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Assessment of Indian Open Access Social Science Publications through the Application of Growth Models

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ABSTRACT

The study aims to investigate and report on the growth of Open-Access (OA) social science scholarly publications in India from 2013 to 2022 by applying various growth models. During the study period, 13,378 records were extracted from the scopus database, and a dataset was created to enhance the effectiveness of statistical analysis using the "R" Open-Source software. It is found that the Exponential Growth Model, with a peak R-squared value of 0.9749, highlights a substantial Annual Growth Rate (AGR), reaching its highest in 2020 (94.43 %) and lowest in 2021 (7.14 %). The Mean Relative Growth Rate (0.42) signifies the average growth pace, and doubling time (average 1.81) indicates a notably rapid doubling rate in OA social science publications. India ranks 18th in open-access social science publications with 13,378 papers (1.31 %), reflecting a modest contribution compared to China (5.12 %) and Germany (3.78 %). A cross-disciplinary analysis highlights significant disparities, with medicine leading at 115,228 publications (17.67 %), while social sciences (2.05 %) and humanities contribute comparatively less (0.39 %). This emphasises the urgent need for substantial support from Indian social scientists to augment the OA movement in the field. Notably, 2021 witnessed a rise to 2.92 citations annually, contrasting sharply with 2022's decline to 1.65, revealing dynamic trends in influence within Indian open-access social science papers.

Keywords: Open access; Social science research; Growth models; Polynomial model; Exponential growth model; Linear growth model; Gompertz growth model

1. INTRODUCTION

Open-access social science publications represent a transformative approach to disseminating scholarly knowledge. It breaks down traditional barriers, making research findings readily available to a global audience without financial or access constraints. By leveraging the power of the internet, open-access social science publications ensure that valuable insights, studies, and academic discourses are accessible to researchers, students, and the public alike. This democratisation of knowledge fosters collaboration, accelerates the dissemination of ideas, and empowers individuals to engage with critical societal issues. Open access in social sciences is not just a mode of publication; it's a catalyst for advancing research, enriching public discourse, and promoting evidence-based decision-making in our increasingly interconnected world. Open access revolutionizes scholarly publication by enabling unrestricted online access to academic works. Open Access (OA) journals, available online without financial barriers, utilize two main approaches such as Gold OA, where publishers directly provide access, and Green OA, where authors freely share their manuscripts in online repositories. Both methods enhance articles' accessibility, reaching a broader audience and accelerating the dissemination of cutting-edge research. These Open Access Journals (OAJs) span diverse fields, from Sciences to Social sciences and Humanities, as evident in their inclusion in major databases like Web of Science and SCOPUS. In this context, the current study makes an effort to focus on the trend of Indian Social Science publications accessible in the open-access domain through the application of growth models. This analytical study explains the developmental trends of Social Science OA articles using various growth models.

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2. LITERATURE REVIEW

Many researchers have attempted to apply growth models to show the growth trend of literature in different academic disciplines. In this context, relevant studies have been done by Egghe and Rao[1], who tried to classify and characterize the growth models using two types of growth rates: (1) from time t to t + 1 and (2) from time t to 2t.

By adopting the growth model suggested by Egghe and Rao, Gupta[4], *et al.* have studied the growth of global publications in six sub-disciplines of Social Sciences. These were anthropology, economics, history, political

science, psychology, and sociology. The models were evaluated based on model parameters, fit statistics, and graphical fit to the data.

Hadagali & Anandhalli[6] analysed the growth of neurology literature. They used 291,702 records from 1961 to 2010 from the Science Direct Database. They calculated the Relative Growth Rate and Doubling Time of the neurology literature. They found that the growth does not follow the linear or logistic growth model, according to them it follows the exponential growth model.

Nayak and Bankapur[7] compared the agriculture literature published from 1930 to 2016. They emphasised various Scientometric parameters like Relative Growth Rate (RGR), Doubling Time (Dt), Skewness, Kurtosis, and Regression (r2) to check which growth model fits to agriculture literature; exponential, linear, logistic, or power models. They found that for recent years world agricultural literature follow the linear and exponential growth model.

Elangovan[2] took the 10 years of medical literature published by the faculty members of All India Institutes of Medical Sciences (AIIMS) and applied linear and non-linear growth models to the literature. Multiple linear regression analysis was applied to evaluate the effect of faculty strength and department on the research output.

By analysing the Relative Growth Rate and Doubling Time trends, Neelamma and Anandhalli[5] have shown the growth of Crystallography literature from 1989 to 2013. The study results indicated that the Relative Growth Rate (RGR) of Crystallography publication was a decreasing trend, and the Doubling Time (Dt) was an increasing trend.

