Research Performance of Universities in West Bengal: A Comprehensive Metric Study

Thesis submitted to the Faculty of Arts of Jadavpur University
in partial fulfilment of the requirements for the degree of
Doctor of Philosophy in Library and Information Science

by

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Dated: 27/01/2023

CERTIFICATE OF APPROVAL

It is hereby certified that the thesis titled "**Research Performance of Universities in West Bengal: A Comprehensive Metric Study**" is prepared by Arijit Das, for the partial fulfilment of the requirements of the degree of Doctor of Philosophy in Arts at Jadavpur University under my supervision and guidance.

It is also certified that no part of the thesis has been submitted for any other degree.

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Declaration

I hereby declare that the thesis entitled 'Research Performance of Universities in West Bengal: A Comprehensive Metric Study' is a bona-fide record of work done by me and no part of the thesis has been submitted for any other degree.

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Dedicated

to my beloved parents to whom my success is their success

Mr. Akul Chandra Das & ***Mrs. Rekha Das***

&

all my well wishers

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Place: (Arijit Das)
Dated:

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LIST OF ABBREVIATIONS

AAS	Altmetric Attention Score
ACP/AC	Average Citation per Publication / Citation Per Article
AISHE	All India Survey on Higher Education
BU	University of Burdwan
CP	Cumulative Publications
CU	University of Calcutta
DC	Degree of Collaboration
Dt (P)	Doubling Time of Publications
FCR	Field Citation Ratio
GER	Gross Enrolment Ratio
JU	Jadavpur University
KU	University of Kalyani
NAAC	National Assessment and Accreditation Council
NBU	University of North Bengal
Nm	Number of Multi Author
Ns	Number of Single Author
PCA	Principal Component Analysis
PU	Presidency University
RCR	Relative Citation Ratio
RGR (P)	Relative Growth Rate of Publications
RI	Research Indicators
SPSS	Statistical Package for Social Sciences
TC	Total Number of Citations
TP	Total number of publications / Total Papers
UGC	University Grant Commission

Chapter I

Introduction

CHAPTER - I

INTRODUCTION

"A nation is advanced in proportion to education
and intelligence spread among the masses."

– Swami Vivekananda

1.1 Introduction

The scientific position of a university in the national and international context usually could be measured from both quantitative and qualitative point of view. First, the number of total research publications of a university and its contribution to the total country can be used. Second, the impact of discipline wise research output of a university can be measured through citation analysis or some other alternative impact factor measures.

Introducing metrics-based studies in the form of Bibliometrics, Scientometrics has become an essential part of research quality evaluation of higher education institutions and has been responsible for changing the practice of research in the sector.

In early days, to determine the quality of scientific research work, peer review process has been used by publishing the work in a certain journal, the method of peer review has also been applied to assess the contribution of researchers, faculty members or of institution's total research performance. Since 1990s, for the quantitative evaluation of research outputs of any institution indicator-based procedures has been used frequently where bibliometric analysis has gained more attention to make productive decisions of policy makers at higher education system where numbers are easily compared than comments of peer team. A large number of units such as university outputs can easily be assessed by the aid of quantitative assessment tools whereas individual experts could not be able to analyse such units with a single evaluation method.

Bibliometrics has been introduced as a Standard technique to measure the scientific publications of an institution of higher studies or of a country. The methods of bibliometrics have been applied to evaluate the research publications on some large units but it has both the advantages and disadvantages. On the drawbacks of the processes, it

was mentioned in the literature by Bornmann and Leydesdorff, 2014 that "bibliometrics can only be applied to disciplines where the literature and its citations are available from appropriate databases". Later, introduction of scientometrics in academic research evaluation could be fruitful to resolve the drawbacks of bibliometrics. It is used as an alternative indicator based scientific research evaluation process, where both the quantitative and qualitative measures have been employed intensively.

Bornmann and Leydesdorff, 2014 have mentioned that "scientometrics has become an integral part of research evaluation and plays a crucial role in making decisions about national research policies, funding, promotions, job offers and so on, and thereby on the careers of scientists. Scientometrics therefore has demonstrated that it provides reliable, transparent and relevant results, which it largely achieves with citation-based data if it is done correctly."

The best practiced indicators of scientometrics and bibliometrics studies have become an important technique of analysing and measuring the research outputs of universities. An attempt has been made to reveal the overall scenario of research outputs and also to give hints on how to improve the productivity of the research carried out by these higher education institutions.

By keeping these main purposes in mind, the researcher designed to take up a study on "Research Performance of Universities in West Bengal: A Comprehensive Metric Study". Through this study an attempt has been taken to analyse the publications of researchers and faculty members of six NAAC 'A' graded Universities in West Bengal. The focus of the study is to analyse the research data in terms of growth rate, authorship pattern, main areas of research concentration, received citations, institution wise contribution and so on.

1.2 Higher Education in India

It is noted that Higher Education in India has started its journey as early as 1000 B.C. The ancient learning institutions were mainly associated with the dissemination of Vedic education. The present education system of India has a strong base of the colonial legacy. Earlier this was carried by the British East India Company and then by the British Parliament under the British rule in India. Calcutta Madrasa, established in 1781 by the British East India Company as the first higher education institution in India, was followed

by Asiatic Society, Bengal in 1784, Banaras Sanskrit College in 1791 and Fort William College in 1800. British Parliament passed Charter Act of 1813 to declare that Indian education is one of the main duties of the state and this act also removed the restrictions on missionary work of British India. As a result of this Serampore College was established in 1818 and after that first three universities were established in Bombay, Calcutta and Madras in the year of 1857. These three official universities were modelled as the University of London and the focus of these universities were then on English Language and Humanities. Before the independence of India, the British control on Indian education was highly noticed. But the Government of India Act of 1935 gave more power to the Indian politicians and helped them to look on the buildup of India's own education system.

"India's higher education achievements since independence in 1947 are impressive. With some 21 million students enrolled in postsecondary education, India has the third-largest higher education system in the world and is about to overtake the United States and become number two—although it serves approximately 18 percent of the age group." (Altbach, 2013)

Since independence in 1947 the achievements in India's higher education were phenomenal. India become third largest higher education system around the world with approximately 21 million students enrolled in the postsecondary education. India aims to overtake the United States higher education system and become number two in higher education system in the world (Altbach, 2013). In 1948, the University Education Commission was formed and since then many colleges and universities were established in the country for the growth and improvement of higher education system in India. During 1960s and 1970s government supported financial assistance to not only set up the state-funded colleges and universities but also the private institutions. As a result of this many private institutions were also established in the country. Since the British rule Indian education largely focused on the languages and humanities. From post 1980s India looks to build up institutions of professional education and as a result of this many Indian Institutes of Technology, Indian Institutes of Management, regional engineering colleges and many more of this kind of institutions were established. At that time many foreign fundings were welcomed to build up these institutions as the financial condition of the country was not enough to do on its own. From then onwards in the state-funded higher

education colleges and universities, the rate of growth was decreased and it opened the gateway for increasing the private institutions in the country.

"The Indian higher education system is one of the largest such systems in the World. It is estimated that during the X Five Year Plan period (2002-07), there will be a tremendous pressure of numbers on this system and many additional students will be knocking at the doors of higher education institutions in the country. There are also new challenges of management and regulation being faced by these institutions, which require serious attention, both at the institutions in the public sector and those in the private sector now growing at a fast pace. As a result, the old structures of management established in pre-independent India and working during most of the twentieth century are now required to undergo drastic changes. Besides, the demands of the society for equity and accommodation cannot be neglected anymore." (UGC, 2003)

The final report of UGC (UGC, 2003) mentioned that the higher education system of India is one of the largest systems in the world and estimated that during the 10^{th} Five Year Plan period from 2002-2007, there will be a huge pressure of numbers of enrolled students and a huge number of students will be awaiting at knocking at the door of higher education institutions in the country. The report also highlights about some new challenges to be faced by these institutions in the form of management and regulations related issues. To overcome from these challenges, it requires some serious attention by growing at a fast pace both at the public and private sectors of higher education systems. Therefore, the old formation of management established in pre-independent time and those which are still working in the twentieth century are needed to be changed. Along with, the commission suggested that the demands of the society for equity and accommodation could be fulfilled by the improvement of the educational systems of the country.

Over the last 60 years, the Government of India initiated many decisions to organise one of the leading higher education systems in India and for that substantial public funds and full policy supports were made. As a result of these initiatives, total number of universities in India as on 01.02.2020 was 935. Among all these universities mainly four kinds of universities are there in the country, State Universities 409, Deemed to be Universities 127, Central Universities 50 and 349 Private Universities (UGC, n.d.).

"University Grants Commission (UGC) set up under UGC Act 1956 is responsible for coordination, determination, and maintenance of standards and release of grants to universities and research organizations. In order to evaluate performance of an institution and bring about a measure of accountability a mechanism of accreditation has been developed by UGC. This is an autonomous council under UGC called National Accreditation and Assessment Council (NAAC) with a purpose to carry out periodic assessment of universities and colleges. NAAC has evolved a methodology of assessment which involves self-appraisal by each university/college and an assessment of the performance by an expert committee." (Kaul, 2006)

UGC, an autonomous body, set up under UGC ACT 1956, has been bestowed upon the responsibility of coordination, determination, and maintenance of standards of higher education and release of grants to Universities and Research Institutions. UGC has set up an autonomous council called National Accreditation and Assessment Council (NAAC) in order to evaluate performance of an Institution. It has framed a mechanism to measure accountability and UGC has also developed a mechanism for accreditation through NAAC. This council carry out periodic assessment of Universities and Colleges and has evolved a methodology of assessment. The methodology gives a scope to each University/College for self-appraisal and an assessment of the performance by expert committee. (Kaul, 2006)

All India Survey on Higher Education (AISHE) was initiated for collecting data and presenting overall scenario of higher education in India. The latest report, i.e. published during the year 2018-2019 has highlighted some key issues. According to this report (AISHE, 2019), "Total enrolment in higher education has been estimated to be 37.4 million with 19.2 million male and 18.2 million female. Female constitute 48.6% of the total enrolment. Gross Enrolment Ratio (GER) in Higher education in India is 26.3%, which is calculated for 18-23 years of age group. About 79.8% of the students are enrolled in Undergraduate level Programme. 1,69,170 students are enrolled in Ph.D. that is less than 0.5% of the total student enrolment. At Ph.D. level, maximum number of students is enrolled in Science stream followed by Engineering and Technology. On the other hand, at Post Graduate level maximum students are enrolled in Social Science stream and Management comes at number two."

"Research is seen as a primary and a vital function of a university and, therefore, of the higher education systems worldwide. Higher education plays an important role in supporting a nation's R & D efforts. It provides skilled human resources for the R & D system. It is often the lead player in public research arena. Academic research through universities forms an important component of the technological base of a country. In the USA that has the most vibrant and the largest R & D system in the world, higher education plays a vital role." (Agarwal, 2006)

1.3 Higher Education in West Bengal

Higher Education has always been a supreme power of West Bengal's culture. Whether in the Arts, Social Sciences or the Sciences, students with outstanding merit from the state have excelled themselves in the national and international level.

The State belongs to an ecosystem that has traditionally known for its high social value on educational achievements. West Bengal as the gateway to north eastern region of India and adjoining Bangladesh, Bhutan, Nepal, Orissa, Sikkim, Bihar and Jharkhand can emerge as a center of higher education. Students and researchers from neighbouring countries and States from East and Northeast India can easily come and join the Universities for their higher education and research works.

Historically, Kolkata was the capital of British India where first developed the modern system of education. For the promotion of Oriental Studies, Sir William Jones in 1784 established the Asiatic Society. Ram Mohan Roy, Ishwar Chandra Vidyasagar, David Hare, Shashi Bhushan Chatterjee and William Carey are the pioneers of foundation of modern education in Kolkata.

As the first medical college, Calcutta University (1857) was one of the first universities to be set up in India. After Calcutta University, Hindoo College or later Presidency College established in 1817; in 2010 it was gained the status of a University. Then Jadavpur University established in 1955. The Visva-Bharati University established by Rabindranath Tagore in 1921 is a Central University now.

Development in the field of Science and Technology were also seen, first The Bengal engineering College, Shibpur established in 1856. Now it is taken over and renamed by Government of India as Indian Institute of Engineering Science and Technology, Shibpur in 2014. Today this institution serves as one of the premier institutions for research and

higher education in the field of science, engineering and technology. From West Bengal IIT Kharagpur, IIM, Calcutta is the top ranked institutes in Science, Engineering and Technology.

As per list of universities mentioned in UGC Presently West Bengal has one Central University, i.e. Visva-Bharati; Two Deemed University, i.e. Ramakrishna Mission Vivekananda Educational and Research Institute and Indian Association for the Cultivation of Science (IACS); 27 State Universities and 10 State Private Universities.

1.3.1 University of Calcutta

The University of Calcutta (CU) is a public state university located in Kolkata, West Bengal. In July 1854, the Court of directors of the East India Company sent a despatch (Known as Wood's despatch) to the Governor General (Lord Dalhousie) of India in council. The main motto of this dispatch was suggesting the establishment of three Universities, Calcutta, Bombay and Madras. As a result of this dispatch the University of Calcutta was established on 24 January, 1857. Also, the Calcutta University Act came into effect on 24 January 1857 and as a policy making body a 41-member senate was formed. At the time of establishment CU had a huge catchment area which was the largest of any Indian University, covering the area from Lahore to Rangoon (at present in Myanmar). At present the University is governed by the Calcutta University Act, 1979. The Act allows the reconstitution of the University which enables it to work more effectively for enhancement of higher education to meet the growing needs of the society. The Act has given autonomy to the academic bodies of the University.

The University of Calcutta has many campuses spread all over the metropolis and its suburbs, major ones are Ashutosh Shiksha Prangan (the college Street Campus), Rashbehari Shiksha Prangan (in Rajabazar), Taraknath Palit Shiksha Prangan (in Ballygunj) and Sahid Khudiram Shiksha Prangan (in Alipore).

Internationally, the University of Calcutta ranked 801-1000 in the QS World University Rankings (previously known as Times Higher Education-QS World University Rankings) and 68 among BRICS nations of 2019. In India, University of Calcutta ranked 12 overall by National Institutional Ranking Framework (NIRF) and ranked 5 among all universities in 2019.

Analysis of Research Activities and Facilities as seen by the NAAC Peer Team during Institutional Assessment & Accreditation (Cycle 3)

Date of NAAC Visit: 19th to 21st December, 2016

Promotion of Research	• Centralized Research Advisory Committee & Ph.D. Committee at the departmental level constituted • Interdisciplinary research undertaken • Vast gap exists between total budget expenditure and actual utilization of amount • Post-doctoral fellowships are made available and researchers need to be encouraged by providing sabbatical leave
Resource Solidarity for Research Work	• No functional IPR cell • 35 patents have been registered and a couple of U.S. patents granted • About 63 lakhs UGC research grants received up to 2013 • Non-UGC funding for research needs to be enhanced • 303 projects undertaken and funds generated through them
Research Facilities	• University Science Information Centre exists • Upgraded and modernized laboratories, computers and a common instrumentation facility available • Residential facility extended to research scholars • Centres of national and international repute have been established
Research Publications	• Good record of publications by the faculty • Many faculty members serve as members of editorial boards of national and international journals

	• 33 international and 31 national awards won by faculty
Library for Research Support	• 10 storied central library, 4 libraries in campuses and 40 departmental libraries with excellent collections • Integrated online resources and databases

1.3.2 Jadavpur University

Jadavpur University is a public state university placed in Kolkata in the state of West Bengal in India. It was founded in 1955.

In 1910, for the Promotion of Technical Education in Bengal which looked after Bengal Technical Institute (which later became College of Engineering and Technology, Bengal) was amalgamated to National Council of Education (NCE). In the future NCE looked after the College of Engineering and Technology, Bengal which by 1940 was acting as a University. After Independence, the Govt. of West Bengal, with the consent of the Government of India, enacted the required legislation to establish Jadavpur University on the 24th of December 1955.

Jadavpur University is semi-residential, which at present operates two campuses located at Kolkata, one in Jadavpur covering 58 acres and another in Salt Lake covering 26 acres.

Internationally, Jadavpur University ranked 601-650 by the QS World University Rankings and ranked 74 among BRICKS nations. In India, Jadavpur University ranked 13 among overall institutions and ranked 6 among all universities by National Institutional Ranking Framework (NIRF).

Analysis of Research Activities and Facilities as seen by the NAAC Peer Team during Institutional Assessment & Accreditation (Cycle 3)

Date of NAAC Visit: 22-25th July, 2014

Promotion of Research	• Research culture clearly evident across university campus. • University promotes interdisciplinary research and teachers encouraged to get research projects from funding agencies.

	• University provides seed money for research, and offers research fellowships. • University bears cost of patents applications.
Resource Solidarity for Research Work	• Large number departments supported by programs like CAS, DRS, FIST, PURSE, UPE, COSIST. • Significant resources through government funding agencies for research projects. • Industry support for research can be strengthened.
Research Facilities	• Wi-Fi connectivity, LAN facility and Remote access facilities available. • Good research facilities in all departments. • Visible management support for research facilities creation. • More funds required for maintenance and upgradation of research facilities.
Research Publications	• Good record of quality research publications. • Many of the departments have their own peer reviewed journals. • Patents and Copyrights submissions encouraged. • UG students motivated and encouraged for publications. • Adequate rewards and recognitions for faculty and students.
Library for Research Support	• Library services fully computerized. • Good numbers and titles of books and periodicals and digital resources. • Departmental libraries well equipped to cater to students and faculty.

- Member in resource sharing networks / consortia like INFLIBNET, INDEST, AICTE, DELNET.
- Remote access facility to library resources available.

1.3.3 University of Kalyani

The University of Kalyani is a public state university established in 1960, located in Nadia district of West Bengal, India.

In the early 1950s, the township of Kalyani was developed as a planned city under the leadership of Dr. Bidhan Chandra Roy, who was then the Chief Minister of West Bengal. For the growth and development of the town, it was point out that value should be given to the infrastructure in the sectors of education and health. As a result of the master plan of the Town University of Kalyani was established in November 1960, as a separate university with faculties of Science, Arts, Education and Agriculture. Since commencement, the university showed progress and attracted students from local regions and students from other regions. The university was bifurcated in 1975 when the Faculty of Agriculture emerged as a full-fledged agricultural university, named as Bidhan Chandra Krishi Viswavidyalaya (BCKV), located at Mohanpur, Nadia. After the bifurcation university left only twelve departments under Faculty of Science and Arts. The activities reorganized and university started more departments. Till 1998 it was a unitary university system. After that it became an affiliating university covering jurisdiction area to the districts of Nadia and Murshidabad. At that time 38 colleges affiliated to University of Kalyani, which was earlier affiliated under University of Calcutta. After then undergraduate teaching programmes were shifted to the affiliated colleges. Many more departments started their journey in different stages and now it is one of the renowned universities supporting growth of higher education and research works as a progress path of the society as well as the country.

Presently University of Kalyani is one of the sixth ‘A’ graded university in West Bengal according to the accreditation of National Assessment and Accreditation Council (NAAC) with institutional CGPA of 3.12 (NAAC certificate of quality profile issued date: 16 December, 2016).

Analysis of Research Activities and Facilities as seen by the NAAC Peer Team during Institutional Assessment & Accreditation (Cycle 3)

Date of NAAC Visit: 5-7th December, 2016

Promotion of Research	• Committees constituted to give impetuous to research. • Faculty and students are encouraged to present papers in conferences in India and Abroad. • The Institution has adequate infrastructural • facilities for research and development
Resource Solidarity for Research Work	• Good number of research projects from Government funding agencies completed and ongoing. • Research grants from Government agencies visible. • Central Instrumentation facility maintained
Research Facilities	• Adequate infrastructure for research in the Institution for all Departmental Research Centres. • Many centres of national repute exist at the • Institution level. • Centralized Computing facility to meet the computational requirements of the research scholars. • Adequate library facility for research • Activities.
Research Publications	• Good number of research projects and collaborative projects • Researchers are bagged with good number of publications in reputed journals. Faculty members received number of research awards during last four years. • Patents registered limited

Library for Research Support	• The Institution has a library with Open Access system • Web based OPAC facility available. • Good collection of books, journals, theses and dissertations.

1.3.4 University of Burdwan

Burdwan University started its journey on 15th June, 1960, when an ICS, Sukumar Sen was its first Vice-chancellor. After the annulment of Zamindari system in 1950s, the last representative of Burdwan Raj Uday Chand Mahtab showed his liberality to donate entire property to the state government. This initiative was takenat that time due to facilitate the establishment of Burdwan University under the leadership of the chief minister of West Bengal then, Dr. Bidhan Chandra Roy. Burdwan University has two main campuses, first one the Rajbati Campus, where mostly administrative works are done and the other one is Golapbag Campus, where mainly the academic centers are present. Two other campuses are also there, UIT Campus for engineering and Tara bag campus for Medical education.

