000	52	1.13
12	2001	53	1.02
13	2002	64	1.21
14	2003	61	0.95
15	2004	67	1.10
16	2005	95	1.42
17	2006	106	1.12
18	2007	105	0.99
19	2008	204	1.94
20	2009	420	2.06
21	2010	472	1.12
22	2011	542	1.15
23	2012	539	0.99
24	2013	576	1.07
25	2014	633	1.10
26	2015	799	1.26
27	2016	1213	1.52
28	2017	1134	0.93
29	2018	1301	1.15
30	2019	1396	1.07
31	2020	1526	1.09
32	2021	1560	1.02
Total		13125	-

Table 3 indicates that the annual growth ratio wise research output in the Technology Roadmap, with the highest growth ratio is 3.67 in the year 1991, 2.06 in 2009 with second rank, 2.00 in the year 1999 with third place, 1.94 growth ratio value in the year2008 with fourth rank and 1.52 in the year 2016 with fifth rank respectively. The lowest growth ratio value was 0.84 in the year 1996.

Table 4. Relative Growth Rate and Doubling Time of Research Output

S.No	Year	Articles	Cumulative	*W*1	*W*2	*RGR*	*DT*
1	1990	3	3	0	1.10	1.10	0.63
2	1991	11	14	1.10	2.64	1.54	0.45
3	1992	12	26	2.64	3.26	0.62	1.12
4	1993	17	43	3.26	3.76	0.50	1.38
5	1994	22	65	3.76	4.17	0.41	1.68
6	1995	25	90	4.17	4.50	0.33	2.13
7	1996	21	111	4.50	4.71	0.21	3.30
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25	2014	633	4196	8.18	8.34	0.16	4.24
26	2015	799	4995	8.34	8.52	0.17	3.98
27	2016	1213	6208	8.52	8.73	0.22	3.19
28	2017	1134	7342	8.73	8.90	0.17	4.13
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Total		13125	84325	196.52	206.00	9.48	106.86

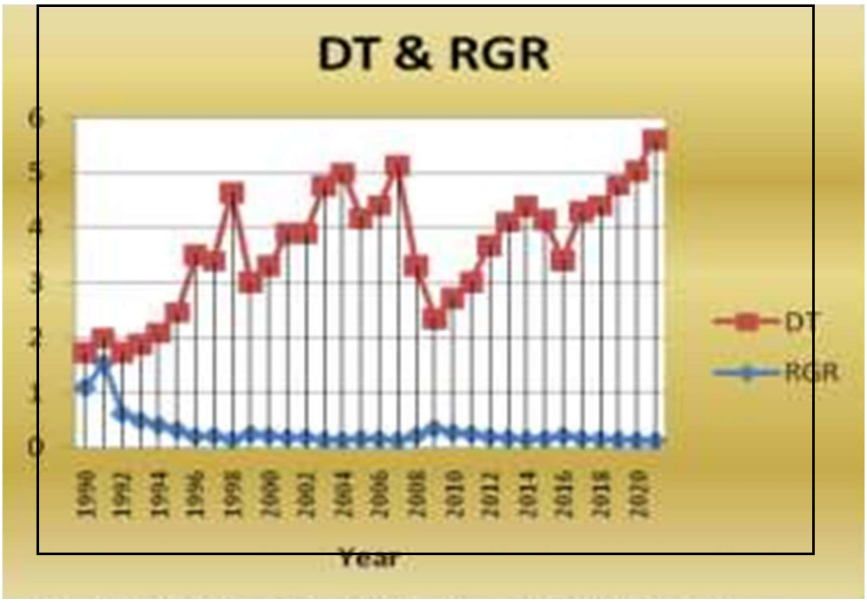

Figure 2. Relative Growth Rate and Doubling Time

The growth rate of Technology Roadmap research literature is intended by using Relative Growth rates (RGR) and Doubling time (DT) for the publications. The particulars of this model are already discussed in the previous chapter. Table 4 indicates the RGR and DT time of total research output on Technology Roadmap research. The RGR value for the year 1990 is 1.19 and the value for the final year 2021 is 0.13. The result shows that the value was gradually decreased over the years. The Doubling Time (DT) shows an increasing trend, from the year 1990 with 0.63 values and the final year 2021 is 5.48. RGR has shown a decreased trend, which means the rate is low in terms of proportion, and on the other hand, the Doubling Time (DT) has increased during the same period.