Verma & Singh[8] conducted a study to determine the best-fit model in the Food Science and Technology field. The research suggested that the literature in Food Science and Technology demonstrates viability in both publications and citations; all the models also explain the growth of literature and citations, underscoring its potential for further expansion.

Ganjihal Ganjihal & Kwati[3] have examined the growth pattern in bacterial blight research publications over the past 25 years and have shown the growth rates, doubling time, and distribution patterns research landscape on bacterial blight research. The author has emphasised the need for continued exploration and investigation of bacterial blight research publications.

Das[9], *et al.* validated the Citation Swing Factor (CSF) for measuring citation diffusion in Indian Physics and astronomy research. Mondal[10], *et al.* analysed 24 years of biotechnology research from Indian DBT institutes, focusing on publication trends and impact. Fatima[11] examined citation patterns in "Business Research" (2008-2016) and analysed the core journals and authorship trends. Bautista-Puig[12], *et al.* explored the effects of Open Access (OA) on journal performance by analysing two datasets of flipping journals (119 from DOAJ and 100 from OAD). These were compared with two control groups: one based on bibliometric criteria and the other on national orientation. Paired t-tests showed an OA citation advantage but no significant OA publication advantage. Ming & Zhao[13] investigated the impact of reversing from Open Access (OA) to subscription models on citation impact by analysing 60 journals across various disciplines from 2005 to 2015. By examining bibliographic and citation data for 4,800 articles using a Difference-In-Difference (DiD) approach, they found that the reversal did not significantly affect citation visibility but could lead to systematic changes in journal submissions, impacting overall journal impact. Khan[14], *et al.* compared the citation impact of Open Access (OA) and non-OA journals in the Library and Information Science (LIS) field globally. The analysis employed the Mann-Whitney U-test to compare citation counts and h-index. Results showed that non-OA journals outperformed OA journals across all citation metrics, suggesting a citation advantage for non-OA publications in LIS. Ali[15], *et al.* analysed global neuro technology research and its citation impact using data from 1,473 Web of Science articles. The authors found a notable increase in research from 2020 to 2023, and the U.S. and the University of California were top contributors. The study revealed that while research funding and collaboration positively influenced citation impact, open-access availability correlated negatively.

3. OBJECTIVES OF THE STUDY

The study aims to achieve the following specific objectives:

- To assess the annual growth rate, relative growth rate, and doubling time of open-access Social Science Publications;
- To determine the growth patterns of Indian open-access Social Science Publications applying various growth models;
- Identifying citation patterns and publication trends of Indian open-access Social Science Publications.

4. METHODOLOGY

The bibliographic dataset is obtained from the Scopus database using specified keywords. AFFIL("India") AND PUBYEAR > 2012 AND PUBYEAR < 2023 AND (LIMIT-TO (SRCTYPE,"j") AND (LIMIT-TO (OA,"all")) AND (LIMIT-TO (SUBJAREA,"SOCI")) AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (LANGUAGE, "English")). A total of 13,378 records were retrieved on 20th September 2023, systematically arranged in an MS Excel worksheet to optimize the efficiency of statistical analysis. "R" open-source statistical software is used to analyse the extracted data based on the statistics for each year, including article count and the journals published in India.

The study aims to apply diverse growth models to evaluate the expansion of Indian open-access publications in social science. These models, commonly utilised for analysis, have been carefully selected for this research (Egghe1):

4.1 Linear Growth Model

It is suitable for short-term growth approximation. In high-quality literature, exponential growth eventually stabilises, resulting in a consistent number of publications over time. In this scenario, the growth function simplifies to F0(t) = Log(a) + bt, where a = initial size of the literature; b = continuous growth rate, and t = unit of time.

4.2 Exponential Growth Model

It occurs when the growth rate is proportional to the existing quantity. This model signifies a swift rise in publications, with a fixed proportion for each unit of time, often expressed as a percentage or doubling time. Mathematically, it is represented as $F(t) = ae^{bt}$, where, a = initial size of the literature; t = unit of time; b = continuous growth rate = R/100; and R= percentage by which the size increases in each fixed time unit.