At the beginning only humanities section started in function, then after year mainstreams of science were started. More than 175 colleges (including degree colleges, B.Ed. colleges and private institutes) are affiliated to Burdwan university and these colleges spread over its jurisdiction territory that covers five districts, viz. Burdwan, Bankura, Birbhum, Purulia and Hooghly (without Serampore subdivision). In present time, Burdwan University is in a position to offer courses and research activities in various disciplines.

Burdwan University awarded grade A by the National Assessment and Accreditation Council (NAAC) with CGPA 3.11 on 5 November, 2016.

Analysis of Research Activities and Facilities as seen by the NAAC Peer Team during Institutional Assessment & Accreditation (Cycle 3)

Date of NAAC Visit: 20-22nd October, 2016

Promotion of Research	• Excellent research in Crop Research and Seed Multiplication and in Science disciplines is being carried out

	• University facilitates research and funds new faculty projects by providing seed money • University supports faculty to attend conferences within India and abroad • Most of the faculty involved in guiding research • Research based instruments in place, however some of them need maintenance / replacement
Resource Solidarity for Research Work	• Institution has a structured budgetary provision for research and development activities • Grants are being received from State governments and other Funding agencies for carrying out research in some of the departments • Limited Interdepartmental/ interdisciplinary research projects are undertaken by the students • IPR policy is not in place for filing patents.
Research Facilities	• e-Journals, e-resources available • Research facilities do exist in most of the Departments • University Science Instrumentation Centre has been established with sophisticated instruments • Residential facilities for research scholars, PDFs, Visiting Scientists exist • Research facilities being enhanced through research projects
Research Publications	• Appreciable number of faculty involved in research

	• Some departments publish their own journals, but needs to have ISSN number • Research outcome is significant and recognized • Limited Industry relevant research being carried out and transfer of technology not started • Institutional research visible through citations in science departments
Library for Research Support	• Available journals and e-resources not accessible in the departments • Access to library resources to students and researchers may be made available by strengthening Campus Network

1.3.5 University of North Bengal

Socio-economically most of the people of North Bengal belong to the backward classes. Since its foundation in 1962, University of North Bengal offers higher education and research activities to the people of the arena. For the advancement and requirements of the Region University take necessary responsibility on his own shoulder on the field of higher education and research. University of North Bengal try to maintain high standards of education and take initiatives for dissemination of knowledge to meet the growing needs of the society.

NBU plays important roles relating to social responsibilities, for instance, the Centre for Women's Studies has organized various activities relating to the advancement of the society, the Centre for Differently Abled Persons promotes inclusion among diversities without any discrimination, different departments organises seminars, workshops on topics related to the subject as well as topics on social value.

North Bengal University receives grade A by the accreditation system of NAAC with a CGPA score of 3.05 on December 2, 2016.

Promotion of Research	• Many teachers engaged in research • Most of the regular teachers guiding Ph.D. scholars • Interdisciplinary research encouraged by the • University
Resource Solidarity for Research Work	• Many teachers have completed minor and major research projects from Govt. funding agencies • Limited budgetary provision for research activity • Negligible participation of industry in research
Research Facilities	• University campus partially wi-fi enabled • e-resources exist in library • Many Lab equipments need up-gradation for research purposes
Research Publications	• Most of the teachers have research publications and books to their credit • Some of the social sciences and commerce departments are publishing their own journals
Library for Research Support	• Library has adequate built-up area, has 2,78, 561 books and subscribes to 640 journals • Access to library provided with OPAC/INFLIBNET and Electronic resource management website.

1.3.6 Presidency University

The 'Hindoo College' established in 1817 and was transformed into Presidency College in1855. It is located in College Street, Kolkata. In recognition of rich heritage of academic excellence and for the top constituent college of Calcutta university, the legislature of West Bengal upgraded the status of a University on Presidency College on

7th July of 2010. It is also a public state University. Second campus of this University is under construction at Rajarhat.

There are 16 departments functioning under the university. They are- Bengali, English, Hindi, History, Performing Arts, Philosophy, Political Science, Sociology, Life Science, Chemistry, Economics, Geography, Geology, Mathematics, Physics and Statistics.

The University is guided by a mentor group. The group is chaired by Sugata Bose, Gardiner Professor of Harvard University and Noble Laureate and Economist Amartya Sen serves as the advisor to the chair.

According to the grading system of National Assessment and Accreditation Council Presidency University accredited with an Institutional CGPA score of 3.04 and grade 'A', on December 16, 2016.

Analysis of Research Activities and Facilities as seen by the NAAC Peer Team during Institutional Assessment & Accreditation (Cycle 3)

Date of NAAC Visit: 5-7th December, 2016

Promotion of Research	• Research Advisory Committee monitors research, facilitates research proposals to be submitted to funding agencies. • Faculty Research and Professional Development grant is provided to teachers (Rs.1-3 lakhs annually). • Facilitatory procedures in place for speedy utilization of research grants. • Faculty members/students encouraged to attend seminars/conferences; budget allocation available for hosting National/International Conferences.
Resource Solidarity for Research Work	• State, Central funding agencies support research • Several departments supported by DST-FIST CAS, UGC, DBT. • Few research projects supported by Industry.

Research Facilities	• Research facilities – equipment, instruments located in respective Departments. • Sophisticated instrumentation facility needs to be developed.
Research Publications	• Publications in national and international journals, books, edited works, monograph good. • Scopus based h-index at the institutional level is 19. • Research publications in humanities and social sciences are also impressive.
Library for Research Support	• University has Arts library including its Annex and Science Library, some departments have departmental libraries. • Library has about 3.5 lakh books, rare-books, manuscripts, monographs; e-books, journals and e-journals, E-databases subscribed. • Library automation is in place. • Digitization process ongoing.

1.4 Growth of Scientometrics

Among all the metrics study, Scientometrics is the most important one to measure or analysis of the scientific production of researchers or of an institution. The meaning of the term 'Scientometrics' is the science of measuring and analyzing science. The term 'Scientometrics' came with the introduction of the famous book wrote by Vasiliy Nalimov and Zinaida Mul'chenko in 1969, title of the book was 'Naukometriya, the Study of the Development of Science as an Information Process'. The Russian term 'Naukometriya' became known in the west as 'Scientometrics' (Rousseau, 2021).

The term Scientometrics has been defined by several authors at time to time with the growth of the concept. First Nalimov and Mul'chenko defined the term in 1971 as "the quantitative method of research on the development of science as an informational

process". In other words, the term defined as "an approach of the science of science which attempts to measure science reproducibly" by Haitun, 1980. Tague-Suticlifee (1992) defined Scientometrics in this manner that it is "the study of the quantitative aspects of science as discipline or economic activity. It is a part of sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities, including, among others, publication and so overlaps bibliometrics to some extent". There are plenty of definitions of Scientometrics present in the literature. The evidence of definitions in the literature given above and in the literature of Vann Rann, 1997, Hess, 1997, it could be summarized that Scientometrics deals with the quantitative aspects of research performance of published literature of a scientist or of on a specialized field of study or of on any institution's research output. The main concerned areas of scientometrics analysis are measurement of productivity of published literature, citation analysis, use of scientific indicators for the measurement of growth of literature, distribution of literature, authorship pattern, channels of communication etc. and mapping of science using visualization tools of scientometrics/bibliometrics analysis.

The concept of scientometrics has gained attention over the time. It's started with the introduction of *Science Citation Index* by Eugene Garfield in 1960s. The main purpose behind the invention of this tool is to ease the dissemination and retrieval of scientific literature. Then a dedicated journal named as *'Scientometrics'* started in 1978 to facilitate the scope to publish research articles carried on the development and growth of the concept. From that time the Scientometrics concept became popular as a tool of measuring scientific literature. The study of Derek J. de Solla Price by producing several books and articles in 1960s and 1970s on quantitative science studies laid the foundation of the field scientometrics. In the starting period of 21st century the major growth of the field has been made with the introduction of *h-index* (Hirsh, 2005) and *g-index* (Egghe, 2006) which are applicable to measure the quantitative aspects of published literature at individual level, of journal's productivity and at institutional level measurement. The availability of data through the databases like Google Scholar, Scopus, Web of Science, Dimensions etc. has also caused the increase of research with the indicators used in scientometrics. Mapping of science is an important indicator of scientometric analysis and there are numbers of open-source visualizing tools available to ease the work of the researchers conducting research with the indicators of metrics analysis.

Scientometric is the study of the quantitative aspects of the process of science as a communication system. It is centrally, but not only, concerned with the analysis of citations in the academic literature. In recent years it has come to play a major role in the measurement and evaluation of research performance.

The present study attempts to measure the research performance of Universities in West Bengal based on sample from the Scopus database for the period from 2001 to 2020. Further this study corresponds to an assessment of metrics analysis of the pattern of publication, authorship, growth rate of publication, citation pattern, journals coverage, subject wise contribution, countries collaboration, Organizational collaboration, visualization of different aspects related to research performance of the researchers from these Universities. Study also finds the social impact of highly cited articles by correlating citation data and altmetric data. The study also measures the factors influencing the research productivity among the Research Scholars, Assistant Professors, Associate Professors and Professors based on the primary data.

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Chapter II

Literature Review

CHAPTER - II

LITERATURE REVIEW

The review of literature traditionally highlights a historical overview of the research topic or theme of the research, with a special attention on the specific literature to the thesis topic. It serves as well as to support the adjuration behind the topic of the thesis, using instances drawn from previous works in the related research field.

This chapter describes the meaning of literature review, steps to follow during making a review of literature and the purposes it serves. The chapter also dedicates to examine the review of literature on Scientometric studies, Bibliometric studies, citation analysis, and analysis of authorship patterns etc., which are all done to measure the research performances of an institution or of a particular topic. It could also be noted that there are number of research works of same types, measuring the research performances based on the data collected from bibliographic databases. Hence, such works need to be reviewed keeping in mind the relevance of the present study.

2.1 Overview of Literature Review

2.1.1 Meaning

Literature refers to primary and secondary publications (print and electronic), which are presented in various forms, like, Books, Journal papers, Conference/Seminar papers, Encyclopedias, Theses and Dissertations, Bibliographic Databases– abstracting and full text, Websites etc. The term Review refers to a critical synthesis of the state of knowledge in a given topic or subject; also a critical analysis of information and literature on a topic or subject contained in its broader format. Thus a literature review means a survey of all that has been written on a particular topic or written against a theory or research question. It may provide the background for further work in a large scale, or it may stand on its own. An effective literature review can synthesize information from different documentary sources (both print and electronic) about key issues or topics.

A literature review is both a brief and explanation of the entire and current state of knowledge on a defined topic or theme as found in journal articles, conference

proceedings, in academic books or in other sources. All relevant documentary sources selected, analyzed, evaluated and restructured in order to arrange and prepare new bodies of knowledge.

2.1.2 Steps

Conducting and writing a report of literature review on a topic or theme one has to follow certain steps one after another, first a topic has to be chosen and define of research question on that particular topic needed; then, the scope of the review to be decided, followed the selection of databases for conducting necessary searches; after that, conduct the searches and find the literature and then finally review of the literature to be done.

2.1.3 Purposes

From the perspective of a pure research, the purpose of a literature review is to give a basis upon which researchers can make critical decisions on the directions of a research program. Except this, a literature review performed the purposes generally are –

- It provides readers easy access to research on the selected topics or subjects by selecting relevant, valid and important documents (articles, books, reviews etc.) and summarizing them into one report.
- Literature review ensures to know the work that has already been completed, which allows researcher beware about the duplication of the work.
- It mentions key findings from previous works on the particular topics.
- It gives assumptions about the scope of future research on a particular topic.
- Literature review aims to find the inconsistencies and contradictions in the literature.

With the vast amount of literature available in the field and scattered in different sources, also keeping in mind the objectives set for the present study, an attempt has been made to gather this scattered literature and analysed them under following subheadings for the understanding of the present study.

- Metric Studies Related to Research Performance on a Particular Topic/Theme
- Metric Studies Based on Bibliographic Databases
- Metric Studies Based on Institutional Research Performance

2.2 Metric Studies Related to Research Performance on a Particular Topic/Theme

With the huge amount of literature available in the field of Scientometric, Bibliometric studies based on a particular topic, this section attempts to analyse the following articles-

Scarazzati, S. and Wany, L. (2019) discussed scientific collaboration to understand more beneficial types of collaboration. This study examines the effect of different types of collaboration considering regional scientific development. The paper was based on Chinese regions and discussing the research output in the field of nanoscience according to its purpose. The results showed there were many differences present between collaboration effects across regions. Findings of the study reveal many things like scientifically weak regions may be benefitted from more concentrated collaboration and in a broader collaboration network scientifically strong regions could be benefitted from a centrally placed position. The analysis of the study also indicated that international collaboration might not be helpful for a regional collaboration, but one region's benefit largely depends on that region's local capacity. In another study by Waleed Iqbal et al. (2019), studied the publications trend in computer networking research using bibliometric indicators. This study used four important computer networking periodicals as a source of data for a span of 18 years covering 2000 to 2017. This study mainly included metadata analysis, content-based analysis and citation analysis. Analysing the results of the study significant trends and the most active authors, institutes and countries in the concerned field were identified based on the citation and publication data. The publication productivity of computer supported cooperative work (CSCW) measured by Correia, A., Paredes, H. and Fonseca, B. (2018) found CSCW research has recorded significant structural changes and significant growth rate over the last decade. This study was carried out to show the quantitative characteristics and mapping of the intellectual structure of scientific literature of CSCW research during a span of 15 years from 2001 to 2015. During this period a total of 1713 papers were retrieved and they analysed several publication productivity related activities by applying various statistical methods. Various publication productivity indicators that were highlighted in this study are top cited papers, citation patterns, most productive authors, collaboration patterns, topic and keyword wise clusters etc. The results of the study expressed that improvement was there in some areas of the field and a number of well-recognized topics were also there

which changes the citation impact. With the analysis of statistical methods, it was revealed that the field of CSCW has influenced by highly recognized scientists and highly cited papers. A few numbers of papers were there having no citation, and an average of more than 39 citations per paper indicates strong and growing nature in the field of CSCW research.

Ram, S. (2017) has discussed the contribution of India to breast cancer research using the tools and techniques of bibliometric analysis. In terms of total research output India ranks 12thand 80% of the Indian research publications in this field has been published during the period 2004-2014. Tata Memorial Hospital was recorded as the highest number of publication holder during the study period. Among all the publications about 30.35% of the works published collaboratively with 94 countries. In this study, Indian contribution in Breast Cancer research has been measured in several ways, for instance, performance by the institutions, journals, authors and their citation impact and h-index etc. The research, carried by Naheem, K. T., Nagalingam, U. and Ramesha, B. (2017) have analysed the research performance of SAARC countries in the field of Chronic Liver disease (CLD). A total of 2312 documents were obtained which were contributed by the SAARC countries together from Scopus database during 1996-2015. Study found that CLD research output has increased over the last five years of the study period. In terms of publication share among the SAARC countries India was noted as the leading country, India also placed top as the most institutional production on the concerned area of research. Study mentioned that there is a need of more collaborative work among the SAARC member countries which will help to increase both quantity and quality of the research work in Chronic Liver disease.

Singh, V.K., Uddin, A. and Pinto, D. (2015) have analysed computer science research output of top 100 institutions in India and abroad. Computer science literature indexed in Scopus multidisciplinary database was the base of the study which studied for a span of 25 years from 1989 to 2013. Several scientometric indicators have been discussed, and research output of computer science in leading Indian institutions has been compared with other leading institutions of the world. Traditional scientometric indicators, viz. total publication, citation analysis, co-authorship patterns, level of international collaborations etc. have also been reflected here. The study identified similarities and differences in computer science research output of Indian and World institutions. A study to show the cereal crops research publications of India during

1965-2010 is attempted by Tripathi, H. K., Sharma, J. and Garg, K. C. (2015) based on the literature available in Indian Science Abstracts and CAB Abstracts. The analysis of the data reveals that most of the research publications were done on rice and wheat crops. Most of the research publications were published through Indian journals with low impact factors. Study also mentioned many aspects, such as the journal names in which most of the papers were published, Institutes with highest number of publications, topics on which major research were carried out etc. Citation analysis of the papers was done using Google scholar and found that 57% of the total papers remained uncited, whereas 36.8% papers have received citations ranging from 1-10. Study concluded by commenting that this type of study will be helpful for the researchers and scientists who are interested to work on the crop sciences and the findings will give the necessary data to the policy makers in the field of agricultural sciences. In another same kind of research, by Coursaris, C. K. and Osch, W. V. (2014) analysed research productivity and citation patterns of researchers, institutions and countries in the field of social media research. This study mainly carried out based on 610 peer-reviewed papers published in journals and conference proceedings during October 2004 to December 2011. Several scientometric indicators have been introduced to measure different aspects relating to research productivity. The results of the study indicated that social media research has limited diversity and the field still very much influenced by the research of practitioners.

Tripathi, H. K. and Garg, K. C. (2014) have studied Indian crop science research output during 2008-2010 obtaining data from Scopus, CABI and Indian Science Abstracts. After the deletion of duplicate and irrelevant papers a total of 3530 papers were carried out for the study on which different scientometric techniques were applied to measure the research productivity. Study reveals many things relating to research performances, such as, most of the research papers was published on rice and wheat crops, agricultural institutions and universities under the affiliation to ICAR were most productive institutions in terms of publishing papers on crop sciences. The authorship pattern also indicates that most of the papers were published collaboratively i.e. 72% of the total research output. In another study where the literature obtained from Web of Science database describes the research productivity and collaboration pattern of solar cell research in India for a period of 20 years from 1991-2010. This study mainly focused on the collaboration pattern of the research outputs. Several indicators have been used,

such as, Co-authorship Index (CAI), Collaboration Co-efficient (CC), Domestic Collaborative Index (DCI), International Collaborative Index (ICI) etc. Study found that among all the papers, one half was contributed by domestic collaborations and the other half by international collaborations. To show the network of collaborating countries this study used Bibexcel Software and Pajek software to visualize the map of collaboration, South Korea, USA, Japan, Germany, France identified as the most collaborative country from the visualize map in the concerned area of research. The analysis of the citation pattern reveals that the percentage of uncited papers decreased from domestic work in respect to international research outputs (Dutt, B. and Nikam, K., 2014).

Bhardwaj, R. K. and Ram, S. (2013) have studied the Indian research publications in osteoporosis which is one of the main cause of fractures and disability in the aged peoples. The literature for the present study was obtained from Scopus bibliographic database during the period 1973 to 2012. Several quantitative and qualitative indicators of measuring research outputs have been applied to study the obtained data. Medical Subject Headings (MeSH) has been used to identify the key terms and then the literature on the topic were retrieved from Scopus. Study found that USA was the most productive country in osteoporosis research with 27.21% publications of global share. Indian researchers contributed only 1.02% papers of the total osteoporosis research conducted during the study period and AIIMS Delhi found as the most productive institution on the concerned topic. Study concluded by saying that funding agencies should formulate more necessary policies to help the researches and initiates more programs for the development between India and other developing countries on the concerned area. Another research, carried by Karpagam, R. et al. (2011) based on Scopus multidisciplinary database analysed the pattern of growth and publications trend of research output in the field of nanoscience and nanotechnology in India during a span of 20 years from 1990 to 2009. For this study they downloaded the publication data, a total of 22,765 bibliographical records have been found during this period which are all published by the Indian scientists and academicians. For mapping the literature on nanoscience and nanotechnology different aspects of scientometric analysis have been applied, such as average citation per paper, collaborative coefficient, degree of collaboration, doubling time, relative growth rate etc. to analyse the qualitative aspects of publications output several indexes were used, viz. *h*-index, *g*-index, and *p*-index. The study concluded that research contributions on the concerned topics are increased

gradually in the last 5 years of the study period. USA, China and Japan are found leading countries in the field of nanoscience and nanotechnology, and they suggested that India needs infrastructural advancement to upgrade the literature in the field.