S. No	Author	Rees	Rank	LCS	GCS
1	Wang Y	131	1	23	1861
2	Zhang Y	131	1	23	2758
3	LiY	126	2	44	2431
4	Liu Y	104	3	37	3589
5	Wang J	101	4	36	3943
6	Li J	96	5	33	1547
7	Zhang J	93	6	15	1788
8	Scott D	91	T	118	12720
9	Wang L	87	8	18	3025
10	Zhang L	83	9	21	4630
11	Lin J	75	10	20	1798
12	LiL	71	11	21	1327
13	Chen L	69	12	6	1017
14	Dickinson C	67	13	124	8961
15	Li H	67	13	14	1090
16	Bond JR	63	14	21	12079
17	Remazeilles M	62	15	43	11923
18	Zhang H	62	16	18	1214
19	Calabrese E	61	17	19	11674
20	de Zotti G	61	17	3	11611

Table 5 identifies that the most prolific author is Wang Y with 131 records dealing with Technology Roadmap research ranked as first place, LCS 23, GCS 1861, and Zhang Y also ranked as first position. Li Y has produced 126 articles, LCS 44, and GCS 2431 ranked as second place. Liu Y has published 104 records, LCS 37, and GCS 3589 with the third rank. Wang J has produced 101 articles with fourth place, Lcs 36, GCS 3943. The remaining authors are contributing 96 and below in Technology Roadmap research out of the top 20 contributors.

Table 6. Bradford's Law of Journals Scattering in Technology Roadmap Research

S. No	Source	Rank	Freq	cumFreq	Zone
1	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	1	519	519	Zone 1
2	ASTROPHYSICAL JOURNAL	2	307	826	Zone 1
3	ASTRONOMY & ASTROPHYSICS	3	212	1038	Zone 1
4	REMOTE SENSING	4	198	1236	Zone 1
5	SENSORS	5	147	1383	Zone 1
6	SCIENTIFIC REPORTS	6	99	1482	Zone 1
7	HUMAN BRAIN MAPPING	7	98	1580	Zone 1
8	ISPRS INTERNATIONAL JOURNAL OF GEO-INFORMATION	8	87	1667	Zone 1
9	PHYSICAL REVIEW D	9	65	1732	Zone 1
10	IEEE ACCESS	10	64	1796	Zone 1
11	SUSTAINABILITY	11	62	1858	Zone 1
12	ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES	12	57	1915	Zone 1
13	EXPERT SYSTEMS WITH APPLICATIONS	13	57	1972	Zone 1
14	SCIENCE OF THE TOTAL ENVIRONMENT	14	54	2026	Zone 1
15	IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY	15	53	2079	Zone 1
16	BMC GENOMICS	16	52	2131	Zone 1
17	ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	17	51	2182	Zone 1
18	APPLIED SCIENCES-BASEL	18	49	2231	Zone 1
19	INTERNATIONAL JOURNAL OF REMOTE SENSING	19	49	2280	Zone 1
20	INTERNATIONAL JOURNAL OF ADVANCED MANUFACTURING TECHNOLOGY	20	47	2327	Zone 1
21	JOURNAL OF CLEANER PRODUCTION	21	47	2374	Zone I
22	JOURNAL OF COSMOLOGY AND ASTROPARTICLE PHYSICS	22	45	2419	Zone 1
23	NATURE COMMUNICATIONS	23	45	2464	Zone 1
24	IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS	24	43	2507	Zone 1