4.3 Logistic Growth Model

A typical sigmoid function, describes S-shaped curve. Initially, growth is nearly exponential, but it slows as the saturation point approaches, ceasing at maturity. Developed by Belgian mathematician Pierre Verhulst in 1838, this model assumes growth rate is proportional to the product of present and future sizes. It exhibits an S-shaped cumulative curve, in contrast to exponential growth, indicating an upper limit to growth. The pattern involves a gradual start, followed by stepped growth and a prolonged saturation period, and is mathematically represented as Ut = K/1+μ, where, U = expected size of the literature; K and μ are constants

4.4 Polynomial Model

A mathematical expression comprising terms with variables raised to various powers and multiplied by coefficients. Polynomial curve fitting is widely applied in scientific, engineering, and social science data analysis. The least squares method is commonly used to fit a curve to data, determining polynomial coefficients by minimizing errors between data points and the fitted curve. This method establishes relationships between independent and dependent variables. Historically, polynomials have been frequently used for curve fitting due to their simplicity, well-understood properties, and moderate flexibility in shaping. Mathematically, it is represented as: $Y = ax^2 + bx + c$.

4.5 Gompertz Growth Model

It is a mathematical expression, formulated with exponential terms, designed to capture growth patterns characterised by a decreasing proportional growth rate as a quantity approaches a saturation point. This model, exhibiting an S-shaped curve, is widely applied in scientific and biological data analysis, particularly when modeling phenomena with limiting growth. The model's defining characteristic is its ability to represent growth that initially accelerates but gradually slows, converging towards a finite upper limit. Mathematically, it is represented as: (t)=Ae−Be−kt, where 'A' represents the asymptotic limit, 'k' governs the rate of deceleration, and 't' denotes time.

5. DATA ANALYSIS

Table 1 shows that the comparative analysis of India's share in global Open-Access (OA) Social Science publications among the other leading countries. The United States leads with 164,567 publications (16.13 %), followed by the United Kingdom with 128,942 (12.64 %), reflecting their robust research ecosystems in OA publications. India ranks 18th with 13,378 publications (1.31 %), indicating a modest contribution compared to countries like China (5.12 %), Germany (3.78 %), Netherlands (3.76 %), Australia (3.57 %) and Spain (3.43 %) etc. Even smaller nations such as Sweden (2.06 %), South Africa (1.71 %), Indonesia and Poland (1.62 % each) outperform India. Collectively, 139 other countries account for 28.74 % of publications, showcasing global diversity. To enhance its position, India needs increased investment in research infrastructure and open-access policies.

Table 1. India's share in global open-access social science publications among leading countries

Country	No. of OA social science publications	%	Ranking
United States	164567	16.13	1
United Kingdom	128942	12.64	2
China	52205	5.12	3
Germany	38549	3.78	4
Netherlands	38385	3.76	5
Australia	36462	3.57	6
Spain	34966	3.43	7
Canada	28979	2.84	8
Italy	26093	2.56	9
Sweden	20988	2.06	10
Brazil	18446	1.81	11
France	18384	1.80	12
South Africa	17485	1.71	13
Indonesia	16526	1.62	14
Poland	16519	1.62	15
Norway	15153	1.49	16
Russia	14380	1.41	17
India	13378	1.31	18
South Korea	13399	1.31	19
Belgium	13189	1.29	20
Other 139 Countries	293240	28.74	…
Total	**1020235**	**100**	---

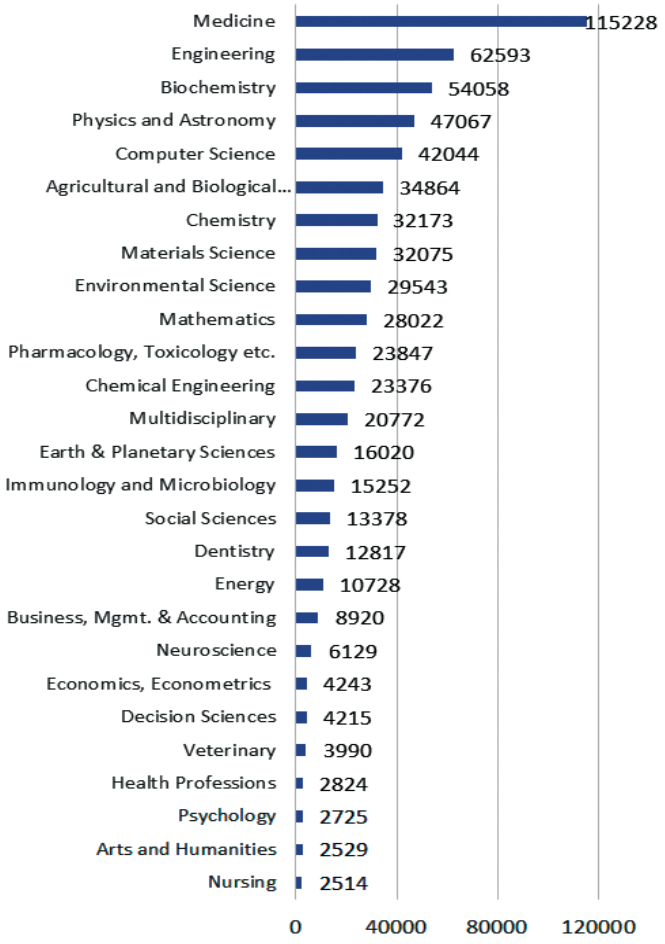

Figure 1. Comparison of social science open-access publications with other disciplines.