Garg, K.C. et al. (2011) have analysed plant genetics and breeding research output of USA, UK, China, India and Brazil during 2005-2009. A total of 32, 574 papers were downloaded from Web of Science database and by using scientometric indicators a comparative analysis has been done with special reference to India. During this period USA produced highest number of articles followed by China. By calculation values of different impact factors UK found to be highest ranked in terms of research performance. 9 percent of the world publication contributed by India and about 41 percent among the total Indian contributions was concentrated among 23 institutions. Garg, K. C., Dutt, B. and Kumar, S. (2006) have analysed research papers published on malaria research. Data for the study were retrieved from journals indexed by Commonwealth Agricultural Bureaux International (CABI), Tropical Diseases Bulletin (TDB) and Pub Med Medline (web version) databases. The study found that malaria research publications scattered all over the countries across world but high rates of output of research papers and institutions located in the developed countries, such countries were UK, USA, Australia, China, Brazil etc. Subfield wise distribution of malaria research has been highlighted in this study. Results of the study also indicated that one third of the malaria research output has been produced by journals not indexed in SCI, mainly from developing countries. A comparative research performance in computer science between India and China based on the INSPEC abstracting database during 1993 to 2002 is done by Guan, J. and Ma, N. (2004). Total 9,632 research papers in computer science were used to measure as per the objectives of the study. The result of the study indicated that China holds a remarkable place in terms of total papers indexed in INSPEC database. Several scientometric indicators were also introduced, for instance normalized impact factor, percentage of papers in high quality journals etc. indicates high rate of progress in computer science research for China. The study concluded by connecting that, the use of proper catch-up strategy China and other less developed countries in science stream can achieve better position in newly emerging fields such as computer science, as was then at the time of the study. There are basic scientometric indicators has been used to measure the publication output of Indian organic chemistry research. For this study chemical abstract taken as a source of

literature of Indian authors. The entire period of the study has been divided into three parts, 1st part from 1971-75, 2nd part 1976-80 and the 3rd part from 1981-85, then qualitative characteristics were discussed using different scientometric and bibliometric indicators, such as impact per paper, relative quality index, number of high-quality papers, relative paper citation rate, relative journal citation rate. During 70s and 80s, it was found that the Indian performance in the field of organic chemistry research was very poor. But the lost period has performed slightly better as measured by the relative indicators (Karki, M. M. S. and Garg, K. C., 1999).

2.3 Metric Studies Based on Bibliographic Databases

There are numbers of metric-based analysis on research performance of any institution or universities which has been carried out by mentioning the name of the source database of retrieved literature in the title, and that have been treated to review those literature in this section –

Siva, N., Vivekanandhan, S. and Rajendran, P. (2019) have analysed the research publications on hepatitis C based on data downloaded from Scopus database. The study identified several parameters, for instance, year wise growth rate, authorship pattern, document type, citation analysis, impact factor of the journal productivity in the concerned field. During the study period 59926 publications have been produced in the field of hepatitis C. Maximum number of publications contributed by United States with 23.10% share of all publications. Study also measured the relative growth rate and doubling time of the publications and found relative growth rate has been decreasing from 2009 to 2018 from 0.71 to 0.10 and doubling time has been increased during the study period from 0.98 to 7.28. Study concluded by keeping in mind by the impact of worldwide death due to hepatitis C, the research activity in the field should also increase. The research, attempted by Khurshid Ahmad, Arslan Sheikh and Muhammad Rafi (2019) on library and information science research publications globally based on the literature got indexed in Web of Science database. The study was carried out for a span of fifteen years starting from 2003 to 2017 and several indicators have been used to measure the quantitative aspects of the literature data. These indicators are country wise research productivity, annual publications and received citations, highly cited LIS journals, highly cited research papers, institutions with highest production of articles, most prolific authors etc. They found USA as the top country in terms publications,

2016 noted the peak of the year in terms of total publications, whereas 2017 counted as the most productive year in terms of citations received of all documents published in that year. The Journal of Medical Library Association identified as the most highly cited journal in field and Indiana University noted as the top institution for producing highest number of articles in the field of library and information science research. Vivekanandhan, S., Rajendran, P. and Sivasamy, K. (2019) analysed Indian research publications in the field of pollution control research. The study was carried out on the basis of research publications during 2007 to 2018 and as a source of literature Scopus multidisciplinary database has been retrieved. A total of 33084 research publications downloaded and analysed by several indicators of scientometric analysis. Such indicators applied in the study were, year wise growth rate, relative growth rate, doubling time, country wise contribution, authorship pattern etc. This study gave a special attention to measure the authorship pattern and used different collaborative measures indicators; such were degree of collaboration, collaborative coefficient, collaborative index, co-authorship index. 2018 noted as the peak year of publications with 226 publications which accounted 0.68% of total outputs during the study period. A major finding of the study reveals that relative growth rate of research in the field holds a decreasing trend and doubling time holds an increasing trend from 2007 to 2018.

Velmurugan, C. (2018) has attempted to map the scholarly communications on nephrology based on research publications indexed in Science Citation Index. Study observes several indicators, such were yearly growth rate, author productivity, productive keywords, degree of collaboration, collaborative index etc. USA identified as the most number of outputs and most citations received during the study period. By the analysis of all the parameters taken for the study, they concluded that an increasing rate of nephrology research has been noted with the year goes on. Study also mentioned that this type of study can help the librarians of health science institutions to select the relevant journals for provide effective service in the field. The research productivity of the researchers and their affiliated institutions in the field of computer science in Malaysia is measured by Abrizah, A. and Wee, M. C. (2011). Web of Science database has been used as a source of literature for the present study. Total 903 research works were retrieved for the evaluation during the study period from 2000 to 2010 of which only journal articles (74.8%) and conference proceedings (25.2%) are taken as the

major document types. In this study Lotka's law of author productivity and Bradford's law of journal scattering have been applied to determine the productivity of authors and core journals of publication. The result of the study reveals that author's productivity does not agree with Lotka's law, whereas journals distribution is found quite similar to the Bradford's law. Lecture notes of computer science were responsible for most number of publications of articles by the researchers and Multimedia University is ranked first in terms of highest number of publications with 22.3%.

Kumar, S., Garg, K. C. and Dutt, B. (2009) have analysed 18,224 papers published in Indian science journals during 2006 and indicates that a large number of scientific publications of India comes from academic institutions, state agriculture universities and from medical colleges. The study was carried out to examine the scientific publications of India based on the literature retrieved from Indian Science Abstracts (ISA). Study revealed major institutions in the field of agriculture and found Punjab Agriculture University at the top in terms of research output. Forestry, animal husbandry, fisheries were identified as major disciplines in the field of agriculture. A considerable growth of Indian publications was also noted in 2006 compared to a result of a similar study of 1984. The literature published on thorium research during 1982 to 2004 based on Science Citation Index. During the study period a total of 3987 papers were retrieved for analysis with the measured techniques of scientometrics. Study reveals many things as per the objectives of the study. Average number of publications was noted as 173 per year during the study period and peak of the year was 2001 with 249 publications. USA was the top producing country with 21.11% authorships followed by India with 10.51% authorship contribution in the field. Among the published papers in thorium research, 586 accounted as collaborative papers. Among these 586 papers bilateral collaboration found 80.55%. Study also identifies the most prolific authors in the field of research; R. K. Agarwal was the top author with 39 publications. Bhabha Atomic Research Centre noted as the top institution in India as per the number of authorships with 153 authorships in thorium research. Study concluded by assuming that if the non-SCI covered journals are also included in this study the result would be different and more interesting. Overall, these types of results can help the science policy makers to develop in the concerned field. (Kademani, B. S. et al., 2006). In another study of same kind based on the Science Citation Index Expanded examined the agricultural research performance for a period of 10 years from

1993-2002. Among the sub fields of agricultural sciences, dairy and animal sciences and veterinary sciences has produced most number of publications. Most of the high producing research institutions identified as the agricultural universities or the institutes under the aegis of ICAR. In this study they used Garfield's impact factor to measure the impact of research output. Citation rate of the papers was very low and half of the papers published in the field were not cited in any international literature of agricultural sciences (Garg, K. C., Kumar, S. and Lal, K., 2006).

2.4 Metric Studies Based on Institutional Research Performance

Various metrics studies have been conducted on the institutional research performances from different angles using different metric indicators. These studies hint at the research productivity of a nation's progress in research at the higher level. These have been gathered in this section to focus on the existing knowledge in measuring the research performance of an institution. The literatures are arranged in a decreasing order of their publishing year.

Kozma, C. and Calero-Medina, C. (2019) have focused on mapping the scientific collaboration of researchers based on Africa and measured the role of South African researchers within the international collaboration based on publication output. For this study the research data were accessed from Web of Science database and visualization tool VosViewer 1.6.6 used for visualization of co-authorship maps. They have selected 10 scientific fields where most research works were carried out in Africa for the fulfillment of the purpose of the paper. At first stage cooperation network was created and visualize them on world maps, then a measurement was done to see the frequency of engagement regarding different countries. In the final stage, most prominent funding organizations and their contributions in the particular field were identified from the visualized map. Through these steps this study identified a clear picture of high level of association of South African authors in within the intercontinental and international collaboration. Hugar, J. G. (2019) has evaluated the publication productivity of University of Goa, which involves as a premier higher education institute to fulfill the educational needs of Goa. This study mainly based on data retrieved from Web of Science during 2008-2017. Publication productivity of Goa University has been analysed with various scientometric measurement indicators and results found increasing growth rate of publications. Analysis of the study identified that among the

faculty members of the university used current science as the most preferred journal. Study also revealed that the relative growth rate was decreasing of publication output in this university and they concluded by suggesting that to increase the publication productivity University of Goa needed more international funding in research and development activities. In the same year another study published by Payumo, J. G. et al. (2019) described United States University research engagement with African Universities in different subject fields including education, environment, and global health. The analysis was carried out with metrics-based indicators and the results showed that research engagement in these subjects have increased in the last 15 years. This study aims to examine the research output, collaboration pattern, research trend and impact of Michigan State University's engagement on African universities' research activities. In this regard, various scientometric and social networking analysis has been carried out. Statistical techniques were used to measure the characteristics and then visualization mapping tools, viz. VosViewer was used to show the mapping of research outputs. By the analysis of the data, it was found that strong quantitative evidence of scholarly success was present there especially in science, technology and engineering. The co-authorship data indicates that there was a strong collaboration rate between MSU and non-African countries on the context of African focused research but a trend of growing partner institution from African countries was also identified. This study also discusses the research impact based on gender and international perspective and there were clear evidences that the increasing participation of women was there to covey the socio-economic challenges of African countries by participating in global research.

Pradhan, B. and Ramesh, D. B. (2018) have attempted to measure the scientific impact of six IITs of India based on the bibliographic data downloaded from Scopus bibliographic database during the period from 2006-2015. A total of 72940 research papers were retrieved during the study period and analysed using different bibliometric and scientometric indicators. These indicators included, total number of papers, total number of citations, citations per paper, types of documents, citation analysis with mentioning highly cited papers, preferred journals for publishing etc. From this study it is observed that research outputs of six IITs has increased 3027 articles in ten years from 2006 to 2015, but this was not in a consistent way. The pattern of citation found that the scientific impact of these IITs is strongly associated with mainstream science.

In another study Shashnov, S. and Kotsemir, M. (2018) analysed current trends, thematic structures of research articles published by BRICKS countries; the relative influence of the partners has also been discussed. Study is based on Scopus database and samples are taken for a time span of fifteen years from 2001 to 2015. They used wide range of indicators for examining the research activities of BRICKS nations, these indicators include citation indicators, indices of structural difference, scientific collaboration indicators. For the comprehensive analysis of the publication activity, this study applied various indexes, such indexes are field-weighted impact, share of publication in Q1 journals, relative comparative advantage (RCA) index, Cosine similarity index, Gatev index of structural difference, index of differences, Salton index of Collaboration closeness, Index of relative influence of scientific partners (RISP index). With the results found after applying such indexes, key points are identified in changing both the role of BRICKS countries in perspective of world research outputs as well as the role within the BRICKS countries.

The qualitative and quantitative characteristics of research output of Indian Institutions for a period of six years from 2011-2016 showed by Rajan, K. S., Swaminathan, S. and Vaidhyasubramaniam, S. (2018). In their study, a qualitative indicator has been used, i.e. SciVal, a product by Elsevier to measure the top ten percentile of the research output. This study also found that out of the 15 subjects, 7 contribute to more than 65% of the contribution. They have attempted a subject wise analysis of Indian institutions and this analysis includes major subjects, such as medicine, engineering, computer science, physics and astronomy, chemistry and material science. The subject wise field weight citation index (FWCI) of these Indian institutions was also shown. Two quality-based indicators have been applied in this study, one was top 10 percentile calculation and the other was calculation of field weight citation index. These two indicators revealed that only few numbers of institutions in India were engaged in scholarly research in terms of impactful publications. Study also identified that materials science, physics and astronomy found leading subjects in research output compared to global average. The research, where publications of National Environmental Engineering Research Institute, Nagpur has been analysed for a span of five years from 2012-2016 and the study identified A total of 399 research papers have been retrieved and analysed with several scientometric indicators. This study aims to analyze the year wise productivity in terms of total papers published, authorship pattern and to identify the

top ten most productive authors, to calculate the degree of collaboration, to show the area wise distribution of publications. Study also aims to identify the collaboration trend of the institute and preferred documents type of publications. The study concluded by suggesting that such type of studies on research productivity should be carried out periodically which can be very helpful for the decision makers to take necessary initiatives on the requirements for overall growth and development of a research institute or university (Patel, V. and Thakur, N. S., 2018).

Nagarkar, S. and Kengar, M. (2017) have analysed the research contributions of the faculty members of Savitribai Phule Pune university for the period 1990-2014. For this study bibliographic and citation data were downloaded from the Scopus database. A total of 1629 publications were found for the study period of twenty-five years which all together receives 22618 citations. The study found that most of the faculty members of the SP Pune University are working in the core areas of physics and interdisciplinary subjects like chemistry, instrumentation science etc. Year-wise analysis states that the research productivity increased over the period. Journal of Applied Physics is the most preferred journal among the faculty members as a channel of publication of papers, 72 papers have published during the period in this journal. Study also found that the international collaboration of the university faculty members is with the scientists from USA, UK, Germany and Japan, whereas the physicist's national collaboration mostly noted with Bhabha Atomic research Centre. Patel, V. (2017) has analysed the growth and development of the research publications of Institute of Occupational Medicine and Environmental Health. Standard forms of methodologies were applied to evaluate different parameters like year wise growth rate of publications, highly prolific authors, internationally collaborated papers, top productive authors etc. During the study period 118 papers were published by the institute and among which most of the papers were found as journal articles followed by letters. Study also mentions the top favoured area of research along with national and international collaborated institutions and countries. The study, carried by Pradhan, B. and Ramesh, D. B. (2017) identified the publication trends and other parameters of research productivity of Indian Institute of Technology Madras and Bombay based on the data downloaded from Scopus database for a span of 10 years during 2006 to 2015. During this time 5378 papers were published by these two IITs and these papers are mainly on the field of engineering research publications. Study found that most of the authors from these two IITs published their papers in

foreign journals from USA, UK and Germany. Percentage share of uncited papers during the study period was 19.66% for IIT Madras and 26.54% for IIT Bombay in engineering sciences and authors of IIT Bombay were found to have more highly cited papers than IIT Madras.

The research output of Indian Institute of Kharagpur during 2010-2015 as seen through Scopus database has been attempted to analyze the growth of publications, year wise distribution, authorship pattern, geographical distribution, types of documents, preferred journal for publishing. A total of 18927 publications have been downloaded and analysed according to its purposes. Study found publications followed the exponential growth pattern, most of the articles written as journal articles. Study concluded by suggesting that such type of study can be carried out and the data can be reflected along with institutional repositories of the institution (Bid, S., 2016). In the same year another study published on the research output of Netaji Subhas Institute of Technology covering the span of 1996 to 2015. The study analyses the literature with scientometrics indicators and based of the literature was Scopus. The main purpose of the study was to identify the main subject areas of research and measure the growth of publications with received citations by the publications of this institute. The study noted a slow rate of growth in publications during first two block years during 1996-2001 and 2001-2006, but it increased significantly between last two block years of 2006-2011 and 2011-2015. The growth of publications has increased from 300 publications in between 2001-2006 to 500 publications in between 2011-2015. Electronics and communication engineering, computer engineering with information technology, instrumentation and control engineering and mathematics are the major four subject areas contributed 75% of the total publications during the study period (Choudhary and Choudhary, 2016).

Nagarajan, M. (2016) studied the research performance of Universities in Tamil Nadu. This study tried to present a scientometric analysis of the publications mainly in science streams. General quantitative scientometric indicators were mainly used for this study and these were number of publications, authorship pattern, country wise distribution of the papers, subject wise distribution of the papers etc. Study found more than 50 percent of the papers were collaborative papers. This study also identified that from 1991 to 2015, the research productivity increased in considerable numbers, but after that a decline in productivity was also seen from the calculation of doubling time

research productivity of the universities in Tamil Nadu which generally takes 7.7-8 years to double. Surulinathi, M. (2016) has ranked the universities in Tamil Nadu depending on the publications, citations and indexes. This study also measured the research performance of universities based on data retrieved from Web of Science database by measuring several qualitative and quantitative indicators. By the use of the quantitative analysis total contributions found 39336 publications, among which altogether received 373842 citations including 274327 citing articles. Various qualitative indicators also used to analysis of the data, indicators such as h-index, i10 index were applied for this purpose. Mukherjee, B. (2016) has also attempted to rank the Indian Universities in respect to the research and professional performances. The main purpose of the study was to understand the feasibility of the parameter, research and professional practice in National Institutional Ranking Framework by measuring the research performance of five central university of India. Data were retrieved from three bibliographic databases, namely, Web of science, Scopus and Indian Citation Index for measuring several aspects. The study mentioned that only 80% articles of an institution's covered by any international database and quantity of research output of the institution could not be treated as an exhaustive measureable indicator of research performance. The study also indicated that these international databases mostly covered fields of sciences and applied sciences whereas arts and humanities, social sciences are hugely ignored. So, any one of the databases could not be considerable as a measuring parameter for one particular institution's overall performance. Though, the study identified some parameters, such were most of the journals of the research output preferred by these universities having impact factor range from 1-3 and JNU authors received least number of citations per article but in NIRF ranking JNU was in the top. The study concluded from the analysis of data that in NIRF ranking citations received by any institution do not have much role to play.

Parameswaran, R. (2015) has studied the contribution and growth of research publications performed by the authors of Anna University. Different scientometric indicators and HistCite software was used to analysis the research output for a period of 34 years counting from 1980 to 2013. During the study period total 7112 records retrieved from bibliographic database Web of Science. Study examined the year wise distribution of publications, authorship patterns, journal of communication, and collaboration rates of authors of Anna University. Annual average research output

identified 67 records, *Journal of Crystal Growth* was found the most preferred journal for publishing articles by the researchers of this university and 275 articles were published collaboratively with University of Madras. Singh, V. K. (2015) has studied research output of IIT, Mandi and found that most of the publications were collaborated with foreign countries, United States recorded highest with 37 publications followed by Israel with 13 publications. A scientometric study was undertaken on the research trends of IIT, Mandi during 2010-2014, using Web of Science (WOS) indexed publications only. A total of 152 publications were identified for the period of five years. Different performance indicators have been analysed like, h-index, g-index and 2013 was found best performed year in the period. Physics and Mathematics were noted dominant research fields in IIT, Mandi. Hasan, N. and Singh, M. (2015) have evaluated five top IITs in India on the basis of publications indexed in Web of Science for the period of five years from 2009-2013. Total 215019 articles retrieved which are 2.72% of the global records during the study period. They tried to compare different aspects relating to research performance, such as, annual output of India vs. global research articles, degree of collaboration among IITs in India and with global countries or institutions, also the comparison of citation data of five IITs. 2013 identified as the most productive year with 49,406 publications with 22.98% of total publications. IIT Khragpur, IIT Madras, IIT Bombay and IIT Kanpur were recorded as highest productive IITs during the period. IIT Kanpur noted as most collaboration rate of 4.05% with other four IITs in the country and IIT Bombay receives highest average citations of 6.7 per paper. Internationally Indian authors collaborated with 177 countries of the world and USA ranked top in the list of collaborations. Other performance indicator of research performance, in the form of calculation of h-index, it was noted that IIT Bombay and IIT Madras secured h-index of 45 each followed by IIT Khragpur with h-index of 42.