25	ECOLOGICAL INDICATORS	25	42	2549	Zone 1
26	JOURNAL OF HIGH ENERGY PHYSICS	26	42	2591	Zone 1
27	ICARUS	27	41	2632	Zone
28	JOURNAL OF MAGNETIC RESONANCE IMAGING	28	41	2673	Zone 1
29	NATURAL HAZARDS	29	41	2714	Zone 1
30	THEORETICAL AND APPLIED GENETICS	30	41	2755	Zone 1
31	JOURNAL OF APPLIED REMOTE SENSING	31	40	2795	Zone 1
32	PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING	32	39	2834	Zone 1
33	ASTROPHYSICAL JOURNAL LETTERS	33	38	2872	Zone 1
34	PLOS ONE	34	37	2909	Zone 1
35	COMPUTERS & GEOSCIENCES	35	36	2945	Zone
36	COMPUTERS AND ELECTRONICS IN AGRICULTURE	36	36	2981	Zone 1
37	MEASUREMENT SCIENCE AND TECHNOLOGY	37	36	3017	Zone 1
38	MOLECULAR BREEDING	38	36	3053	Zone 1
39	MULTIMEDIA TOOLS AND APPLICATIONS	39	36	3089	Zone 1
40	SENSORS AND MATERIALS	40	34	3123	Zone 1
41	EUPHYTICA	41	33	3156	Zone 1
42	OPTICS EXPRESS	42	33	3189	Zone 1
43	ENVIRONMENTAL EARTH SCIENCES	43	32	3221	Zone 1
44	NEUROCOMPUTING	44	32	3253	Zone 1
45	TRANSPORTATION RESEARCH RECORD	45	32	3285	Zone 1
46	ENVIRONMENTAL SCIENCE & TECHNOLOGY	46	31	3316	Zone 1
47	INTERNATIONAL JOURNAL OF APPLIED EARTH OBSERVATION AND GEOINFORMATION	47	31	3347	Zone 1
48	BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY	48	30	3377	Zone 1
49	OPTICAL ENGINEERING	49	30	3407	Zone 1
50	ADVANCES IN SPACE RESEARCH	50	29	3436	Zone 1
51	COMPUTERS & EDUCATION	51	29	3465	Zone 1
52	MATHEMATICAL PROBLEMS IN ENGINEERING	52	29	3494	Zone 1
53	NUCLEIC ACIDS RESEARCH	53	29	3523	Zone 1

54	ASTRONOMICAL JOURNAL	54	28	3551	Zone 1
55	INTERNATIONAL JOURNAL OF CLINICAL AND EXPERIMENTAL MEDICINE	55	27	3578	Zone 1
56	INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH	56	27	3605	Zone 1
57	EXPERIMENTAL AND THERAPEUTIC MEDICINE	57	25	3630	Zone 1
58	CB-GENES GENOMES GENETICS	58	25	3655	Zone 1
59	JOURNAL OF ALLOYS AND COMPOUNDS	59	25	3680	Zone 1
60	JOURNAL OF ASIAN EARTH SCIENCES	60	25	3705	Zone 1
61	NEUROIMAGE	61	24	3729	Zone 1
62	REMOTE SENSING OF ENVIRONMENT	62	24	3753	Zone 1
63	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	63	23	3776	Zone I
64	ZOOTAXA	64	23	3799	Zone 1
65	BMC PLANT BIOLOGY	65	22	3821	Zone 1
66	CATENA	66	22	3843	Zone 1
67	JOURNAL OF ATMOSPHERIC AND OCEANIC TECHNOLOGY	67	22	3865	Zone 1
68	RSCADVANCES	68	22	3887	Zone 1
69	TECTONOPHYSICS	69	22	3909	Zone 1
70	JOURNAL OF THE INDIAN SOCIETY OF REMOTE SENSING	70	21	3930	Zone 1
71	MEDICINE	71	21	3951	Zone 1
72	ARABIAN JOURNAL OF GEOSCIENCES	72	20	3971	Zone 1
73	INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES	73	20	3991	Zone 1
74	JOURNAL OF BIOLOGICAL CHEMISTRY	74	20	4011	Zone 1
75	PHYSICAL REVIEW LETTERS	75	20	4031	Zone 1
76	BMC BIOINFORMATICS	76	19	4050	Zone 1
77	GEOPHYSICAL JOURNAL INTERNATIONAL	77	19	690	Zone 1
78	BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS	78	18	4087	Zone 1
79	INFRARED PHYSICS & TECHNOLOGY	79	18	4105	Zone 1
80	JOURNAL OF GEOPHYSICAL RESEARCH - SPACE PHYSICS	80	18	4123	Zone 1
81	JOURNAL OF HYDROLOGY	81	18	4141	Zone 1