Figure 1 illustrates the distribution of Open-Access (OA) publications across various disciplines, revealing notable disparities in publication trends. Medicine dominates with 115,228 publications (17.67 %), underscoring its focus on public health and mandates for open dissemination. Engineering (62,593 publications, 9.60 %) and Biochemistry (54,058 publications, 8.29 %) also exhibit high publication rates, likely fueled by technological progress and interdisciplinary research. Natural sciences such as Physics, Computer Science, and Agricultural Sciences maintain significant shares. In contrast, Social Sciences (13,378 publications, 2.05 %) and Humanities show comparatively lower contributions, potentially due to funding limitations and traditional publishing practices. The presence of Multidisciplinary research (20772 publications, 3.19 %) highlights the increasing relevance of cross-disciplinary collaborations in contemporary scientific advancements.

Table 2 illustrates the publication trends from 2013 to 2022, showing a consistent increase in the cumulative number of publications, starting at 302 in 2013 and reaching 13,378 over the 10-year study period. The Annual Growth Rate (AGR) represents the percentage increase compared to the previous year. Notably, 2020 recorded the highest AGR at 94.43 %, driven by the COVID-19 pandemic, which spurred heightened research activity in social sciences, particularly in public health policy and education. This was followed by 2015, with an AGR of 57.31 %. In contrast, 2021 saw a sharp decline, with the lowest AGR at 7.14 %. As pandemic-related research demand stabilised, factors such as funding constraints, peer-review backlogs, and shifts in research priorities contributed to the slowdown in publication growth. These fluctuations highlight the dynamic nature of Indian OA Social Science publications and the external influences shaping their trends.

Table 2. Annual growth rate of Indian OA social science publication

Year	Number of publications	Cumulative no. of publications	Annual growth rate (AGR)
2013	302	302	0
2014	349	651	15.56
2015	549	1200	57.31
2016	589	1789	7.29
2017	708	2497	20.20
2018	993	3490	40.25
2019	1311	4801	32.02
2020	2549	7350	94.43
2021	2731	10081	7.14
2022	3297	13378	20.73

5.1 Relative Growth Rate (RGR)

Relative Growth Rate measures growth concerning the population size and is known as the exponential or continuous growth rate in scientific literature publications. It indicates the rise in articles per unit of time. The mean RGR for a specific period can be calculated using the formula: RGR= W2-W1 / T2-T1

Where, RGR=Growth Rate over the specific period of the interval

W1 = Log_e (natural log of the initial number of contributions)

W2 = Log_e (natural log of the final number of contributions)

T1 & T2 = the unit of initial time and final time

5.2 Doubling Time (Dt)

Doubling time signifies the duration needed for a quantity to double in size or value. It is linked to RGR, where RGR remains constant. When a quantity experiences exponential growth, it maintains a consistent doubling time, directly calculable from the growth rate.

"There is a direct correlation between the relative growth rate and doubling time. Doubling time is calculated using the formula: Doubling Time = 0.693 / R, where R represents the relative growth rate."

Table 3 depict data concerning the Relative Growth Rate (RGR) and Doubling Time (Dt) for Indian OA Social Science Publications. Notably, there was a significant decrease in RGR from 0.76 in 2013 to 0.29 in 2022, with an overall mean RGR of 0.42 during this period. Specifically, RGR was higher from 2013 to 2017 compared to the years from 2018 to 2022. On the other hand,

Table 3. Relative growth rate & doubling time of Indian OA social science publication

Year	No. of publications	Cumulative no. of publication	W1	W2	RGR	Mean RGR	Doubling time	Mean dt
2013	302	302		5.71	0	0.53	0	1.46
2014	349	651	5.71	6.47	0.76		0.91	
2015	549	1200	6.47	7.09	0.62		1.11	
2016	589	1789	7.09	7.48	0.39		1.77	
2017	708	2497	7.48	7.82	0.34		2.03	
2018	993	3490	7.82	8.15	0.33	0.37	2.10	2.1
2019	1311	4801	8.15	8.47	0.32		2.16	
2020	2549	7350	8.47	8.9	0.43		1.61	
2021	2731	10081	8.9	9.21	0.31		2.23	
2022	3297	13378	9.21	9.5	0.29		2.38	
	13378					**0.42**		**1.81**

Doubling Time values increased from 0.91 in 2013 to 2.38 in 2022. It is crucial to mention that the year, 2014 recorded the highest RGR at 0.76, and the highest Dt was observed in 2022 at 2.38.