Hadimani, N., Mulla, K. R. and Kumar, N. S. (2015) have evaluated qualitative and quantitative aspects of the research publications of Indian Institute of Science Education and Research (IISER), Thiruvananthapuram. The study was carried out for a period of six years from 2008-2013 and during this study period total 157 research publications were analysed and those publications were retrieved from 76 journals. From the quantitative aspects study examined year wise, journal wise and document wise distribution of research publications, whereas research productivity of faculty and

researchers are analysed to identify the qualitative characteristics of the institution. Focus of this study was to measure the growth and impact of research publications in the fields of science and technology. In this short period of time this study enlightens so many aspects through bibliometric analysis of the research publications of IISER-TVM and it ensures to make an in-depth analysis of research productivity of IISER. Vanathi, B., Saravanan, T. and Nagarajan, M. (2015) have examined the publication productivity in chemistry research among the faculty members of selected state universities in Tamil Nadu with the help of methodologies applied of scientometric analysis. The study was carried out obtaining data from Web of Science database during 1989 to 2014. Total 4033 papers were published during these 26 years, among which 2014 was the peak of the year in terms of publication with 417 papers. With 134 papers, Dr. R. Ranganathan was the most productive author and most frequently published document type was journal article publication. By the analysis of the research output of these universities, for the growth and development of research seen during the period the study acknowledges to the agencies like CSIR, UGC, etc. The prime goals of these agencies were to promote the R&D activities in academic sectors, to help the government, educators or to the policy makers to upgrade the quality of research activity in higher education. In a study on measuring the research trends Banaras Hindu University based on Indian Citation Index (ICI) is carried by Choudhary and Choudhary (2016). The study was carried out for a span of 10 years from 2004 to 2013. The current study investigated the scholarly research publication productivity and regarding this total 1041 papers have been downloaded from ICI database during the study period. The study focuses to measure the publication productivity with several scientometric parameters, these includes year wise distribution of publication output which helps to highlight the growth of literature, index of co-authorship, collaboration rate etc. Analysing the data, the result found that research productivity of this university was increasing at an average rate of 104.1 publications per year and most of the researchers of this university contributed by collaboration. The study concluded that the actual publication productivity was much higher than it found in this study, because this study included only ICI indexed journal, apart from ICI indexed journal researchers of BHU published their work in different peer-reviewed and referred journals also. If all these publications were taken for the study, the findings could have been different.

Balasubramani, R. and Parameswaran, R. (2014) have analysed 6943 research publications published by Banaras Hindu University (BHU) during 2000-2011 and a gradual growth of publications were identified during the study period. Annually the scientists of BHU published 578 research papers and those are collaborative. "Current Science" is the most preferred journal for publishing articles by the BHU authors. Physics, Chemistry, Mathematics and Engineering contributed most articles (43% approx.) of total BHU publications during the period. It is also found from this study that the scientists of BHU collaborated in huge numbers with foreign authors. Silaghi-Dumitrescu, R. and Sabau, A. (2014) highlighted the relative research performance of a university in Romania by highlighting strong and weak areas with respect to leading international universities. Both the qualitative and quantitative parameters have been considered for analyzing the relative research performances, such are as total publications, subject wise analysis, types of publications, citation analysis, h-index etc. The study identified internationally, physics, chemistry, mathematics, computer science, geology, religion etc. are as the leading active areas of research and nationally, subjects such as psychology, history environmental sciences have the most interested research areas. The study concluded by mentioning that increasing rate of national GDP and growth of research budget worked as a decisive factor for the exponential growth of publications in Romania. Bornamann, L. et al. (2014) analysed the institutional performances based on the publication and citation data. The main purpose of the study was to reveal the centres of excellence in different subject fields. The study used Scopus as a source of data and identifies excellence institutions by specific fields from where highly cited papers have been published on that specific field. Several statistical procedures have been applied to measure the performance of individual institution, multi-level logistic regression one of them used to properly estimate the standard errors. A visualization map of highly produced institutions worldwide was also shown in this study. At the end of this study, they described about ways of more several developments and directions in the concerned areas.

Gupta, B. M. (2013) has attempted to draw an overall scenario of research activity of Bangladesh in science and technology. Overall science and technology of Bangladesh was mainly organised under two sectors, first sector represented by the institutions getting direct fund from government and was specially created for research and development, other sector includes general universities, technical universities of

agriculture and engineering universities. This study based on these two sectors of universities where the R&D institutions give attention to scientific research and the universities carry out basic and applied research. A total of 11,688 papers were studied for a 10-year period during 2001-2010. Several scientometric indicators were applied for measuring the research output. By the analysis of the study, it was found that Bangladesh has produced only 39 research papers which have received over 100 citations, among these 39 papers, 37 were internationally collaborative papers. The study concluded that the research climate of Bangladesh needs to be improved, thus initiatives can be taken by increasing the funding for research activity and can introduced much more manpower in the field. Sooryamoorthy, R. (2013) has measured the characteristics of research publications of South Africa in natural sciences based on the sample gathered from Web of Science during 1975 to 2005. Among the African continent South Africa has done a remarkable job in the research publications in the field of Science disciplines. In this study several scientometric measures have been applied to show the qualitative and quantitative characteristics of the publications during the study period. In this study, characteristics of natural science publications has been highlighted from different perspectives, such as trends of the research, pattern of collaboration of the research etc. The study found that the authors were mostly based on universities of the country and the rate of international collaboration has also increased over the period. In the same year another study published on examining the trends of research performance of Malyasian universities. New scientometric indices have been introduced in this study. Study aimed to find the reason behind the countries or regions having fewer publications and receives less citation. Scientometric measurement metrics, viz. *h*-index along with other indicators has been applied in the field of Engineering. They have examined the functional correlation, value of prediction and its relationship with countries' criteria. The results of the study reported that the indicator applied in the study has potential to work alone and to measure the performance. In this study two size independent institutional indexes were applied to check its validity. Study also indicated that these indexes can be used for better decision-making purposes (Tahira, M., Alias, R. A., and Bakri, A., 2013). A study on the research contribution of All India Institute of Medical Sciences (AIIMS) has been attempted by Zhaid Asharf Wani, Omar Hameed and Asif Iqbal. (2013). The Study carried out several perspectives relating to measuring research productivity, these were decadal growth rate of publication, subject wise distribution, national and international collaboration, citation

impact of the publication etc. From the findings of the study, it was observed that medicine among the subjects contribute 64.52% research output, the most cited subject areas were biochemistry, genetics and molecular biology.

Gupta, B. M. (2012) has analysed the research performance of Pakistan especially in Science and Technology on different parameters, such are growth of research and its share in the world's research contribution, collaboration rate in national and international level, geographical distribution of research publications, communication pattern of research in core local and foreign journal. The study was carried out for a period of 10 years starting from 2001 to 2010 and a total of 34,195 research papers were retrieved from Scopus multidisciplinary database and most of these papers covers the core subjects in science & technology, like health sciences, physical sciences, life sciences and engineering sciences. Study concluded that improvement should be needed in Pakistan's research output and they should try to improve its quality too by taking few initiatives, these can be as by increasing budgets in research and developmental activities, by recruiting more qualified faculties, by performing in much more international collaboration or by modernization of R&D infrastructures in the higher level of education. Mohammad, A., Fakhree, A. and Jouyban, A. (2011) have compared six Iranian medical universities with each other based on the research publications. Data were accessed from Scopus bibliographic database. Before this study, many scientometrics studies were carried out on Iranian scientific performance, but this was the first attempt on medical universities. These six universities were compared by different scientometric analysis techniques; quantitative analysis includes number of articles published per year, total and average citations received per year, citations received per year per article and qualitative analysis included calculation of h-index, identifying top ten authors in terms of publications, received citations, identifying top ten journals. By measuring different parameters of research outcomes the study represents the medical universities on the basis of their research performance rank of order and Tehran University of Medical Sciences found top ranked among all Iranian Medical universities. Later in this study, Tehran University of Medical Sciences as the top ranked Iranian medical university was compared with other top medical universities around the world. The study concluded by mentioning that like developed countries (USA, UK, Germany etc.), Iran does not have much more research budget for holding considerable place in terms of scientific outcomes, and they suggest for the

growth of research activities in Iran. Opportunities should be provided to the Iranian authors to conduct joint research programs with other developed countries. Repanovici, A. (2011) has measured the impact and the visibility of scientific research production of Transilvania University of Brasov using different scientometric methods. This study mainly focused to determine the international value of a university in terms of research production and statistically evaluate individual scientist's or researcher's scientific research outcomes. In this study they defined the scientific productivity of a researcher and highlighted the main indicators of calculating scientific productivity. The freely available database, Google Scholar has been used for this study, where the number of citations of each paper indicates quality of that scientific paper. Google Scholar mainly indexes academic publications from open access repositories, commercial sources and identifies the citations which are used as reference. As an analysis tool, the free Publish or Perish software has been used for evaluating the research performance of the faculty of Transilvania University. Total 2008 research performances consisting research papers, books and research contracts of 60 more productive professors have been analysed using Perish and scientometric indicators, these indicators include, such as *h*-index, *g*-index, HC-index and HI norm. This study also used some correlation tool and discussed about the importance of open access repositories and open access tools for the growth of impact of scientific research. The study concluded by recommending that every institution should have an open access central national repository which may be helpful for visualizing the researcher's or faculty's research work.

A study on the research published by scientists of CSIR- Central Electro chemical Research Institute during the period from 2000 to 2009 published by Jeyshankar, R., Ramesh Babu, B. and Rajendran, P. (2011). They have analysed bibliographical characteristics of 1282 research papers contributed during the period. From the analysis the study found that the peak year of publishing articles was 2009 and collaborative research was highest in the year 2005 with 0.98 collaboration rate. The study also highlighted other aspects of measuring publishing productivity, such as authorship and co-authorship pattern calculated by Co-Authorship Index (CAI), highly prolific authors and preferred journals of publications by the scientist of the institute. Sahu, A. K., Goswami, N. G. and Choudhary, B. K. (2011) have focused to analyse the citation patterns of the research publications carried out by national metallurgical laboratory. The study was based on science citation index during the period 2000 to 2010. Study

revealed many indicators relating to research productivity, major ones of the findings were peak year of publication and it was noted 2010 with 120 papers, 2006 counted as the highest received year of citations with 738 citations from 88 papers out of 107 papers published in the year. Average number of publications per year was 88.1 and average citations received per document was 5.02 during the study period. Most of the publications written by the authors collaboratively, and the works preferred to publish in the international journals rather national journals. Material science, metallurgical engineering and nanoscience & nanotechnology were the areas where most number of citations was received during the period the period and *h*-index was 25 for the publications of this institution.

A scientometric analysis of research performance in the field of analytical chemistry based on the academic publications of National University of Italy have been attempted by Annibaldi, A., Truzzi, C. and Illuminati, S. (2010). The study was carried out using SciFinder bibliographic search engine and data were collected from two databases, CAplus (period covered from 1907-2009) and MEDLINE (from 1950-2009), then total collections are scrutinized by excluding duplicates homonyms, conference proceedings, patents, local publications of minor relevance and duplicate files. Professor's publication in analytical chemistry of eighty Italian University was analysed then a comparison was carried out between senior and junior professors. Various quantitative and qualitative parameters of scientometric analysis have been used to analyse the research output of these universities. This study also mentions about the best suitable statistical techniques to be used for a particular area of research publications. Williams, R. (2010) has measured the relative research performance of Australian institutions. The study has been done based on two databases mainly, Thomson Reuters ISI and Scopus. The study found that there has been some convergence in terms of research outputs and the newer universities catching up the traditional universities on this regard of research publications. In this study, Australian universities has been grouped first into several categories, then research publications of those universities compared by different indicators, some of these were annual rate of growth of research publications defined by quartile calculation, total publications, publication in the reputed journals, analysis of citations etc.

Bala, A. and Gupta, B. M. (2009) in another research, showed the publication pattern of Government Medical College and Hospital, Chandigarh as reflected in Scopus for a

period of 16 years from 1992-2007. During the study period total 754 publications retrieved for analysis. Study aims several parameters for measuring research activities; such are growth and impact of research output, subject wise impact of the research output, collaboration rate, citation pattern etc. By comparing the different parameters of research output with other top medical colleges of the country they concluded that quality of research in Government Medical College & Hospital, Chandigarh needs to be improved and that could be possible by improving research environment, by participating in more international collaborative activities, by upgrading the infrastructural support, recruiting qualified faculty members and also there is need of strengthened the existing library and information services with the provision of access to electronic resources. Kumbar, M., Gupta, B. M. and Dhawan, S. M. (2008) have described the contribution and impact of research output of scientists of University of Mysore in science and technology for the period of eleven years from 1996-2006. A total of 1518 research papers were downloaded from Scopus database and for citation analysis three years citations window has been used for measuring average citations per paper from 1996-2003. Study highlights strong and weak areas of research output, growth rate of publications over period, average citations received per paper, collaboration rates etc. They found an average growth rate of research publications of 23% per annum mainly in science and technology. This study also found growth in receiving average citations per paper from 1.53 in 1996 to 2.62 in 2003. International collaboration rate noted comparatively low with just 14% share of total share during the study period, largest share noted with USA (51%) followed by Germany (23%). They conclude by examining that publication frequency from large number of authors is still very low and the number of highly cited papers is also not very significant. Sevukan, R. and Sharma, J. (2008) have analysed the research publications in the field of biotechnology produced by central universities in India. Two databases have been used to retrieve literature, namely, PubMed and Web of Science during the period 1997 to 2006. Bibliometric indicators have been applied to analyse the research data. Major indicators include collaborative coefficient, application of Lotka's law, Bradford's law. Growth of literature, year wise publication distribution, university wise performance, authorship pattern, identification of core journals, identification of most prolific authors, journals distributed according to the Bradford's zones. They found that the result of the study does validate the applicability of Lotka's law but it does not fit to the Bradford's law of journal scattering.

The research publication based on journal publications of Nuclear Science Centre and the Accelerator Group at the Tata Institute of Fundamental Research (TIFR) is carried out. The data was collected from annual reports of these institutions and analysed by the metrics indicators. Science Citation Index was used to measure the impact of the papers. General indicators of scientometric analysis have been used; these were year wise output, publication in local and foreign journals, number of papers in SCI indexed and non-SCI indexed journal, category wise distribution of the research papers etc. To measure the quality of the papers normalized impact factor was used. This study gave a clear idea about the growth and impact of the research publications carried out in these two institutions (Jeevan, V. K. J. and Sen, B. K., 2007). The work attempted by Gupta, B. M. and Dhawan, S. M. (2003) showed the need and importance of collaboration based scientific research. For this study India's collaboration with China in science and technology has been discussed from several perspectives of scientometric analysis. Particularly nature of co-authored papers and its strong and weak areas are highlighted through this study. The Science Citation Index has been used for a period of 6 years from 1994 to 1999 as a source of data for the study. Articles have been categorized by the country of authors, identification based on the affiliation field, and then co-authorship and international collaboration of the papers identified. This study concluded that for the healthy development of India-China research collaboration in science and technology, these countries should establish smooth exchange channels of information and new institutional mechanisms for cooperation of scientists and students research activities at the doctoral and higher level of education. In another study, where the research output of Indian Institute of Technology, Kharagpur has been measured using several parameters by analysing 1172 research papers downloaded from national and international journals during a period of three years from 1994-95to 1996-97. These articles are separated in three categories, viz. those in journals covered by SCI, those having impact factor but not covered in SCI and those not having information about impact factor. Other qualitative indicators also applied in this scientometric study, such as proportion of high-quality papers, normalized impact of paper, calculation of Publication Effectiveness Index (PEI) etc. The study concluded by the evidence of research publications in different national and international journals that the institute was very active in the areas of technology during the study period (Jeevan, V. K. J. and Gupta, B. M., 2002).

2.5 Inferences:

From the foregoing literature review, i.e. divided under three headings, such are scientometric studies based on research performance by a topic / theme, metric studies based on bibliometric databases and metric studies based on institutional research performances, the following inferences could be drawn –

- The first section of the literature review deals with the literature that are mainly carried out to measure the performance based on a particular topic or on a specific theme. Though it is different from the institutional performance but the indicators like- year wise distribution, citation pattern, productive authors, collaborative pattern, preferred channels of communication and so on that are used in these studies could easily fitted any kind of scientometric studies dealing with the measurement the research productivity.
- The second part of the literature review deals with those studies which are mentioned the source of the literature clearly in the title. Most of these studies are done by the literature available in either Scopus or in Web of Science database. There are other databases also to do such studies, like PubMed, Google Scholar, Dimension and so on. This allows the researcher to choose a database for the literature for the proposed study on measuring the research performance of Universities of West Bengal.
- The third section of the literature review concentrated on the studies, where institutional research performance is being the main concern. There are numbers of work already done on Indian institutions and institutions from abroad. The analysis of these studies with the applications of statistical technics and tools facilitates the researcher to go further to measure the research performance of the institutions which are not attempted before.
- A large amount of data, extracted from the bibliographical databases could easily measurable and presentable with the available software packages such as MS Excel, SPSS, Histcite, Biblioshiny, VOSviewer, CiteNetExplorer, CiteSpace, Bibexcel and so on. In this study some of these tools are key to analyse and visualize the data.

From the literature discussed above it has been clearly manifested that despite so many studies on institutions of other states and abroad in which State Universities, Central

Universities, IIT's, Research Institutions etc. are focused but this type of studies not attempted yet on top Universities of West Bengal, though there are in the state some top universities in the country contributing higher number of publications. Except the research performance these studies have not attempted on measuring the social impact of the highly cited papers. To fulfil this need, the researcher has been chosen the proposed research work on the title of *'Research Performance of Universities in West Bengal: A Comprehensive Metric Analysis'* with the simple scientometric and bibliometric indicators to highlight the individual institution research performance as well as the overall scenario based on the literature available for a span of twenty years in the Scopus database. This study also looks to fill the gap of measuring the influential factors of enhancing research productivity among the scholars and faculties of the universities, which has not been attempted in the studies already done of this type. The study highlights the social impact of the highly cited papers published from these universities using Altmetrics Attention Score as well.

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Chapter III

Research Design

CHAPTER - III

RESEARCH DESIGN

3.1 Introduction

Metric studies are one of those popular methods applied for measure the research productivity of research scholars, faculty members of a university or institution. The present study aims to measure the publication productivity of research scholars and faculty members of six universities of West Bengal as seen through bibliographic database Scopus. The study also highlights the factors responsible for enhancing the productivity based on the primary data collected through an online survey direct from the scholars and faculty members of these universities. This chapter discusses the statement of the problem, research questions, objectives of the study, scope and limitations, need of the study, description of methodologies applied for both primary and secondary data collection and analysis. Chapter also describes about the statistical and visualization tools used for the analysis of the publications pattern and in the determination of scales of research productivity.

3.2 Statement of the problem

Many kinds of sources (journal articles, conference proceedings, reviews etc.) have revealed the publications research productivity of Universities in West Bengal. Due to scattering of publications from these University's researchers haven't been visible to the policy makers of higher education. In order to overcome the problems stated above, the present title *'Research Performance of Universities in West Bengal: A Comprehensive Metric Study'* attempts to convert the publications into an organised structure. The bibliographic database of Elsevier's, i.e., *Scopus,* widely covers information relating to the publication details of a particular institution with details, such as, titles, authors, authorship pattern, citation pattern, communication channels, collaborations pattern, domain wise performance and so on. With respect to the above-mentioned problem, this research attempts to analyze the research outputs of Universities in West Bengal. It aims to evaluate the research activity of these University's researchers and faculty members from different disciplines. With above,

this study also finds the major influencing factors responsible for the growth of research.

The problem stated above along with some necessary and relevant research questions to resolve the course of investigation.

The research questions to this direction may be as follows:

RQ1: What is the Pattern of Growth of Publications of Universities in West Bengal?

RQ2: What is the Pattern of Research Performance of Universities in West Bengal?

RQ3: Which are the Major Channels Preferred for Communication?

RQ4: What is the Pattern of Citation and Collaboration?

RQ5: What are the Factors Influencing the Research Productivity?

RQ6: What is the Social Impact of the Highly Cited Articles?

3.3 Objectives of the study

The study has been designed with the following objectives:

i. To explore the research performance, trends, and status of research outputs of Universities of West Bengal published during 2001-2020;
ii. To examine the rate of growth of publications and examine the expected future growth of research output of universities in West Bengal;
iii. To determine the authorship pattern and the nature of collaboration and identify the most prolific authors;
iv. To identify core communication channels preferred for publishing research papers by these Universities;
v. To examine the citation pattern, viz., cited, non-cited, highly cited publications etc.;
vi. To map the research proliferation among the subject categories/disciplines in the Universities of West Bengal;
vii. To identify the collaborative countries and institutions;
viii. To identify the individual and institutional factors influencing the research productivity;

ix. To propose a model of influential factors regarding the growth of publication among Research Scholars and Faculty Members;
x. To identify the publication of universities being active or not in social platforms;
xi. To identify the social platforms where the top cited articles active most.

3.4 Scope and limitations

The following are the limitations to the study:

i. This study is confined to the *Scopus* database only.
ii. Publications data published from 2001 to 2020 only taken up for the study.
iii. This study is based in the area of Sciences (excluding engineering, computer science and chemical science), Social Science and Arts and Humanities.