82	NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS	82	18	4159	Zone 1
83	PHYSICAL REVIEW B	83	18	4177	Zone 1
84	PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN	84	18	4195	Zone 1
85	SCIENCE	85	18	4230	Zone 1
86	ADVANCES IN MECHANICAL ENGINEERING	86	17	4213	Zone I
87	BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA	87	17	4247	Zone 1
88	COLD REGIONS SCIENCE AND TECHNOLOGY	88	17	4264	Zone 1
89	ENGINEERING GEOLOGY	89	17	4281	Zone 1
90	ENVIRONMENTAL MONITORING AND ASSESSMENT	90	17	4298	Zone 1
91	EUROPEAN RADIOLOGY	91	17	4315	Zone 1
92	GPS SOLUTIONS	92	17	4332	Zone 1
93	MOLECULAR BIOLOGY REPORTS	93	17	4349	Zone 2
94	MOLECULAR MEDICINE REPORTS	94	17	4366	Zone 2
95	TUNNELLINGAND UNDERGROUND SPACE TECHNOLOGY	95	17	4383	Zone 2
96	ANALYTICAL CHEMISTRY	96	16	4399	Zone 2
97	ENERGIES	97	16	4435	Zone 2
98	GENE	98	16	4431	Zonc 2
99	GEOMATICS NATURAL HAZARDS & RISK	99	16	4447	Zone 2
100	INFORMATION SCIENCES	100	16	4463	Zone 2

Table 6 noted that the highest number of papers communicated to journals technology roadmap research. This analysis information 3500 journals to have published 13125 articles. The bold letters state the values of three zones based on Bradford's law of scattering. It is completed from the analysis that the first twenty-five journals are nuclear or core journals.

Table 7. Country-wise Technology Roadmap Publication Growth.

S. No	Country	Articles	SCP	MCP	MCP Ratio
1	CHINA	6668	4934	1734	0.26
2	USA	1569	884	685	0.437
3	UNITED KINGDOM	1417	644	773	546
4	INDIA	597	422	175	0.293
5	CANADA	300	143	157	0.523

6	AUSTRALIA	278	119	139	0.572
7	JAPAN	243	100	143	0.588
8	KOREA	205	139	66	0.322
9	GERMANY	139	33	106	0.763
10	THAILAND	137	84	53	0.387
11	ITALY	104	35	69	0.663
12	IRELAND	103	57	46	0.447
13	SINGAPORE	102	52	50	0.49
14	FRANCE	95	21	74	0.779
15	SPAIN	78	30	48	0.615
16	5 PORTUGAL	76	32	44	0.579
17	NETHERLANDS	75	26	49	0.653
18	SOUTH AFRICA	36	21	35	0.625
19	IRAN	53	24	29	0.547
20	BRAZIL	48	16	32	0.667

Table 7 shows that a total of 150 countries have contributed their publications in the field of Technology Roadmap research from 1990 to 2021. China is the most predominant country with 6668 records the SCP is 4934, the MCP is 1734, MCP ratio is 0.26. The USA appeared in the second rank with 1569 records and SCP is 884, MCP is 685, MCP ratio is 0.437. The UK has occupied the third position with 1417 records and SCP is 644, MCP is 273, MCP ratio is 0.546. India has appeared as the fourth rank with 597 records SCP is 422, MCP is 175, and MCP ratio is 0.293. Canada has appeared in fifth place with 300 records SCP is 143, MCP is 157, and MCP ratio is 0.523 out of the top 92 countries in the Technology Roadmap domain.

Table 8. Continent-wise Technology

S. No	Continent	No of Record	SCP	MCP	Rank
1	Asia	8311	5906	2405	1
2	Africa	112	41	71	5
3	North and Central America	1591	893	698	3
4	South America	38	7	31	6
5	Europe	2741	1180	1561	2
6	Oceania	278	119	159	4
7	Unknown	54	-	-	-
	Total	13125	8146	4925	-

Table 8 shows that a total of 6 continents have contributed their publications in the field of Technology Roadmap research from 1990 to 2021. Asia is the most predominant country with 8311 records and SCP is 5906, MCP is 2405.. Europe appeared in the second rank with 2741 records SCP is 1180, MCP is 1561. North and Central America appeared in the third rank with 1591 records SCP is 893, MCP is 698. Oceania appeared as the fourth rank with 278 records and SCP was 119, MCP was 159 out of six continents in Technology Roadmap research output over the period of time. Unknown record is 54.