The study has identified a mean Doubling Time of 1.81, reflecting a remarkably very high rate. Thus, it can be inferred that the state of Indian Open Access (OA) Social Science Publication is currently in its nascent phase and needs more support from the social science researchers to promote OA movement. There is a clear need for collaborative efforts to bolster the OA movement in social science research in India.

Figures 2-6 provide a visual representation of the progression of Indian Open Access Social Science publications spanning the years 2013 to 2022. Each figure corresponds to a distinct growth model, namely, Exponential Growth Model (Figure 2), Polynomial Growth Model (Fig. 3), Linear Growth Model (Fig. 4), Logarithmic Growth Model (Fig. 5) and Gompertz growth model (Fig. 6).

These graphical depictions offer insights into the diverse growth patterns exhibited by Indian Open Access Social Science publications over the specified timeframe, allowing for a comprehensive understanding of the trends and dynamics within the field.

Table 4 provides the goodness-of-fit (R^2) values for various mathematical models applied to the growth of Indian Open Access Social Science publications: Polynomial model (R^2 = 0.9684), Linear model (R^2 = 0.8667), Logarithmic model (R^2 = 0.8663), Exponential model (R^2 = 0.9749) and Gompertz model (R^2= 0.9640).

Table 4. Application levels of growth models

Growth model	R^2
Exponential growth	0.9749
Polynomial growth	0.9684
Linear growth	0.8667
Logarithmic growth	0.8663
Gompertz growth	0.9640

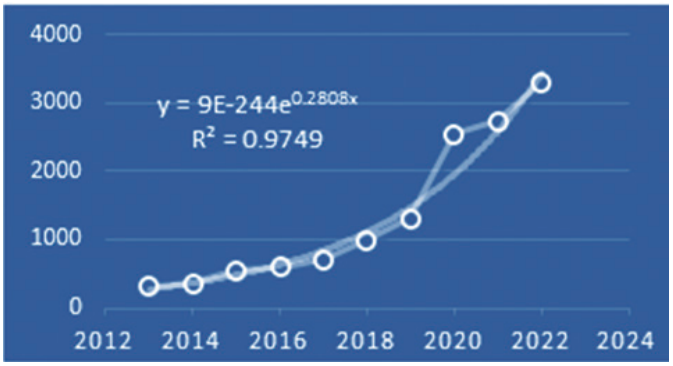

Figure 2. Exponential growth model.

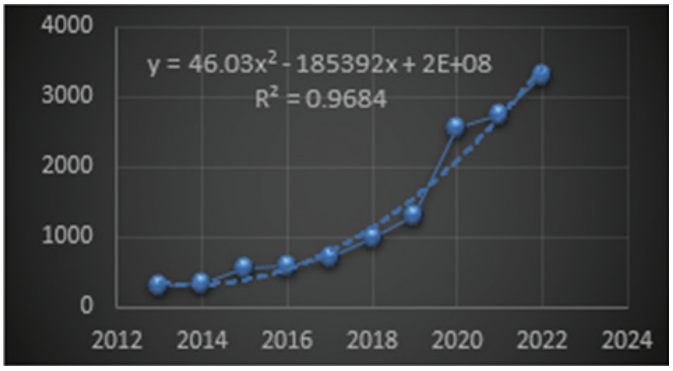

Figure 3. Polynomial growth model.

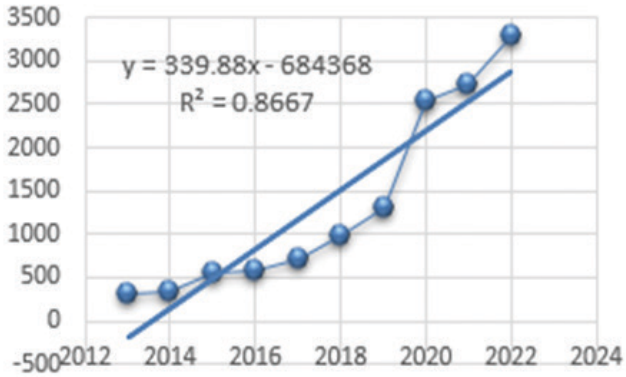

Figure 4. Linear growth model.