3.5 Need for the study

The aim of the present investigation is to analyse the research performance of the Universities in West Bengal measured by simple indicators of metric analysis during the period 2001 to 2020. The study highlights the relation between altmetrics attention score and citation to measure the social impact of the highly cited articles. The study also presents a model regarding the influencing factors for the growth of publications at different levels, like Research Scholars, Assistant Professors, Associate Professors and Professors. The results and analysis of the study could be useful for making decisions at institutional level for the betterment of the research growth by taking initiatives with the necessary changes like building infrastructures for research support, allowing more time for research, motivating at individual level and so on.

3.6 Methodology

This section describes the methodologies applied starting from the selection of the universities to description of publication patterns using the indicators of bibliometric and scientometric indication. Adding to this, methodologies for other two parts of the study that is determination of influencing factors and social impact of highly cited papers are also described.

3.6.1 Selection of Universities:

Top ranked Universities from West Bengal are selected for this study; this ranking is based on the NAAC assessment. The National Assessment and Accreditation Council (NAAC) is an organisation that assesses and accredits higher education Institutions in India. According to NAAC grading Six 'A' graded Universities of West Bengal are taken for this study. Primary and secondary data have been collected from the same six selected universities (the determination of sample size of primary and secondary data has been discussed in a following sections). These universities are as below –

Table 3.1: List of Universities considered for the study with their NAAC Grade

Sl. No.	University	NAAC CGPA	Grade	EC Date (valid 7years from EC date)
1	Jadavpur University	3.68	A	24-09-2014
2	University of Calcutta	3.20	A	23-01-2017
3	University of Kalyani	3.12	A	16-12-2016
4	University of Burdwan	3.11	A	05-11-2016
5	University of North Bengal	3.05	A	02-12-2016
6	Presidency University	3.04	A	16-12-2016

Source: http://218.248.45.211/naac_EC/NAAC_allcycles_accrlist.aspx

The present study consists both primary and secondary data. Primary data were collected from the scholars and faculties of these six universities to meet the objectives viii to ix and secondary data has been used to meet the objectives i to vii & x-xi.

3.6.2 Secondary data selection and measuring procedures

- **Data Source:** For this study the literature is taken from Scopus multidisciplinary database, which is world's largest indexing and citation database of peer-reviewed research literature.

- **Data Collection**: There are different types of sources supplying to the research output of University of West Bengal's research by overall research scholars and faculty members. For this research work the researcher has collected the secondary data from online database. These data were collected from bibliographic database Elsevier's Scopus. Search string used by the researcher during data collection was as field: "name of the university", field: "address", field: "Time Period", for instance, name of the university: "University of

Calcutta", address: "Kolkata", Time Period: "2001 – 2020". A total of 30934 records were downloaded as a form of .txt and .csv comprising of six universities taken for the study.

Then these data were analysed by the aid of Research Indicators (RI) and mapping by visualization and network analysis tool to highlight the research performance of universities taken for the study as per objectives.

- **Data analysis:** With Research Indicators mentioned above statistical tools such as frequency distribution and percentage analysis, Scientometric techniques, Bibliometric indicators such as Relative Growth Rate, Doubling Time, Exponential Growth Rate, Trend Analysis, Authorship Pattern, Citation Analysis, Prolific Authors, Channels of Communication, Document Types, Domain wise distribution, Collaboration Pattern etc. will be used for the study. Visualization tool is also used for analysing the data, for instance countries collaboration network map has been presented.

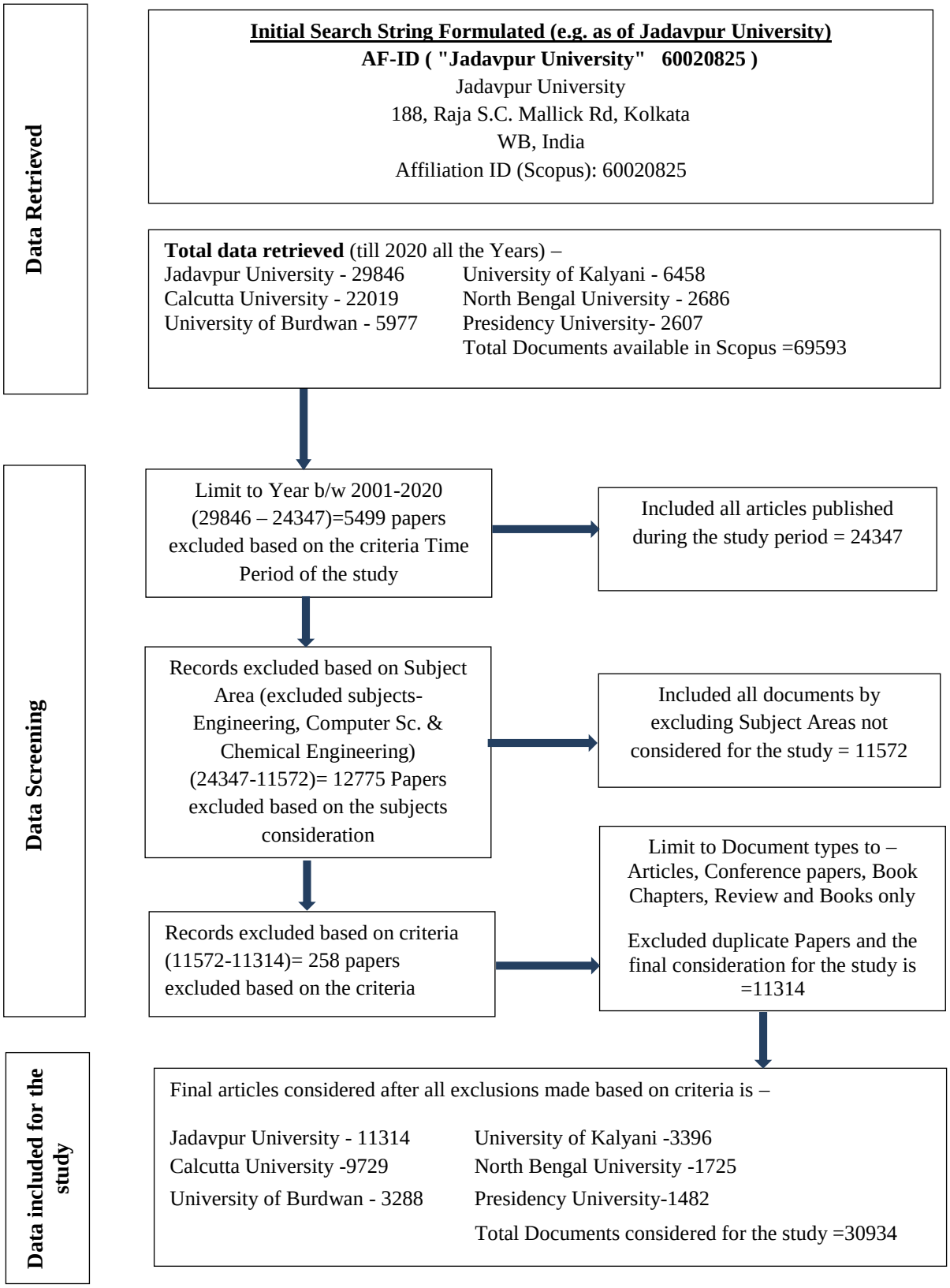

Figure 3.1: Prisma Flow Diagram of Retrieving and Finalizing Secondary Data

- **Altmetric data:** Altmetric attention score has been fetched through dimension.ai database using the doi of top cited articles from each of the Universities.

- **Research Indicators (RI) applied for measuring the research performance using secondary data**

  There are several evidences in the literature about the Research Indicators of measuring the performance of universities or of any higher education institutions. For this case the widely used indicator is the ***h index***. According to Hirsch 2005, a researcher's ***h index*** means that if ***h*** of his/her papers has at least ***h*** number of citations and other papers have fewer than ***h*** no of citations. Similarly, it could be applied on University's research also, in that case ***h*** means, if a university with ***index h*** denotes to ***h*** number of papers of that University have at least ***h*** number of citations and other have fewer than ***h*** no of citations.

  Other indicators of measuring research performance such as the total number of publications (TP), the total number of citations (TC), and citation per article (AC), were also mentioned in the studies of Demetrescu et al. 2020; Babic et al. 2015; Schubert 2015; Gilyarevskii 2014; Bornmann et al. 2011; Garcia-Perez 2008; Csajbok et al. 2007; Hirsch 2007; van Raan 2006. These all indicators depend on some reliable data sources, and for that Elsevier's Scopus and Clarivate's Web of Science is the best source. Abdul-Majeed, 2021 mentioned that these four indicators could not be enough for measuring the research performance of universities and it raises some questions, firstly "which of these four measures is best able to predict research activity of universities?.." and the second one "is it possible to compare the research performance of universities with different sizes, based on these measures?.." None of these indicators alone will fit for measuring the research performance, viz. knowing total publications (TP) without its scientific impact has no value, also total number of citations (TC) is not a reliable indicator without the total publications. Citations per paper or the average citations (AC) is a reliable indicator but with this it cannot be measured the size of the university, which could be measured with the indicators like total publications, total citations. So, altogether application of all

these indicators could be better to understand the overall scenario of research performance of a university during a time period.

3.6.3 Primary data selection and measuring procedures

- **Data Collection and Sampling:** The primary data were collected by using an online survey. The total population with full-time faculties and research scholars at the selected six universities are around 5000 (based on the data available in respective university websites, during the survey in the month of March-April 2022). Stratified random sampling with proportional allocation to each university were applied. A total of 1304 emails were sent out and we received 336 responses (the response rate was around 25%). Out of the total 336 responses, 33 responses have been excluded due to incompletion of the questionnaire, criteria like minimum one year completion in the affiliated universities and at least one publication by the respondents were considered for inclusion in the study, finally with all inclusions and exclusions 303 responses has been considered for the study. The faculty emails were obtained randomly from the websites of the selected universities. We obtained informed consent from the participants for their voluntary participation on the condition that the information provided through the form would remain anonymous and will be used strictly for academic purpose.

  The following Cronbach's formula has been used for the determination of the sample size.

$$n = \frac{z^2 (pq)}{e^2}$$

where,

z = 1.96

p = probability in sample (here, Authors with at least 5 publications are assumed to constitute 70% of the total population, hence the value of p = 0.7)

q = 1-p (1-0.7 = 0.3)

e = acceptable sample error (0.05)

- **Survey Instrument:** The questionnaire used in the study has been written in English. The questionnaire consists of 31 questions.

  The main parts of the questionnaire are Part 1, General and demographic information of the researcher, where questions like name of the affiliated university, gender, academic rank, work experience, discipline etc. Demographic questions are self-explanatory; however, the remaining questions deserve explanation.

  Part 2 has two sub sections. In sub section 2.1 there are 10 questions on behavioural characteristics of the researcher, questions on satisfactory level, curiosity about the research were asked for the measurement of individual factors influencing research productivity. In sub section 2.2 there are 9 questions on institutional level metrics are presented which are associated to the measurement of the factors influencing the research productivity. All these part 2 questions are designed on a five-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5).

  In section 3 few close and open-ended questions (opinion and suggestions) are given to gather the view of researcher's and faculty's about the facilities and infrastructures to increase the rate of research productivity.

  Cronbach's α coefficient has been applied prior to data analysis to check the reliability of the instrument (questionnaire). Overall, the scales have been found to be reliable as the value of Cronbach's α coefficient are above 0.6, indicating an acceptable level of reliability.

- **Determination of Indices using Factor Analysis**

  Reliability and Validity of Constructed Scales: Cronbach's Alpha for each of the used scales demonstrates an acceptable level of internal consistency (correlation among the items), establishing dependability, assuming that 0.6 is the acceptable lowest value of internal consistency for scales with fewer than 20 items (Dall'Oglio, et al. 2010). Additionally, each agency dimension's factor loadings in principal component analysis (PCA) shows that the underlying data match the proposed model reasonably well which is further described in Part II chapter of IV.

However, the factor loadings on Individual motivational factors scale, Institutional factors scale and Research support scale are more reliable as compared to Academic environment scale.

3.7 Statistical Methods and Tools for Analysis

3.7.1 Relative Growth Rate (RGR)

The growth of publications of an individual or of an institution could be measured by calculating the relative growth rate over a specific period of time. The relative growth rate is the increase of publications per unit of time. Here, one year is taken as the unit of time. The formula of relative growth rate derived from previous studies of Mahapatra, G. (1994) and Lohiya, R. K. (2016) -

$$RGR = \frac{\text{Log}_e N2 - \text{Log}_e N1}{T2 - T1}$$

Where,
RGR = Relative growth rate of publications over a specific period
$\text{Log}_e N1$ = Natural Log of the preceding year of publication
$\text{Log}_e N2$ = Natural Log of the following year of publication
T2 – T1 = The unit difference of period between initial and final year

3.7.2 Doubling Time (Dt)

Doubling time is one of those measurement method used in the growth pattern of any field, for instance, population growth of any country could be measured by it. The doubling time in this regard to measurement of publications of an institution, is meant for the required time to double in size the total number of publications of an institution. The doubling time closely associated with the measurement of relative growth rate. The doubling time refers to the ratio between the value of natural logarithms of 2, i.e. $\text{Log}_e 2 = 0.693$ and the value of RGR.

Thus, the Doubling time can be calculated by using the formula -

$$\text{Doubling Time } (Dt) = 0.693 / RGR$$

Where,
Dt= average doubling time of publications
RGR=Relative growth rate over a unit of time

3.7.3 Exponential Growth Rate

Generally exponential growth rate is the calculation method of the rate of population growth. It has two types, one is exponential growth rate and the other one is linear growth rate. Based on the current population exponential growth rate reveals the relative growth rate of population, whereas linear growth rate does not depend upon the current growth rate. So, exponential growth rate is more suitable to predict future population of any species of animals or of anything of having same kind of data available. Globally exponential growth rate is used to predict the human population. If the periodic rate of anything is known to you, that is the number of years through which the growth rate is to be calculated and the original population is also known, then the best suitable measured method is exponential growth rate. Here the periodic rate of producing number of publications of all the universities retrieved from secondary source, i.e. from Elsevier's Scopus bibliographic database. Based on these data the exponential growth rate of the publication can be easily evaluated.

The formula for calculating the exponential growth rate of the publication is given below –

$$N_{(t)} = N_{(o)}\, e^{rt}$$

Where,

$N_{(t)}$ = the population when the time elapsed is "t" years
$N_{(o)}$ = the initial population
"r" = the growth rate
"t" = number of years
"e" = the natural base of logarithms whose value is 2.711828.

3.7.4 Trend analysis

Trend analysis is a technique used in technical analysis that attempts to predict future movements based on recently observed trend data. Trend analysis uses historical data,

such as previous year's publication data, to forecast the long-term direction of growth of publication of a researcher or of an institution.

3.7.5 Degree of Collaboration

Degree of collaboration denotes to the ratio between single-authored papers and multi-authored papers over a specific period of time. It helps to understand that how the emphasis has been given to collaborative work of an institution's research productivity.

Subramanyam (1983) gave the most appropriate formula to measure the Degree of Collaboration. According to this the formula formed as below –

$$C = \frac{Nm}{Nm + Ns}$$

[*Where,*
C= Degree of Collaboration
Nm = Total number of multi-authored articles
Ns = Total number of single authored articles]

3.7.6 Binary Logistic Regression: Binary logistic regression is one of the most widely used method in different fields, commonly for dichotomous dependent variables. Also, in higher education this method has been applied numbers of times to determine various aspects related to qualitative or quantitative issues. The determinants of the several dimensions of factors influencing research productivity have been estimated using binary logistic regressions.

The basic form of the binary logistic regression used is:

$$\textbf{Log (p/1-p) = b0 + b1*x1 + b2*x2 + b3*x3 + b3*x3+... bk*xk}$$

Where,
b0 is the constant
b1, b2, b3... bk are the coefficients of the independent variables
x1, x2, x3.... xk. P is the estimated probability of the dependent variable assuming a value of 1.

A dichotomous dependent variable was created from the continuous variable 'number of publications', such that 5 and above publications for the respondent has been coded as '1' and below 5 publications has been coded as '0'.

3.7.7 Visualization Analysis Tool: VOSviewer

VOSviewer is a software tool for creating and visualizing bibliometric networks. These networks may for example include journal publications, researcher's publications, or individual publications, and they can be shaped based on citation pattern, co-citation, bibliographic coupling, or co-authorship relations. In this study the tool is used to create the country wise collaboration map only.

3.7.8 IBM SPSS 20.0

A sophisticated software package known as IBM SPSS Statistics 20.0 is utilized by the social scientists and other relevant specialists for statistical analysis. In this study, Cronbach's α coefficient has been applied prior to data analysis to check the reliability of the instrument (questionnaire), Principal Component Analysis (PCA) is used to determine the scales and Binary Logistic Regression is used to measure the level of Significance of the factors influencing research productivity. The tool is also used to determine the Pearson's Correlation Coefficient to measure the correlation among the variables.

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Chapter IV

Data Analysis and Interpretation

CHAPTER – IV

DATA ANALYSIS AND INTERPRETATION

The chapter is divided into three parts, in which the first part deals with the different aspects related to research performance of the universities taken for the study during a span of twenty years from 2001 to 2020 based on the secondary data indexed in Scopus database. The second part highlights the significant factors influencing research productivity among the research scholars and faculty members of different levels, the study of this part is based on the primary data collected from the scholars and faculties of the universities taken for the study. The third part of the chapter shows the social impact of the highly cited papers measured based on the altmetric attention score (secondary data) retrieved using the doi of the highly cited papers through dimension.ai database. The parts are described under the below mentioned headings.

- Part-I: 4a Research Performance of Universities in West Bengal During 2001-2020
- Part-II: 4b Factors Influencing Scholarly Publications: The Case of Six Top Universities in West Bengal
- Part-III: 4c Correlating Research Impact Using Citation Counts and Altmetrics Attention Score

Part-I

4a Research Performance of Universities in West Bengal during 2001-2020

The purpose of the present section is to analyze and visualize the research productivity of the Universities of West Bengal. The literatures were collected through the records indexed in Elsevier's Scopus Database for the period of 2001 to 2020. In short, this part of the analysis deals with the data analysis and interpretation of the research carried by the researchers, faculty members of the top Universities of West Bengal (NAAC 'A' graded) to give a clear scenario of research performance comparatively as well as individually.

The researcher extracted and tabulated necessary bibliographic information of the research produced by the Universities during the study period. Such bibliographic details are – Authors Name, Title, Year, Source Title, Citation, DOI, Affiliations, Abstract, Author and Indexed Keywords, Funding details, Publisher details, Conference details, Document Types etc.

The indicators and tools applied in the analysis are – (i) Year-wise distribution of scientific literature, (ii) Relative Growth Rate (RGR), (iii) Doubling Time (Dt), (iv) Exponential Growth Rate (v) Trend Analysis, (vi) Authorship Pattern, (vii) Degree of Collaboration (viii) Citation Analysis (ix) Document Types, (x) Most Productive Sources, (xi) Productive Subject Areas, (xii) Collaborative Countries, (xiii) Organizational Collaboration etc. The study also used the visualization tool VOSviewer to show the country wise collaboration map. The analysis is done with total of 30934 data after all the limitations and screening based on the criterions to highlight the research performance of the following Six NAAC 'A' graded Universities of West Bengal:

4a.1 Jadavpur University
4a.2 University of Calcutta
4a.3 University of Burdwan
4a.4 University of Kalyani
4a.5 University of North Bengal
4a.6 Presidency University

4a.1 Jadavpur University

4a.1.1 Growth of Literature: Year-wise distribution of Publications

Table 4a.1.1 shows the Year-wise distribution of Scientific Literature of Jadavpur University. The total consideration of literature growth is of two decades from 2001 to 2020. The total publication that has reported by Jadavpur University is 11314 which is the greatest number among all other Universities in West Bengal. The highest publication which is reported by the year in 2018 with the number of total 823 publications followed by the second highest in the year 2019 with the 791 total number of publications. The lowest number which is reported by the year is 2002 with the total publication is 227 followed by the second lowest reported by the year 2001 with the total publication of 243.