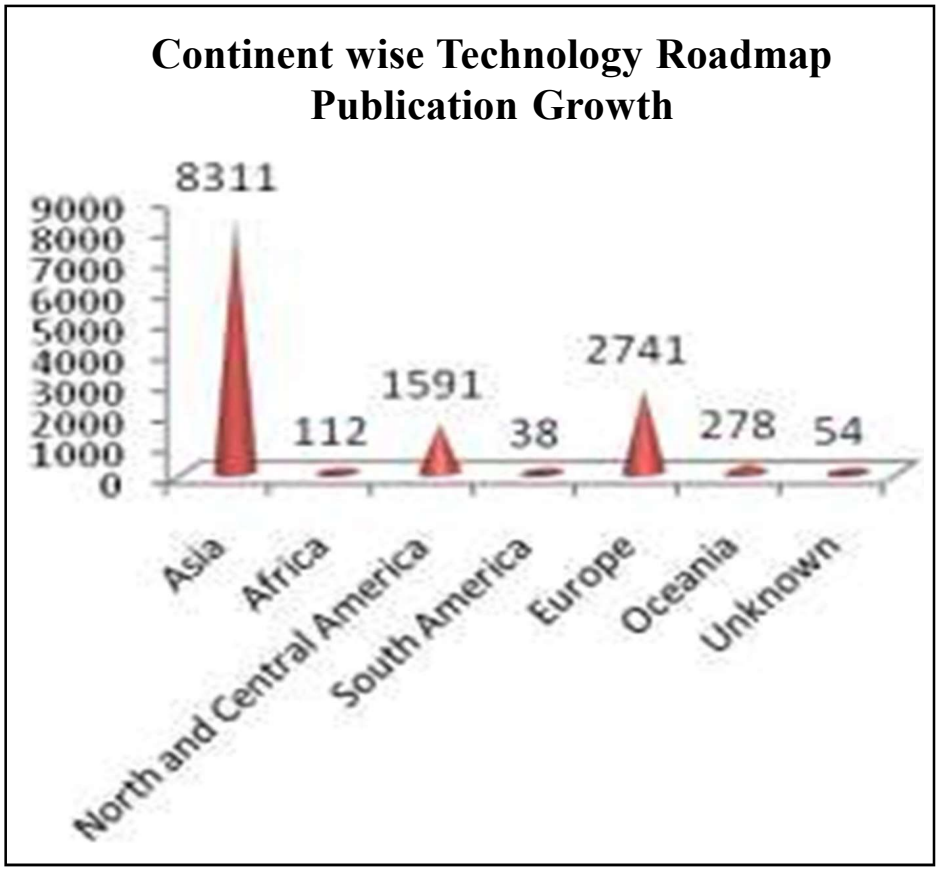

Figure 3. Continent wise Technology Roadmap Publication Growth

4. Conclusion

The research study examines 13125 articles worldwide on Technology Roadmap during the period of time. The highest number of 1560 (11.89%) publications in the year 2021. RGR has shown a decreased trend, which means the rate is low in terms of proportion, and on the other hand, the Doubling Time (DT) has been increased during the same period. The journal articles are in the first position contributing 12020 publications with 91.58 percent. It is identified from the above analysis that most of the scientists prefer English as the communication language (13108, with 99.87%) and TCS is 289686 for exploring their academic research activities. The Bradford multiplier between the number of references in zone 1 and zone 2 is 34.00 while it is 33.00 between zone 2 and zone 3. The average multiplier is 3.75. The most productive journal is Monthly Notices Of The Royal Astronomical Society with 492 (3.75%) papers dealing with Technology Roadmap research as first rank (TCS is 881, TGS is 13157). China is the most predominant country with 6668 records and SCP is 4934, MCP is 1734, MCP ratio is 0.26. Asia is the most predominant country with 8311 records and SCP is 5906, MCP is 2405.

Forging a path to mastery: In the realm of technological innovation and scientific productivity, our journey through “Metrics to Mastery” has revealed a transformative landscape where strategic metrics serve as guiding stars. The findings illuminated a profound truth, Innovation is not a solitary endeavor, it thrives on collaboration, informed decisions, and a relentless pursuit of excellence. This journey does not end here, it extends beyond into the world where innovation reigns supreme. We embark on a path where innovation knows no mounds, and mastery is within reach. The future of technology and scientific productivity lies in our hands, and it is a future illuminated by the brilliance of strategic metrics.

5. Recommendations

- Embrace a culture of data-driven decisionmaking
- Select key strategic metrics carefully
- Establish clear measurement protocols
- Create cross-functional collaboration
- Review and adjust metrics
- Communicate findings transparently
- Celebrate success and learn from failure
- Invest in Innovation Initiatives
- Encourage Employee engagement
- Stay agile and adaptive
- Measure the impact of Innovation
- Benchmark against Industry peers

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