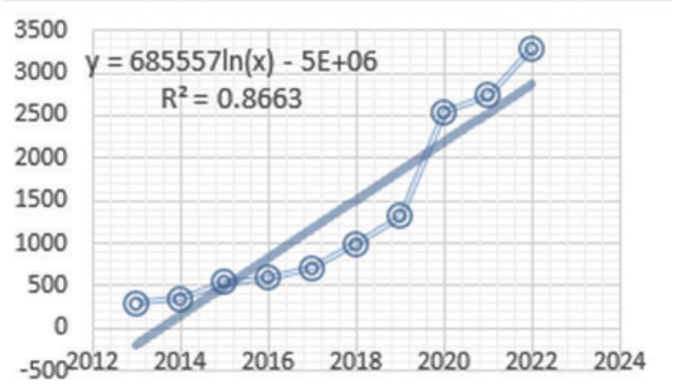

Figure 5. Logrithmic growth model.

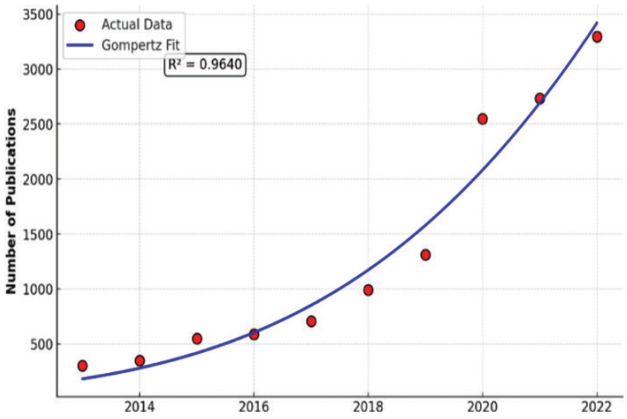

Figure 6. Gompertz growth model.

Table 5 outlines scientific output and its citation patterns from 2013 to 2022. Each year's data includes the number of articles, total citations received, citations per article, duration of citable years and corresponding citations per year per article. Despite an increase in published papers, from 302 to 3,297 over ten years, there was a significant decline in total citations per article, dropping from 21.61 in 2013 to 3.29 in 2022. Older articles tend to accumulate more citations over time as research gains recognition. To account for this, the "Annual Mean Citation Rate per Article" was calculated, revealing an increasing trend from 1.96 in 2013 to 2.92 in 2021. Further, it is observed that the Annual mean citation rate per article is below the average citation per article (2.24) in the first four years and in the year 2019.

These trends provide critical scientific insights into evolving Indian open-access social science dynamics (growth of OA articles) and citation behaviors within the social science domain.

Figure 7 shows the yearly average citations received by Indian open-access social science publications from 2013 to 2022. The data reveals fluctuations in mean citations per year, reflecting the dynamic impact of research in social science publications. Starting at 1.96 in 2013, the average citation declined slightly to 1.84 in 2014 but surged to 2.18 in 2015, indicating growing recognition. In both 2016 and 2017, stability was maintained, with values of 2.12 and 2.61, respectively. However, there was a decline in 2018 (2.40) and 2019 (2.30) before a minor increase in the year 2020 (2.37). Notably, 2021 saw a significant rise to 2.92 citations annually, but 2022 witnessed a sharp drop to 1.65. These shifts reflect evolving trends in acknowledgement and impact, highlighting the dynamic nature of research influence in Indian open-access social science publications.

Figure 8 shows that The Relative Growth Rate (RGR) peaked in 2014 at 0.76 and gradually declined, reaching its lowest point of 0.29 in 2022. A slight rebound in 2020 (0.43) may be attributed to the surge in research output during the COVID-19 pandemic. Meanwhile, the annual mean citation rate per article steadily increased from 2013 to 2021, peaking at 2.92 citations per article in 2021. However, the drastic drop in 2022 suggests that recent publications have not yet accumulated citations.

Table 5. Citation trends in Indian OA social science publications (2013-2022)

Year	No of article	Total citations (TC)	TC per article	Annual mean citation rate per article	Citable years
2013	302	6526	21.61	1.96	11
2014	349	6408	18.36	1.84	10
2015	549	10766	19.61	2.18	9
2016	589	10001	16.98	2.12	8
2017	708	12921	18.25	2.61	7
2018	993	14289	14.39	2.4	6
2019	1311	15090	11.51	2.3	5
2020	2549	24165	9.48	2.37	4
2021	2731	23951	8.77	2.92	3
2022	3297	10847	*3.29*	…	…
	Total=13378	**Total=134963**	10.09	**2.24**	