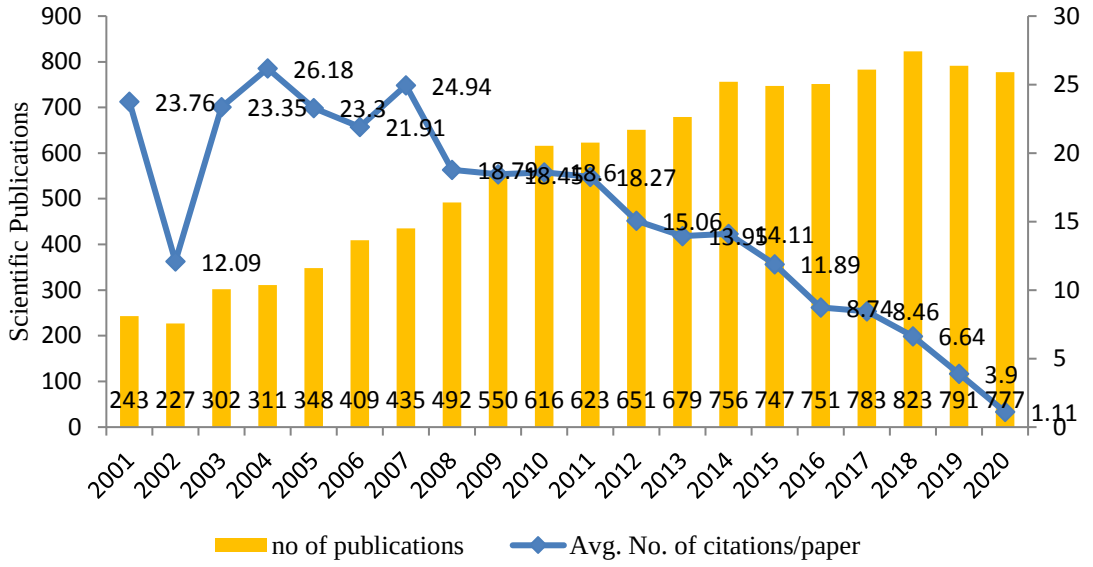

Figure 4a.1.1: Year-wise Publications of Jadavpur University

The table also shows the cumulative publications of the research output of the University. The total year that is considered for the study is divided into two decades, the first from 2001 to 2010 and the second is from 2011 to 2020. During the first decade the total publications noted for Jadavpur University is 3933 which is only 34.76% of the total and during the second decade the number increased to 7381 (65.24%).

Year-wise received citations is also mentioned in the above table. It means how many citations have been received by the documents published in a particular year. From the

year of two decades with a span of year 2001 to 2020 the total received citations is 157574 for 11314 documents at an average of 13.93 citations per publication. The highest citations reported by the year 2010 with 11459 followed by the second largest in the year 2011with 11381 citations. The rate of received citations is associated with the time spending after their publication year. So, in this case to measure the lowest rate of citations it is considered that the publications must spent at least five years after their publication year. As a result, the last year taken as 2015 for considering the citation received by the documents, for Jadavpur University the lowest rate of average citations per publications is reported in the year 2015 with 11.89 followed by the second lowest reported in the year 2002 with 12.09 and on the other hand the highest average noted in the year 2004 with 26.18 followed by the year which is second highest by the year reported is 2007 with ACP contains is 24.94.

Table 4a.1.1: Growth of Literature: Year-wise distribution of Scientific Literature of Jadavpur University

Year	Publications	CP	%	Cited by	ACP
2001	243	243	2.15	5773	23.76
2002	227	470	2.01	5014	12.09
2003	302	772	2.67	7053	23.35
2004	311	1083	2.75	8141	26.18
2005	348	1431	3.08	8109	23.30
2006	409	1840	3.61	8963	21.91
2007	435	2275	3.84	10849	24.94
2008	492	2767	4.35	9247	18.79
2009	550	3317	4.86	10146	18.45
2010	616	3933	5.44	11459	18.60
2011	623	4556	5.51	11381	18.27
2012	651	5207	5.75	9803	15.06
2013	679	5886	6	9469	13.95
2014	756	6642	6.68	10669	14.11
2015	747	7389	6.60	8884	11.89
2016	751	8140	6.64	6566	8.74
2017	783	8923	6.92	6627	8.46
2018	823	9746	7.27	5468	6.64
2019	791	10537	6.99	3088	3.90
2020	777	11314	6.87	865	1.11
Total	11314			157574	13.93

TP = Total papers; CP = cumulative publications; ACP= Average Citation per Publication

4a.1.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

It is observed from Table 4a.1.2 that the relative growth rates have decreased gradually over the time. The year Started with a downward rate in 2002 (-0.068) when the publication reduces from the preceding year. But the following year i.e. in 2003 recorded the highest relative growth rate (0.285) followed by 0.162 in 2006 and 0.123 in 2008. The whole study period has been divided into four block of five years each and the highest mean relative growth rate (0.114) has been recorded during the period of 2006 to 2010 and the lowest mean relative growth rate (0.031) noted during the period from 2016 to 2020.

Table 4a.1.2: Calculation of Relative Growth Rate (RGR) and Doubling Time (Dt)

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	243	243	-	5.493	-		-	
2002	227	470	5.493	5.425	-0.068		10.19	
2003	302	772	5.425	5.710	0.285	0.099	2.43	8.38
2004	311	1083	5.710	5.740	0.03		23.1	
2005	348	1431	5.740	5.852	0.112		6.19	
2006	409	1840	5.852	6.014	0.162		4.28	
2007	435	2275	6.014	6.075	0.061		11.36	
2008	492	2767	6.075	6.198	0.123	0.114	5.63	6.72
2009	550	3317	6.198	6.31	0.112		6.19	
2010	616	3933	6.31	6.423	0.113		6.13	
2011	623	4556	6.423	6.435	0.012		57.75	
2012	651	5207	6.435	6.479	0.044		15.75	
2013	679	5886	6.479	6.521	0.042	0.043	16.5	30.85
2014	756	6642	6.521	6.628	0.107		6.48	
2015	747	7389	6.628	6.616	-0.012		57.75	
2016	751	8140	6.616	6.621	0.005		138.6	
2017	783	8923	6.621	6.663	0.042		16.5	
2018	823	9746	6.663	6.713	0.05	0.031	13.86	44.96
2019	791	10537	6.713	6.673	-0.04		17.33	
2020	777	11314	6.673	6.655	-0.018		38.5	
Total	11314				1.162(0.06)		454.52(23.92)	

CP = Cumulative Publications, RGR (P) = Relative Growth Rate of Publications, Dt (P) = Doubling Time of Publications

Contrarily, the mean doubling time has increased from 8.38 in first five years to 44.96 in the last five years of the study period. There is an opposite trend of association between relative growth rate and doubling time has been noticed.

4a.1.3 Forecasting Jadavpur University Research Productivity using Trend Analysis

To forecast the research productivity in the upcoming days the best possible technique is the application of straight-line equation under trend analysis. The future trend of the research productivity could be measured based on the past data available at a regular interval. Here based on the two decadal data (from 2001 to 2020), a projection of research growth of next thirty years has been calculated (Table 4a.1.3).

Straight-line equation Y= a+b is applied to give the future projection of the research growth of Jadavpur University publications.

Table 4a.1.3: Trend Analysis of research output of Jadavpur University

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	243	-10	100	-2430
2	2002	227	-9	81	-2043
3	2003	302	-8	64	-2416
4	2004	311	-7	49	-2177
5	2005	348	-6	36	-2088
6	2006	409	-5	25	-2045
7	2007	435	-4	16	-1740
8	2008	492	-3	9	-1476
9	2009	550	-2	4	-1100
10	2010	616	-1	1	-616
11	2011	623	0	0	0
12	2012	651	1	1	651
13	2013	679	2	4	1358
14	2014	756	3	9	2268
15	2015	747	4	16	2988
16	2016	751	5	25	3755
17	2017	783	6	36	4698
18	2018	823	7	49	5761
19	2019	791	8	64	6328
20	2020	777	9	81	6993
	N=20	$\sum Y$=11314	$\sum X$=10	$\sum X^2$=670	$\sum XY$=16664

To assume the future growth of publications of Jadavpur University, Trend Analysis has been introduced. In this regard, under Trend Analysis Straight Line Equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 11314 / 20$

$a = 565.7$

$b = \sum XY / \sum X^2$

$b = 16669 / 670$

$b = 24.88$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 565.7 + (24.88 \times 14)$

$Yc = 565.7 + 348.32$

$Yc = 914.02$

Estimated number of publications in 2030, is when

$X = 2030\text{-}2011$ or, $X = 19$

$Yc = a+bX$

$Yc = 565.7 + (24.88 \times 19)$

$Yc = 565.7 + 472.72$

$Yc = 1038.42$

Estimated number of publications in 2040, is when

$X = 2040\text{-}2011$ or, $X = 29$

$Yc = a+bX$

$Yc = 565.7 + (24.88 \times 29)$

$Yc = 565.7 + 721.52$

$Yc = 1287.22$

Estimated number of publications in 2050, is when

$X = 2050\text{-}2011$ or, $X = 39$

$Yc = a+bX$

$Yc = 565.7 + (24.88 \times 39)$

$Yc = 565.7 + 970.32$

$Yc = 1536.02$

The straight-line equation is introduced to measure the future trend of research productivity of Jadavpur University. The calculation is based on Table 4a.1.3 of trend analysis of Jadavpur University publication productivity.

Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next thirty years and the publications will be almost doubled in figure. It will be 914 in 2025, 1038 in 2030, 1287 in 2040 and 1536 in 2050.

4a.1.4 Exponential Growth Rate

Table 4a.1.4 describes the exponential growth rate of Jadavpur University publication for the twenty years of study period, starting from 2001 to 2020. During the period it is found that the growth rate was highest in the year 2003 (1.33) and lowest in 2002 (0.93). The growth rate was negative in the years of 2002 (0.93), 2015 (0.99), 2019 (0.96) and in 2020 (0.98). In these four years the number of publications recorded lower than the preceding year. For rest of the years the growth rate was recorded positive. It was continuous positive growth has been there from 2003 to 2014, in these twelve years there was no downward has been seen in the publications recorded by Jadavpur University.

Table 4a.1.4: Exponential Growth Rate of publications of Jadavpur University during 2001-2020

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	243	-	
2	2002	227	**0.93 (L)**	
3	2003	302	**1.33 (H)**	
4	2004	311	1.03	
5	2005	348	1.12	1.11
6	2006	409	1.18	
7	2007	435	1.06	
8	2008	492	1.13	
9	2009	550	1.12	
10	2010	616	1.12	
11	2011	623	1.01	
12	2012	651	1.04	
13	2013	679	1.04	
14	2014	756	1.11	
15	2015	747	0.99	1.02
16	2016	751	1.00	
17	2017	783	1.04	
18	2018	823	1.05	
19	2019	791	0.96	
20	2020	777	0.98	
		11314		

4a.1.5 Authorship Pattern

The authorship pattern of research papers produced by Jadavpur University (Table 4a.1.5) shows the dominance of three-authored papers (24.92%) followed by the

category belongs in between 6-10 authored papers (18.26%). The percentage of more than ten-authored papers is very low, only 1.4%. Only 621 papers (5.49%) recorded as single-authored paper out of total 11314 papers during the study period, which indicates that the authors of this University are more likely favoured the collaborative research work. The dominance of research contributed by researchers of Jadavpur University are mostly consists of two, three, four and five authored papers. In these four groups of authorship, together contributed 8496 papers (75.09%) out of total 11314 papers.

Total 46076 authors occurrences have been identified to publish the total number of 11314 papers at an average rate of 4.07 authors per paper. The highest average authorship found 4.37 in the year 2019 followed by the second highest 4.26 in 2017. The lowest average authorship identified in 2001 with at an average of 3.53 average authorship.

Table 4a.1.5: Distribution of Articles by Authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	243	13	57	72	47	24	27	3	-	857	3.53
2002	227	13	46	67	56	14	29	2	-	822	3.62
2003	302	24	64	77	65	35	34	3	-	1085	3.59
2004	311	12	67	86	52	42	51	1	-	1178	3.78
2005	348	14	65	98	76	35	51	9	-	1383	3.97
2006	409	20	66	94	81	51	91	6	-	1736	4.24
2007	435	19	62	104	87	73	87	3	-	1796	4.13
2008	492	21	85	120	102	72	88	4	-	1987	4.04
2009	550	41	96	126	122	61	95	9	-	2165	3.94
2010	616	24	113	145	139	89	99	7	-	2456	3.99
2011	623	50	86	149	134	94	106	4	-	2451	3.94
2012	651	36	103	170	134	88	115	5	-	2607	4.00
2013	679	36	104	175	148	89	117	10	-	2775	4.09
2014	756	46	138	184	137	111	134	6	-	2982	3.94
2015	747	34	118	190	123	105	168	9	-	3132	4.19
2016	751	45	140	178	136	106	136	10	-	3020	4.02
2017	783	59	119	181	142	112	150	20	-	3333	4.26
2018	823	41	114	194	163	121	172	18	-	3565	4.33
2019	791	42	100	213	148	124	146	18	-	3457	4.37
2020	777	31	117	197	161	90	170	11	-	3289	4.23
Total	11314	621	1860	2820	2253	1536	2066	158	0	46076	4.07
%	100	5.49	16.44	24.92	19.91	13.58	18.26	1.4	0	-	-

4a.1.6 Degree of Collaboration of Jadavpur University Research Publications

It is observed from the table 4a.1.6 that the degree of collaboration is very fluctuating type of publications of Jadavpur University over the study period. It indicates some years contributed more multi-authored papers and again some years produced more numbers of single-authored papers than the previous year. There are only 621 single-authored papers has been identified among 11314 total papers published during the period of 2001 to 2020. The average degree of collaboration is 0.95 and the maximum degree of collaboration (0.96) reported in six years out of the twenty years of study period, rest of the years reported equals to or less than the average degree of collaboration.

Table 4a.1.6: Degree of Collaboration of Jadavpur University Publications

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC= Nm/Ns+Nm)
2001	13	230	243	0.95
2002	13	214	227	0.94
2003	24	278	302	0.92
2004	12	299	311	0.96
2005	14	334	348	0.96
2006	20	389	409	0.95
2007	19	416	435	0.96
2008	21	471	492	0.96
2009	41	509	550	0.93
2010	24	592	616	0.96
2011	50	573	623	0.92
2012	36	615	651	0.94
2013	36	643	679	0.95
2014	46	710	756	0.94
2015	34	713	747	0.95
2016	45	706	751	0.94
2017	59	724	783	0.92
2018	41	782	823	0.95
2019	42	749	791	0.95
2020	31	746	777	0.96
Total	621	10693	11314	0.95

4a.1.7 Citation Pattern

Table 4.1.7 describes the year-wise citation pattern of Jadavpur University's publications over twenty years from 2001 to 2020. The last year of the study period noted highest number of papers with zero citation, it will surely decrease with the

increase of age of the publications of that particular year, this is because of the fact in which citation is largely associated with the age of the publications and it changes its pattern with time to time. The citation data were retrieved during January, 2021 from Scopus database and at that time total 157574 citations have been recorded for total 11314 publications at an average of 13.93 citations per paper. The most number of papers, i.e. 5451 (48.18%) lies between the range of 1-10 citations, followed by 3319 papers (29.33%) lies between the range of 11-50 citations. There were only 158 highly cited papers received 100 or more citations and 462 papers having 50 or more citations. 17.01% papers were noted zero cited during the time and it is expected to decrease in percentage with the time of publication age. The highest average citation noted in the year 2004 with 26.18 citations per paper followed by 2007 with 24.94 citations per paper.

Table 4a.1.7: Year-wise Citation Pattern of Jadavpur University Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	243	25	92	105	11	10	5773	23.76
2002	227	27	89	87	15	9	5014	12.09
2003	302	36	111	121	23	11	7053	23.35
2004	311	37	115	114	30	15	8141	26.18
2005	348	32	134	141	27	14	8109	23.30
2006	409	40	174	154	27	14	8963	21.91
2007	435	29	170	178	41	17	10849	24.94
2008	492	51	205	193	33	10	9247	18.79
2009	550	62	246	196	35	11	10146	18.45
2010	616	91	248	220	45	12	11459	18.60
2011	623	65	271	240	36	11	11381	18.27
2012	651	61	307	250	28	5	9803	15.06
2013	679	64	355	227	28	5	9469	13.95
2014	756	90	355	278	27	6	10669	14.11
2015	747	85	419	212	27	4	8884	11.89
2016	751	130	430	174	14	3	6566	8.74
2017	783	153	426	192	12	0	6627	8.46
2018	823	151	509	160	2	1	5468	6.64
2019	791	235	488	67	1	0	3088	3.90
2020	777	460	307	10	0	0	865	1.11
Total	11314	1924	5451	3319	462	158	157574	13.93
%	100	17.01	48.18	29.33	4.08	1.4		

4a.1.8 Document Types

The study considers only five types of documents to measure the performance of research output of Jadavpur University. The types limited to only Journal Articles, Conference Papers, Book Chapters, Reviews and Books. It is found from table 4a.1.8 that during the time of the study period of twenty years, Jadavpur University produces total 11314 research publications, out of which most are published as Journal Articles with 9744 (86.22%) papers, followed by Conference Papers- 733 (6.48%), Book Chapters – 421 (3.72%), Reviews- 359 (3.17%) and few Books – 57 (0.50%). In 2020 the most number of Journal Articles recorded, i.e. 675 out of 777 total papers published in that year. Highest conference papers (90) recorded in the year 2019.

Table 4a.1.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	236	3	-	4	-	243
2002	220	2	-	5	-	227
2003	283	7	1	11	-	302
2004	292	7	1	11	-	311
2005	326	16	-	6	-	348
2006	376	18	1	12	2	409
2007	405	16	3	10	1	435
2008	444	30	8	9	1	492
2009	475	29	25	18	3	550
2010	489	60	40	24	3	616
2011	536	41	22	20	4	623
2012	556	57	14	19	5	651
2013	596	38	24	20	1	679
2014	653	43	34	22	4	756
2015	634	36	48	21	8	747
2016	605	58	54	27	7	751
2017	636	47	64	28	8	783
2018	668	89	28	36	2	823
2019	639	90	27	31	4	791
2020	675	46	27	25	4	777
Total	9744	733	421	359	57	11314
%	86.12	6.48	3.72	3.17	0.50	100

4a.1.9 Most productive channels of communication

Table 4a.1.9 highlights the top twenty most preferred journals by the faculties and researchers of Jadavpur University. These top journals were identified based on the number of articles published during the study period. Some of the most favored journals are Polyhedron (287), Journal of the Indian Chemical Society (166), Inorganic Chimica Acta (164). The subject areas covered by these journals are basically from Chemistry, Physics, Material Science and one each from Astronomy, Interdisciplinary and Molecular and Biomolecular Spectroscopy. Among these top twenty journals seven of them published by Elsevier, two by Springer and two by American Chemical Society. Out of total 11314 papers 1936 (17.11%) papers published by these twenty journals. The relative importance of a journal in a domain is measurable by the impact factor of that journal, and all the top journals identified in communicating Jadavpur University research belongs to high impact factor journals, out of the twenty top journals 11 of them having impact factor of more than 2.

Table 4a.1.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area	Impact Factor	Frequency
1	Polyhedron	Elsevier	Chemistry	3.052	287
2	Journal of The Indian Chemical Society	Elsevier	Chemistry	0.284	166
3	Inorganica Chimica Acta	Elsevier	Chemistry	2.545	164
4	Dalton Transactions	Royal Society of Chemistry (United Kingdom)	Chemistry	4.052 (2018)	139
5	Materials Today Proceedings	Elsevier	Materials Science	-	136
6	Inorganic Chemistry	American Chemical Society	Chemistry	5.165 (2020)	95
7	Journal of Molecular Structure	Elsevier ScienceDirect	Chemistry	3.196	95
8	Astrophysics and Space Science	Springer	Astronomy, Astrophysics, Space Science	1.885 (2017)	84
9	Asian Journal of Chemistry	Asian Publication Corporation	Chemistry	-	73
10	Indian Journal of Physics	Springer	Physics	1.407 (2019)	73
11	Applied Surface Science	Elsevier	Materials Science	6.707	70
12	Chemistryselect	Wiley-VCH	Chemistry	2.109 (2020)	70
13	Inorganic Physical Theoretical and Analytical Chemistry	Scientific Publishers of India	Chemistry	0.491 (2020)	63
14	International Journal of Modern Physics	World Scientific	Physics	1.153 (2018)	63

15	Crystengcomm	Royal Society of Chemistry	Chemistry, Crystallography	3.545	62
16	International Journal of Theoretical Physics	Springer	Physics	1.708 (2020)	62
17	Pharmacologyonline	SILAE	Interdisciplinary	-	60
18	Journal of Physical Chemistry	American Chemical Society	Physical chemistry	2.6 (2019)	59
19	Physics of Plasmas	American Institute of Physics (United States)	Plasma	2.023 (2020)	59
20	Spectrochimica Acta	Elsevier	Molecular and Biomolecular Spectroscopy	4.098 (2020)	56

4a.1.10 Most Productive Authors

Table 4a.1.10 presents the most productive authors during the study period. According to the number of publications produced top twenty authors has been identified. The table also highlights the total contribution of the authors as indexed in Scopus and their total citations too. h-index is calculated based on the total publications and received total citations during whole life of a single author. With the Scopus id authors can be identified and can measure the progress of their publication growth in any point of time. In terms of published data during the study period chattopadhyay, k. k. (243 publications), rahaman, f. (233 publications) and chakraborty, s. (220 publications) were the most productive authors. moulik, s.p. noted in the first position in terms of h-index whereas his actual position is 14th in terms of number of publications published.

Table 4a.1.10: Most Productive Authors during the study period under Jadavpur University Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	chattopadhyay, k.k.	7102118538	243	444	9592	48
2	rahaman, f.	7005371506	233	308	4915	38
3	chakraborty, s.	55519902400	220	315	3154	28
4	sinha, c.	7102111901	213	392	6711	42
5	ghosh, d.	7401906364	189	336	2621	26
6	mitra, s.	35466915500	180	232	6296	41
7	roy, k.	56962764800	178	366	10977	46
8	deb, a.	7102673920	168	209	1632	20
9	mukherjee, p.k.	35497543900	158	231	8785	49
10	pal, t.k.	21735907600	137	268	3330	30
11	mondal, t.k.	35242801600	135	173	3188	30

12	mandal, s.c.	34979135700	133	199	4351	37
13	haldar, p.k.	23396547100	121	137	1761	22
14	moulik, s.p.	7006026917	103	304	12381	55
15	ali, m.	7404486341	101	165	2521	29
16	chattopadhyay, n.	7006361235	94	160	4771	37
17	mukhopadhyay, s.	35497723200	94	124	2990	26
18	hazra, s.	57197882363	92	119	1158	18
19	bhattacharya, s.c.	35475479300	90	156	2724	29
20	mazumder, u.k.	7003269732	84	106	2450	26

4a.1.11 Subject area wise performance

Jadavpur University research contributions are highlighted based on several subject domains. and the same is shown in Table 4a.1.11. The highest number of publications (i.e. >1000) noted to five domains; Chemistry (3308), Physics and Astronomy (2989), Material Sciences (2245), Pharmacology, Toxicology and Pharmaceutics (1537) and Biochemistry, Genetics and Molecular Biology (1281) respectively. Top two subject fields, i.e. Chemistry and Physics and Astronomy individually contributed more than half (55.66%) of the total output. The subjects are listed according to the contribution during the twenty years of study, except the first five subjects mentioned earlier, other important subject areas are Earth and Planetary Science (998), Mathematics (975), Environmental Science (903), Medicine (671). The subject fields of Social Sciences, Arts & Humanities are very few in respect to Science subjects in the publication map of Jadavpur University research.

Table 4a.1.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Chemistry	3308
2	Physics and Astronomy	2989
3	Materials Science	2245
4	Pharmacology, Toxicology and Pharmaceutics	1537
5	Biochemistry, Genetics and Molecular Biology	1281
6	Earth and Planetary Sciences	998
7	Mathematics	975
8	Environmental Science	903
9	Medicine	671
10	Agricultural and Biological Sciences	572
11	Social Sciences	503
12	Energy	467

13	Economics, Econometrics and Finance	324
14	Arts and Humanities	300
15	Multidisciplinary	244
16	Business, Management and Accounting	199
17	Immunology and Microbiology	172
18	Decision Sciences	111
19	Health Professions	56
20	Neuroscience	34

4a.1.12 Collaboration with other countries

A total of 98 collaborative countries are noted with which the authors of Jadavpur University collaborated their research work. Top twenty most collaborative countries are listed in table 4a.1.12. Jadavpur University authors published their research mostly with the authors of countries like United States (464 papers), United Kingdom (391 papers), Germany (266 papers), Spain (261 papers) and Italy (198 papers).

Table 4a.1.12: Country wise collaboration of research output in Jadavpur University

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	United States	464	10431	22.48	787
2	United Kingdom	391	9131	23.35	709
3	Germany	266	6738	25.33	507
4	Spain	261	5890	22.57	497
5	Italy	198	3823	19.31	485
6	Japan	169	4095	24.23	367
7	France	149	3343	22.44	311
8	Taiwan	106	1917	18.08	177
9	China	104	1526	14.67	257
10	Canada	90	2111	23.45	159
11	Australia	86	2763	32.13	173
12	South Korea	77	1898	24.65	194
13	Bangladesh	74	1660	22.43	142
14	Portugal	72	1074	14.92	194
15	South Africa	72	1084	15.06	194
16	Malaysia	67	989	14.76	89
17	Poland	61	908	14.89	91
18	Russian Federation	50	764	15.28	121
19	Switzerland	46	1175	25.54	173
20	Turkey	44	754	17.14	78

The table also highlights the total received citations of those collaborative papers listed country wise. The most number of citations received by papers collaborated with United States (10431 citations) at an average rate of 22.48 per paper, followed by United Kingdom where total 9131 citations noted for 391 papers at an average rate of 23.35 citations per paper. Highest 32.13 average citations noted for papers collaborated with Australian authors.

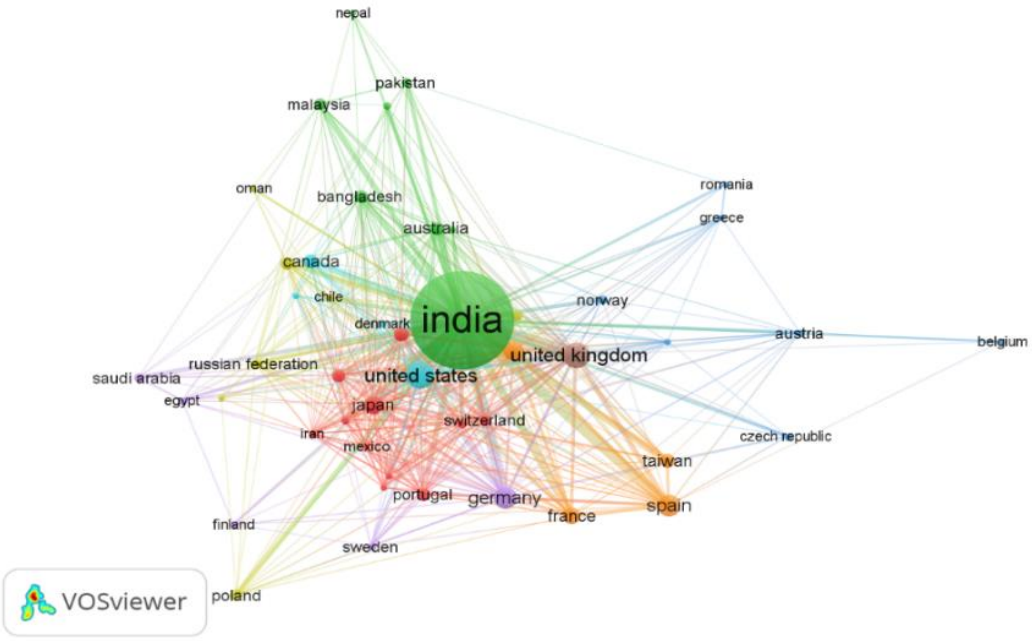

Figure 4a.1.2 Network visualization of Country wise Collaboration of Jadavpur University Literatures

Minimum Document of a Country- 10, Minimum Citation – 1, out of the 115 countries 47 meet the thresholds and eight clusters identified. Top five clusters are –

Cluster 1: 11 Countries	*Cluster 2: 8 Countries*	*Cluster 3: 7 Countries*	*Cluster 4: 7 Countries*	*Cluster 5: 5 Countries*
Brazil, China, Hong Kong, Iran, Israel, Japan, Mexico, Netherlands, Portugal. South Korea, Switzerland	Australia, Bangladesh, Malaysia, Nepal, Pakistan, Singapore, Thailand	Austria, Belgium, Czech Republic, Greece, Hungary, Norway, Romania	Chile, Oman, Poland, Russian Federation, Slovakia, South Africa, Turkey	Egypt, Finland, Germany, Saudi Arabia, Sweden

A network visualization map of collaborative countries is presented in Figure 4a.1.2. The map highlights the association among the collaborative countries in terms of total link strength. The link strength describes the association among the countries in respect

to collaboration of producing articles together as well as by the received citations among those collaborative papers. Higher link strength means higher association among the countries, where in Jadavpur University publications India is highly collaborative with the countries like United States, United Kingdom, Germany, Spain, Italy Japan and so on.

From the network visualization map 8 clusters has been identified comprising 47 countries. The top five clusters are listed above in which the most number of countries has been noted in cluster 1 where 11 countries were there. These clusters indicates that the countries are collaborated with each other and with the publications of University of Calcutta as well.

4a.1.13 Collaboration with other organizations

Most number of publications published by Jadavpur University Faculties and Research Scholars are found as collaborative papers. Only 621 papers have been written as single authors. In this collaboration the researchers from different institutions have been associated, among them top twenty collaborative institutes are shown in table 4a.1.13. The most number of papers published by Jadavpur University researchers are collaborated with University of Calcutta (566), Indian Association for the Cultivation of Science (286), Indian Institute of Chemical Biology (231). Jadavpur University authors preferred to publish their research with the researchers mostly of research institutions rather the researchers of state or private universities. There are some state universities are also in the top list of collaboration, viz. University of Calcutta (556), University of Kalyani (99), The University of Burdwan (81). Few private institutions are also there in the top list.

Table 4a.1.13: Collaboration with other Organizations

Sl. No.	Affiliation Name	Publication Count
1	University of Calcutta	556
2	Indian Association for the Cultivation of Science	286
3	Indian Institute of Chemical Biology	231
4	Indian Institute of Engineering Science and Technology, Shibpur	203
5	Indian Institute of Technology Kharagpur	193
6	Indian Statistical Institute, Kolkata	163
7	Central Glass and Ceramic Research Institute India	141
8	Saha Institute of Nuclear Physics	125
9	Visva-Bharati University	108
10	Bose Institute	100

11	University of Kalyani	99
12	Universitat de les Illes Balears	90
13	Indian Institute of Science, Bengaluru	86
14	The University of Burdwan	81
15	Heritage Institute of Technology	78
16	Council of Scientific and Industrial Research India	75
17	St. Xavier's College, Kolkata	74
18	Bhabha Atomic Research Centre	73
19	Government College of Engineering & Ceramic Technology	71
20	National Institute of Technology, Durgapur	70

4a.2 University of Calcutta

4a.2.1 Growth of Literature: Year-wise distribution of Publications

Table 4a.2.1 highlights the year-wise distribution of literature published by University of Calcutta faculty members, research scholars. The literature growth has been shown during the publication period from 2001 to 2020 as indexed in Scopus database. During the twenty years of span a total of 9729 number of publications has been noted under the affiliation of University of Calcutta excluding the subject areas according to the scope and limitation of the study. The peak year of publication noted in the year of 2017 with 757 number of Publications, 754 publications in the year 2020 and 740 in 2013. The lowest number of Publication noted in the year of 2002 with 179 publications, followed by second Lowest number of publications in the year 2001 with only 180 Publications.

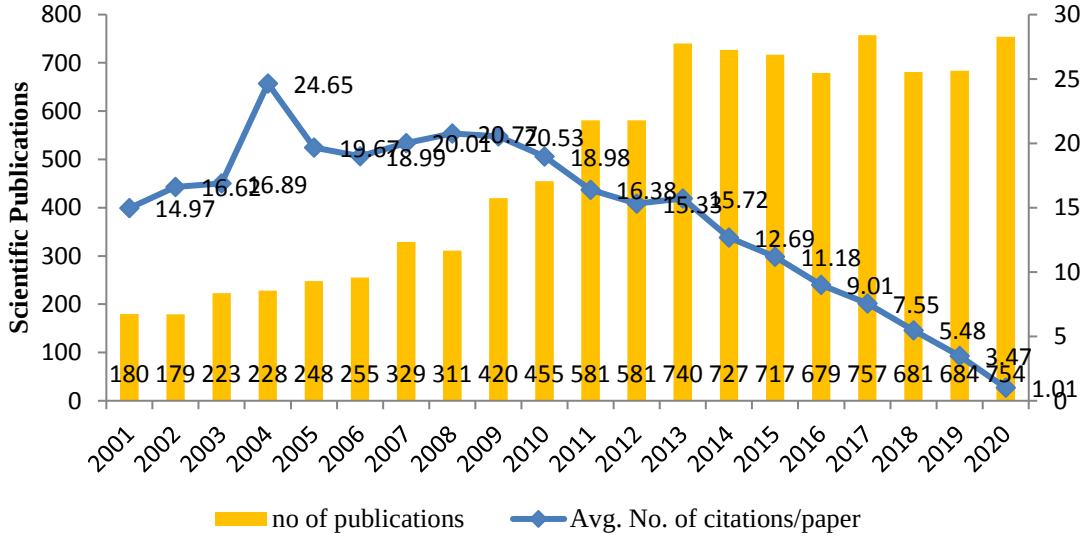

Figure 4a.2.1: Year-wise Publications of University of Calcutta

The total study period that is from 2001 to 2020 is divided into two decades, the first is from 2001 to 2010 and the second is from 2011 to 2020. During first decade University of Calcutta published only 2828 number of papers and it increases to 6901 in the next ten years.

The table also highlights the year-wise received citations of the papers published during these years. During the twenty years of span from 2001 to 2020 the total received citations for 9729 paper is 121080, at an average of 12.45 citations per paper. The highest citation recorded in the year 2013 with 11634 citations for 740 Publication in that year at an average of 15.33 citations per Publication, followed by 9517 citations and 9226 citations counted in the years 2011 and 2014 respectively. Depending on the base that the Publications spent at least five years, the lowest average citation noted 11.18 in the year 2015, and second lowest average citation noted in the year 2014 with 12.69 citation per paper.

Table 4a.2.1: Growth of Literature: Year-wise distribution of Scientific Literature of University of Calcutta

Year	Publications	CP	%	Cited by	ACP
2001	180	180	1.85	2695	14.97
2002	179	359	1.84	2975	16.62
2003	223	582	2.29	3766	16.89
2004	228	810	2.34	5620	24.65
2005	248	1058	2.55	4878	19.67
2006	255	1313	2.62	4842	18.99
2007	329	1642	3.38	6584	20.01
2008	311	1953	3.20	6461	20.77
2009	420	2373	4.32	8624	20.53
2010	455	2828	4.68	8634	18.98
2011	581	3409	5.97	9517	16.38
2012	581	3990	5.97	8905	15.33
2013	740	4730	7.61	11634	15.72
2014	727	5457	7.47	9226	12.69
2015	717	6174	7.37	8017	11.18
2016	679	6853	6.98	6117	9.01
2017	757	7610	7.78	5714	7.55
2018	681	8291	7.00	3734	5.48
2019	684	8975	7.03	2375	3.47
2020	754	9729	7.75	762	1.01
Total	9729		100	121080	12.45

TP = Total papers; CP = cumulative publications; ACP= Average Citation per Publication

4a.2.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

It is observed from table 4a.2.2 that the mean relative growth rate is increased in the middle period of the study and it decreased during the last five years. The year Started with a negative rate in 2002 (-0.006) when the publication reduces from the preceding year. But the following year i.e. in 2009 recorded the highest relative growth rate (0.301) followed by 0.255 in 2007 and 0.245 in 2011. The whole study period has been divided into four block of five years each and the highest mean relative growth rate (0.144) has been recorded during the period of 2006 to 2010 and the lowest mean relative growth rate (0.074) noted during the period from 2016 to 2020.

The mean doubling time has started with a high rate of 31.68 during the first five years and it decreases with the increase of mean relative growth rate during the middle period of the study, i.e. during 2006 to 2015. The mean doubling time was in peak during the last five years when most of the years found a negative rate of relative growth. There is an opposite trend of association between relative growth rate and doubling time has been noted among the growth of literatures of University of Calcutta.

Table 4a.2.2: Calculation of Relative Growth Rate and Doubling Time

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	180	180	-	5.193	-		-	
2002	179	359	5.193	5.187	-0.006		115.5	
2003	223	582	5.187	5.407	0.22	0.066	3.15	31.68
2004	228	810	5.407	5.429	0.022		31.5	
2005	248	1058	5.429	5.513	0.084		8.25	
2006	255	1313	5.513	5.541	0.028		24.75	
2007	329	1642	5.541	5.796	0.255		2.72	
2008	311	1953	5.796	5.739	-0.057	0.144	12.16	10.12
2009	420	2373	5.739	6.04	0.301		2.30	
2010	455	2828	6.04	6.120	0.08		8.66	
2011	581	3409	6.120	6.365	0.245		2.83	
2012	581	3990	6.365	6.365	0		0	
2013	740	4730	6.365	6.607	0.242	0.104	2.86	18.74
2014	727	5457	6.607	6.589	-0.018		38.5	
2015	717	6174	6.589	6.575	-0.014		49.5	
2016	679	6853	6.575	6.521	-0.054		12.83	
2017	757	7610	6.521	6.629	0.108	0.074	6.42	41.25
2018	681	8291	6.629	6.524	-0.105		6.6	

2019	684	8975	6.524	6.528	0.004	173.25
2020	754	9729	6.528	6.625	0.097	7.14
Total	9729				1.432(0.08)	508.92(26.79)

CP = Cumulative Publications, RGR (P) = Relative Growth Rate of Publications, Dt (P) = Doubling Time of Publications

4a.2.3 Forecasting Research Productivity of University of Calcutta using Trend Analysis

The future trend of the research productivity on any institution could be measured based on the past data available at a regular interval. To assume the future trend the best possible technique is the straight-line equation of trend analysis. Depending on published literature during 2001 to 2020 of University of Calcutta a thirty years projection of growth of literature of the institution has been made (Table 4a.2.3).

Straight-line equation Y= a+b is applied to give the future projection of the research growth of University of Calcutta.

Table 4a.2.3: Trend Analysis of research output of University of Calcutta

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	180	-10	100	-1800
2	2002	179	-9	81	-1611
3	2003	223	-8	64	-1561
4	2004	228	-7	49	-1596
5	2005	248	-6	36	-1488
6	2006	255	-5	25	-1275
7	2007	329	-4	16	-1316
8	2008	311	-3	9	-933
9	2009	420	-2	4	-840
10	2010	455	-1	1	-455
11	2011	581	0	0	0
12	2012	581	1	1	581
13	2013	740	2	4	1480
14	2014	727	3	9	2181
15	2015	717	4	16	2868
16	2016	679	5	25	3395
17	2017	757	6	36	4542
18	2018	681	7	49	4767
19	2019	684	8	64	5472
20	2020	754	9	81	6786
	N=20	$\sum Y=9729$	$\sum X=10$	$\sum X^2=670$	$\sum XY=19197$

To assume the future growth of publications of University of Calcutta Time Series Analysis has been introduced. In this regard, under Time Series Analysis straight line equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 9729 / 20$

$a = 486.45$

$b = \sum XY / \sum X^2$

$b = 19197 / 670$

$b = 28.65$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 486.45 + (28.65 \times 14)$

$Yc = 486.45 + 401.1$

$Yc = 887.55$

Estimated number of publications in 2030, is when

$X = 2030\text{-}2011$ or, $X = 19$

$Yc = a+bX$

$Yc = 486.45 + (28.65 \times 19)$

$Yc = 486.45 + 544.35$

$Yc = 1030.8$

Estimated number of publications in 2040, is when

$X = 2040\text{-}2011$ or, $X = 29$

$Yc = a+bX$

$Yc = 486.45 + (28.65 \times 29)$

$Yc = 486.45 + 830.85$

$Yc = 1317.3$

Estimated number of publications in 2050, is when

$X = 2050\text{-}2011$ or, $X = 39$

$Yc = a+bX$

$Yc = 486.45 + (28.65 \times 39)$

$Yc = 486.45 + 1117.35$

$Yc = 1603.8$

The straight-line equation is introduced to measure the future trend of research productivity of University of Calcutta. The calculation is based on Table 4a.2.3 of trend analysis of University of Calcutta publication productivity.

Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next

thirty years and the publications will be almost doubled in figure. It will be 887 in 2025, 1030 in 2030, 1317 in 2040 and 1603 in 2050.

4a.2.4 Exponential Growth Rate

Table 4a.2.4 describes the exponential growth rate of University of Calcutta's publication for the twenty years of study period, starting from 2001 to 2020. During the period it is found that the growth rate was highest in the year 2009 (1.35) and lowest in 2018 (0.90). The growth rate was negative in the years of 2002 (0.99), 2008 (0.95), 2014 (0.98), 2015 (0.99), 2016 (0.95) and in 2018 (0.90). In these years the number of publications recorded lower than the preceding year. For rest of the years the growth rate was recorded positive.