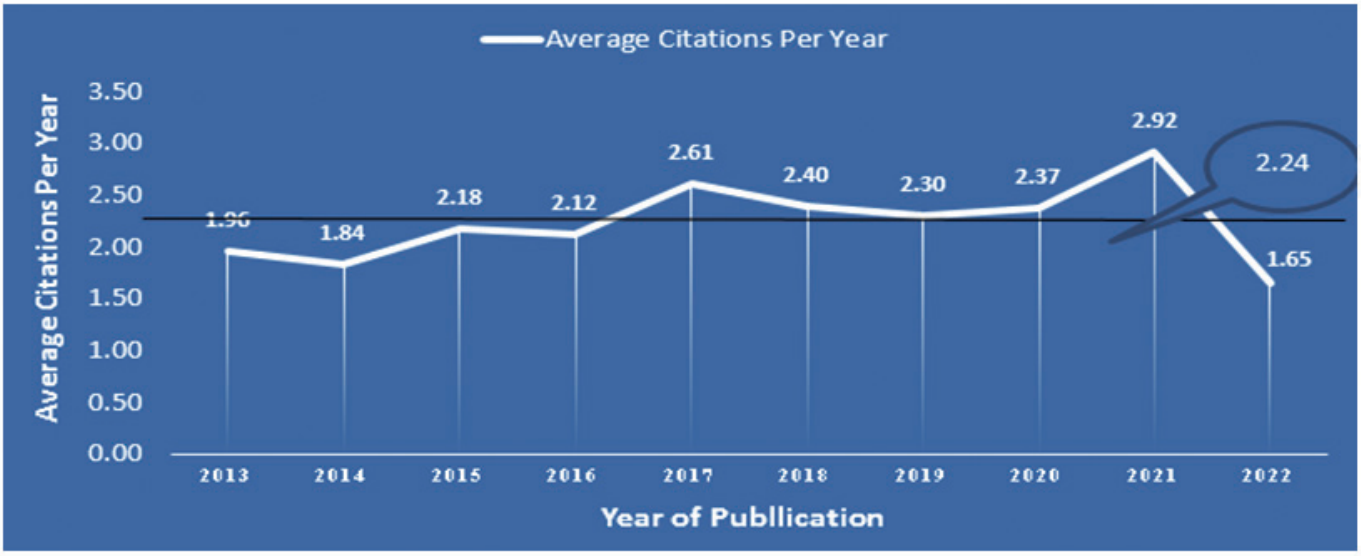

Figure 7. Average citation per year in Indian open access social science publication.

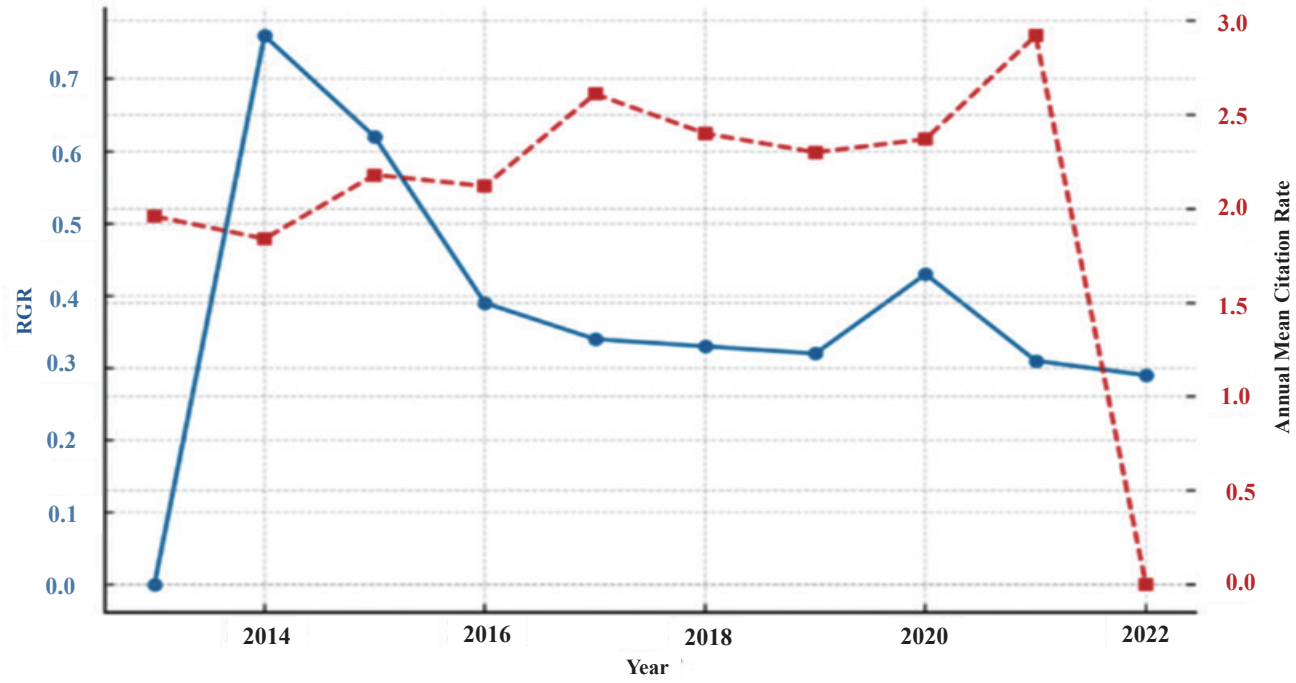

Figure 8. Correlation between the relative growth rate (RGR) and the annual mean citation rate per article (2013–2022).

6. FINDINGS AND DISCUSSION

The study evaluates and presents the Annual Growth Rate (AGR) of Indian open-access social science publications. The results exhibit fluctuating AGRs across the study period, reaching noteworthy peaks in 2020 (94.43 %) and 2015 (57.31 %), while 2021 records the lowest AGR at 7.14 %. The Mean Relative Growth Rate, calculated at 0.42, provides a measure for the average growth pace observed throughout the dataset. Additionally, the Doubling Time, averaging 1.81, offer valuable insights into the temporal dynamics required to double the publication count. This indicates that Indian OA Social Science Publication is still at infant stage and needs more support from the social scientists. India ranks 18th globally in open-access social science publications, contributing 13,378 papers (1.31 %). This reflects a modest presence compared to leading nations such as China (5.12 %) and Germany (3.78 %).A cross-disciplinary comparison of OA publications reveals significant variations in publication patterns. Medicine leads with 115,228 publications (17.67 %), emphasizing its strong focus on public health and open dissemination mandates. In contrast, Social Sciences (13,378 publications, 2.05 %) and Humanities exhibit lower contributions, likely influenced by funding constraints and traditional publishing practices.

Various growth models, namely Exponential, Polynomial, Linear, Gompertz growth and Logarithmic, are employed

as curve-fitting methodologies for Indian open-access social science publications. The outcomes indicate that the Exponential Growth Model surpasses other models, boasting the highest R-squared values (0.9749). This revelation underscores the significance of employing this model as a powerful tool for accurately describing the growth dynamics inherent in the dataset.

The study further investigates into the citation patterns and publication trends in Indian OA social science publications and also Correlation between the Relative Growth Rate (RGR) and the Annual Mean Citation Rate per Article. A meticulous analysis of citation patterns yields insights into these publications' scholarly impact and influence. Simultaneously, identifying publication trends sheds light on evolving themes, key contributors, and the overall landscape of open-access social science research in India. These findings collectively contribute to a nuanced understanding of the scholarly dynamics within this specific domain.

7. SUGGESTIONS AND RECOMMENDATIONS

- Increase funding for OA social science research to support scholars and institutions in publishing high-quality work.
- Raise awareness about the importance of OA in increasing the visibility and impact of social science research.
- Encourage interdisciplinary research to address complex social issues and increase the relevance of OA publications
- Introduce awards and recognition for outstanding OA social science publications to motivate researchers
- Encourage researchers to cite and engage with Indian OA social science publications to build a stronger scholarly ecosystem.

8. CONCLUSION

The exploration of curve-fitting methodologies applied to Indian OA social science publications, employing five diverse growth models, reveals a prospect of compelling insights. The Exponential Growth Model is the most robust, demonstrating unparalleled efficacy and attaining the highest R-squared values (0.9749). This model demonstrates superior goodness-of-fit, emphasizing its appropriateness for describing the growth trajectory of the dataset.

The novelty of this study lies in its comprehensive comparison of five growth models and the correlation analysis between Relative Growth Rate (RGR) and Annual Mean Citation Rate per Article. The correlation trend indicates that while research output fluctuated during the study period, the citation rate continued to rise, suggesting that the impact of research remains strong despite a lower growth rate. The comparative assessment of India's share in global OA Social Science publications provides unique insights into its position among leading countries and disciplines.

Beyond the confines of academia, this study assumes a pivotal role as a valuable resource for a broad spectrum of stakeholders, including researchers, policymakers, and academic professionals. The meticulous findings facilitate informed decision-making processes, empowering stakeholders to strategize and implement initiatives that foster advancements in Indian OA social science research. The enriched understanding provided by this study not only contributes to the existing body of knowledge but also catalyzes future research endeavors. This study, therefore, stands as a testament to the transformative potential of meticulous research in shaping the trajectory of academic and policy discourse in the dynamic landscape of open-access social science research in India.

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