Table 4a.2.4: Exponential Growth Rate of Publications of University of Calcutta during 2001-2020

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	180	-	1.09
2	2002	179	0.99	
3	2003	223	1.25	
4	2004	228	1.02	
5	2005	248	1.09	
6	2006	255	1.03	
7	2007	329	1.29	
8	2008	311	0.95	
9	2009	420	**1.35 (H)**	
10	2010	455	1.08	
11	2011	581	1.28	
12	2012	581	1.00	
13	2013	740	1.27	
14	2014	727	0.98	
15	2015	717	0.99	1.06
16	2016	679	0.95	
17	2017	757	1.11	
18	2018	681	**0.90 (L)**	
19	2019	684	1.00	
20	2020	754	1.10	
Total		9729		

4a.2.5 Authorship Pattern

The authorship pattern of published literatures by University of Calcutta (Table 4a.2.5) shows the dominance of two-authored papers (23.53%) followed by three-authored

papers (22.76%). The percentage of more than ten-authored papers is very low, only 2.36% of the total share. Only 595 papers (6.12%) recorded as single-authored paper out of total 9729 papers during the study period, which indicates that the authors of this University are more likely favoured the collaborative research work. The dominance of research contributed by researchers of University of Calcutta are mostly consists of two, three, four and five authored papers. In these four groups of authorship, together contributed 7105 papers (73.03%) out of total 9729 papers.

Total 40149 authors occurrences have been identified to publish the total number of 9729 papers at an average rate of 4.13 authors per paper. The highest average authorship found 4.78 in the year 2020 followed by the second highest 4.49 in 2016. The lowest average authorship identified in 2001 with at an average of 2.72 average authorship.

Table 4a.2.5: Distribution of Articles by Authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	180	24	78	38	21	10	9	-	-	489	2.72
2002	179	14	64	38	33	15	14	1	-	580	3.24
2003	223	11	70	67	34	19	21	1	-	740	3.32
2004	228	14	58	60	41	25	28	2	-	826	3.62
2005	248	17	58	53	61	24	31	4	-	945	3.81
2006	255	9	68	62	41	29	42	4	-	1021	4.00
2007	329	20	92	67	62	25	57	6	-	1282	3.90
2008	311	21	82	67	47	38	51	5	-	1187	3.82
2009	420	37	102	98	60	44	71	8	-	1590	3.79
2010	455	29	117	114	76	35	80	4	-	1732	3.81
2011	581	44	132	139	108	56	90	12	-	2298	3.96
2012	581	32	134	139	104	67	98	7	-	2259	3.89
2013	740	52	186	161	110	67	144	20	-	3020	4.08
2014	727	33	177	152	124	85	132	24	-	3098	4.26
2015	717	42	183	169	106	69	125	21	2	3035	4.23
2016	679	41	122	158	110	94	136	17	1	3052	4.49
2017	757	58	161	157	116	67	177	19	2	3371	4.45
2018	681	32	132	152	120	81	142	22	-	2969	4.36
2019	684	38	133	163	95	71	161	23	-	3051	4.46
2020	754	27	140	160	124	88	190	24	1	3604	4.78
Total	9729	595	2289	2214	1593	1009	1799	224	6	40149	4.13
%	100	6.12	23.53	22.76	16.37	10.37	18.49	2.30	0.06	-	-

4a.2.6 Degree of Collaboration of University of Calcutta

It is noted that the degree of collaboration is very high during the study period of University of Calcutta's publications (Table 4a.2.6). It indicates that the authors of this university are intends to publish their work collaboratively rather individually. There are only 595 single-authored papers has been identified among 9729 total papers published during the period of 2001 to 2020. The average degree of collaboration is 0.94 and the maximum degree of collaboration (0.96) reported in 2006 and 2020 which indicates that in these years the rate of collaboration is higher than other years, and the lowest degree of collaboration found in 2001 which indicates the most number of contributions of single-authored papers.

Table 4a.2.6: Degree of Collaboration of University of Calcutta Publications

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC=Nm/ Ns+Nm)
2001	24	156	180	0.87
2002	14	165	179	0.92
2003	11	212	223	0.95
2004	14	214	228	0.94
2005	17	231	248	0.93
2006	9	246	255	0.96
2007	20	309	329	0.94
2008	21	290	311	0.93
2009	37	383	420	0.91
2010	29	426	455	0.94
2011	44	537	581	0.92
2012	32	549	581	0.94
2013	52	688	740	0.93
2014	33	694	727	0.95
2015	42	675	717	0.94
2016	41	638	679	0.94
2017	58	699	757	0.92
2018	32	649	681	0.95
2019	38	646	684	0.94
2020	27	727	754	0.96
Total	595	9134	9729	0.94

4a.2.7 Citation Pattern

Table 4a.2.7: Year-wise citation pattern of University of Calcutta Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	180	37	88	54		1	2695	14.97
2002	179	34	82	61	2		2975	16.62
2003	223	40	109	72	1	1	3766	16.89
2004	228	49	96	82	1		5620	24.65
2005	248	41	118	89			4878	19.67
2006	255	44	111	99	1		4842	18.99
2007	329	60	131	137	1		6584	20.01
2008	311	56	120	134		1	6461	20.77
2009	420	89	170	159	1	1	8624	20.53
2010	455	98	183	172		2	8634	18.98
2011	581	101	263	216		1	9517	16.38
2012	581	98	270	210	2	1	8905	15.33
2013	740	139	323	278			11634	15.72
2014	727	133	341	250	3		9226	12.69
2015	717	109	386	222			8017	11.18
2016	679	103	394	182			6117	9.01
2017	757	139	457	161			5714	7.55
2018	681	147	431	103			3734	5.48
2019	684	219	415	50			2375	3.47
2020	754	444	294	16			762	1.01
Total	9729	2180	4782	2747	12	8	121080	12.45
%	100	22.41	49.15	28,24	0.12	0.08		

The Table 4a.2.7 highlights year-wise citation patterns of publications of University of Calcutta over the period from 2001 to 2020. The greatest number of papers with zero citation recorded in the year of 2020, but this number will change with the time. By analysing the overall scenario, the highest number of papers belongs to citations ranging 1-10 with 4782 papers (49.15%), followed by 2747 papers (28.24%) with citations received in between 11 to 50. The percentage of highly cited papers is very low in respect to total publications during the study period, recorded only 20 papers which has at least 50 citations or more.

4a.2.8 Document Types

The study considers only five types of documents to measure the performance of research output of University of Calcutta's literatures. The types limited to only Journal Articles, Conference Papers, Book Chapters, Reviews and Books. It is noted that (table 4a.2.8) during the study period of twenty years, University of Calcutta produces total 9729 research publications, out of which most are published as Journal Articles with

8750 (89.94%) papers, followed by Book Chapters- 329 (3.38%), Conference Papers – 325 (3.34%), Reviews- 286 (2.94%) and 39 Books. In 2020 the most number of Journal Articles recorded, i.e. 686 out of 754 total papers published in that year.

Table 4a.2.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	166	12	-	2	-	180
2002	171	4	-	4	-	179
2003	207	9	-	7	-	223
2004	210	7	-	11	-	228
2005	220	17	2	9	-	248
2006	236	12	2	5	-	255
2007	298	15	10	6	-	329
2008	287	9	5	10	-	311
2009	373	14	26	6	1	420
2010	405	20	20	8	2	455
2011	514	15	31	18	3	581
2012	531	24	13	12	1	581
2013	655	23	39	16	7	740
2014	651	18	46	9	3	727
2015	655	31	21	9	1	717
2016	610	18	24	22	5	679
2017	660	23	38	29	7	757
2018	600	26	26	26	3	681
2019	615	14	22	28	5	684
2020	686	14	4	49	1	754
Total	8750	325	329	286	39	9729
%	89.94	3.34	3.38	2.94	0.40	100

4a.2.9 Most Productive Channels of Communication

Table 4a.2.9 highlights the top twenty most preferred journals by the faculties and researchers of University of Calcutta. These top journals were identified based on the number of articles published during the study period. Some of the most favored journals are Journal of The Indian Chemical Society (166), Polyhedron (130), Inorganic Chimica Acta (88). The subject areas covered by these journals are basically from Chemistry, Polymer Science, Zoology, Physics, Natural Sciences, Interdisciplinary etc. Among these top twenty journals seven of them published by Elsevier and Springer, Wiley, American Institute of Physics produced two journals each among the top list.

Out of total 9729 papers 1413 papers (14.52%) published by these twenty journals. The relative importance of a journal in a domain is measurable by the impact factor of that journal, and all the top journals identified in communicating University of Calcutta research belongs to high impact factor journals, out of the twenty top journals 10 of them having impact factor of more than 2.

Table 4a.2.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area	Impact Factor	Frequency
1	Journal of The Indian Chemical Society	Elsevier	Chemistry	0.284	166
2	Polyhedron	Elsevier	Chemistry	3.052	130
3	Inorganica Chimica Acta	Elsevier	Chemistry	2.545	88
4	Journal of Applied Polymer Science	Wiley	Polymer science	3.125 (2020)	84
5	Proceedings of The Zoological Society	Springer	Zoology	-	84
6	Indian Journal of Experimental Biology	CSIR-NISCAIR	Experimental Biology	0.818 (JCR 2020)	81
7	Dalton Transactions	Royal Society of Chemistry	Chemistry	4.052 (2018)	73
8	Journal of Applied Physics	American Institute of Physics	Physics	2.546 (2020)	73
9	Tetrahedron Letters	Elsevier	Organic chemistry	2.379 (2014)	70
10	Plos One	PLOS	Interdisciplinarity	3.24 (2020)	67
11	Scientific Reports	Nature Portfolio	Natural Sciences	5.133 (2020)	66
12	Inorganic Chemistry	ACS Publications	Inorganic Chemistry	-	63
13	International Journal of Biological Macromolecules	Elsevier	Biochemistry	6.953 (2021)	62
14	Current Science	Current Science Association & Indian Academy of Sciences	Interdisciplinarity	1.102 (2020)	58
15	Carbohydrate Polymers	Elsevier	Glycoscience	-	54
16	Indian Journal of Physics	Springer	Physics	1.407 (2019)	54
17	Aip Conference Proceedings	American Institute of Physics	Physics	-	52
18	Journal of Molecular Structure	Elsevier ScienceDirect	Chemistry	3.196	52
19	Physical Review	American Physical Society	Particles Fields Gravitation and Cosmology	-	50
20	Chemistryselect	Wiley-VCH	Chemistry	2.109 (2020)	49

4a.2.10 Most Productive Authors

Productive authors are identified based on the number of articles produced by an author during a period. Among the forty thousand author occurrences during the period top twenty authors is listed according to their producing number of publications (Table 4a.2.10). The table also highlights the total contribution of the authors as indexed in Scopus with their total received citations. h-index is calculated based on the total publications and received total citations during whole life of the top authors affiliated to University of Calcutta. Table also provides the Scopus id of the authors, which will be useful to trace the progress of their publication growth in any point of time. In terms of published data during the study period acharya, k. (214 publications) noted as the most productive author with 5822 citations and h-index of 40. Followed by ghosh, a. (209 publications) and guchhait, n. (170 publications) were the productive authors. ghosh, a. noted in the first position in terms of h-index whereas his actual position is 2nd in terms of number of publications.

Table 4a.2.10: Most Productive Authors during the study period under University of Calcutta Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	acharya, k.	7005757775	214	300	5822	40
2	ghosh, a.	57196479964	209	293	7994	50
3	guchhait, n.	6602654730	170	242	4755	36
4	sarkar, s.k.	56670664800	127	147	4269	36
5	de, u.c.	7007046738	120	213	1224	18
6	mohanta, s.	6602614538	105	122	3445	34
7	saha, g.k.	7007185397	105	137	1203	20
8	bera, s.	7006818815	99	137	1593	20
9	mukhopadhyay, c.	7006107630	92	95	1498	23
10	saha, a.	57198513128	91	136	1785	21
11	mukherjee, a.	35427888100	76	126	3119	32
12	bishayi, b.	6603429787	74	85	1083	18
13	pramanik, a.	7006732373	72	117	1612	22
14	chattopadhyay, d.	56207587800	71	246	4219	34
15	aditya, g.	14424208900	70	104	1037	20
16	jha, s.	7202726898	70	116	1613	22
17	bhattacharyya, a.	57201696278	69	89	2066	24
18	sen, p.	57210528886	69	107	1539	17

19	gangopadhyay, g.	7003321520	67	89	990	16
20	Ghosh, M.	57192431407	66	103	1308	19

4a.2.11 Subject area wise performance

The subject areas mostly associated of research publications produced during the period 2001 to 2020 by University of Calcutta scholars, faculty members and others are presented in table 4a.2.11, where top twenty most contributed subject fields are shown with their corresponding number of documents. The top five most productive subject fields are Chemistry (2230), Physics and Astronomy (2047), Biochemistry, Genetics and Molecular Biology (1874), Materials Science (1166) and Pharmacology, Toxicology and Pharmaceutics (1037). Other productive subjects are Environmental Science, Medicine, Mathematics etc. The contribution from Social Sciences (416), Economics, Econometrics and Finance (260), Multidisciplinary (257) and Arts and Humanities (154) are relatively very less than the science-based subjects.

Table 4a.2.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Chemistry	2230
2	Physics and Astronomy	2047
3	Biochemistry, Genetics and Molecular Biology	1874
4	Materials Science	1166
5	Pharmacology, Toxicology and Pharmaceutics	1037
6	Environmental Science	983
7	Medicine	965
8	Mathematics	903
9	Earth and Planetary Sciences	687
10	Immunology and Microbiology	436
11	Social Sciences	416
12	Economics, Econometrics and Finance	260
13	Multidisciplinary	257
14	Energy	172
15	Arts and Humanities	154
16	Decision Sciences	141
17	Business, Management and Accounting	134
18	Neuroscience	109
19	Psychology	77
20	Health Professions	67

4a.2.12 Collaboration with Other Countries

A total of 129 collaborative countries are noted with which the authors of University of Calcutta collaborated their research work. Top twenty most collaborative countries are listed in table 4a.2.12. Authors of this university published their articles mostly with the authors of countries like United States (536 papers), United Kingdom (358 papers), Spain (210 papers), Italy (197 papers) and Germany (159 papers). There are plenty of countries where only very few numbers of collaborative papers are also seen among those 129 countries.

Table 4a.2.12: Country wise Collaboration of Research Outputs of University of Calcutta

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	United States	536	10698	19.96	920
2	United Kingdom	358	8323	23.25	674
3	Spain	210	5530	26.33	446
4	Italy	197	4597	23.33	528
5	Germany	159	2979	18.74	458
6	France	158	2601	16.46	437
7	China	152	3145	20.69	418
8	Japan	143	2840	19.86	314
9	Canada	134	2717	20.28	206
10	South Korea	102	1097	10.75	261
11	Australia	81	1439	17.77	197
12	Russian Federation	77	1494	19.40	283
13	South Africa	69	802	11.62	164
14	Taiwan	67	1648	24.59	121
15	Belgium	66	1667	25.26	194
16	Sweden	62	639	10.31	115
17	Poland	61	627	10.28	197
18	Portugal	58	654	11.28	157
19	Brazil	56	1275	22.77	207
20	Turkey	56	406	7.25	145

Country wise collaboration network map has been shown (figure 4a.2.2) where the countries published most number of documents are networked in the figure in respect to association among each other which is denoted with the link strength. There are 49 countries have been identified based on the criteria like minimum number of documents to be published with Calcutta University authors is at least 10 and at least one citation to be received by that document. The countries with most number of documents

published in collaboration to Calcutta University authors are United States and United Kingdom, the total link strength for both these countries are 920 and 674 respectively.

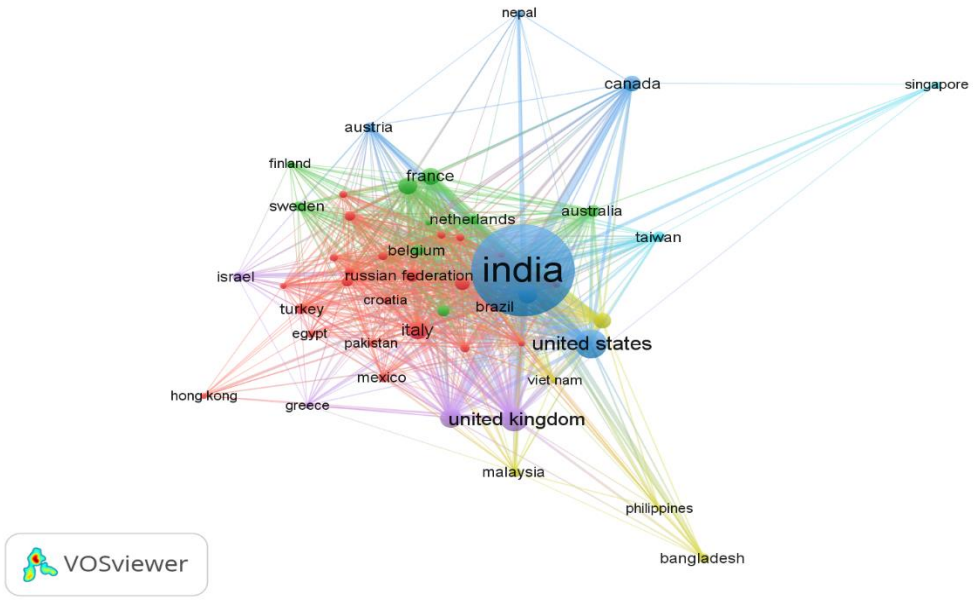

Figure 4a.2.2 Network visualization of Country wise Collaboration of University of Calcutta Publications

Minimum Document of Country- 10, Minimum Citation – 1, out of the 131 countries 49 meet the threshold and Six Clusters identified. Top five clusters are –

Cluster 1: 23 Countries	*Cluster 2: 9 Countries*	*Cluster 3: 6 Countries*	*Cluster 4: 5 Countries*	*Cluster 5: 4 Countries*
Brazil, Chile, Croatia, Czech Republic, Egypt, Hong Kong, Hungary, Iran, Italy, Mexico, New Zealand, Norway, Oman, Pakistan, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, South Korea, Switzerland, Thailand, Turkey	Australia, Belgium, Bulgaria, Finland, France, Germany, Netherlands, South Africa, Sweden	Austria, Canada, China, India, Nepal, United States	Bangladesh, Japan, Malaysia, Philippines, Vietnam	Greece, Israel, Spain, United Kingdom

There are six clusters has been found based on the association among the countries in which the cluster one consists with 23, cluster two 9 and cluster three 6 countries respectively. These clusters denote the association among the countries in respect to collaboration and received citation for a particular document.

4a.2.13 Collaboration with other organizations

The most of the percentage of publications published by University of Calcutta Faculties and Research Scholars noted as collaborative papers. Table 4a.2.13 shows the collaboration of institutes with University of Calcutta authors published between 2001 to 2020. The greatest number of papers published by University of Calcutta authors are collaborated with Jadavpur University (556), Bose Institute (251), Saha Institute of Nuclear Physics (225), Indian Institute of Chemical Biology (218) and Indian Association for the Cultivation of Science (201). University of Calcutta authors preferred to publish their research work with the researchers mostly of research institutions rather the state or private universities. There are some state universities are also in the top list of collaboration, viz. Jadavpur University, University of Kalyani, The University of Burdwan, Presidency University, Kolkata Vidyasagar University etc.. Among the international institutions University of Reading, Universitat de Barcelona are also there in the top list of collaboration.

Table 4a.2.13 Collaboration with other Organizations

Sl. No.	Affiliation Name	Publication Count
1	Jadavpur University	556
2	Bose Institute	251
3	Saha Institute of Nuclear Physics	225
4	Indian Institute of Chemical Biology	218
5	Indian Association for the Cultivation of Science	201
6	Indian Statistical Institute, Kolkata	191
7	Indian Institute of Technology Kharagpur	158
8	Institute of Radio Physics and Electronics India	153
9	University of Kalyani	148
10	University of Reading	147
11	The University of Burdwan	119
12	Presidency University, Kolkata	102
13	Indian Institute of Engineering Science and Technology, Shibpur	100
14	Bidhan Chandra Krishi Viswavidyalaya	96
15	Vidyasagar College	94
16	Medical College and Hospital Kolkata	93
17	Visva-Bharati University	93
18	Vidyasagar University	89
19	Institute of Post Graduate Medical Education and Research Kolkatta	87
20	Universitat de Barcelona	82

4a.3 University of Burdwan

4a.3.1 Growth of Literature: Year-wise distribution of Publications

Growth of literature were analysed based on the year-wise distribution of number of publications of University of Burdwan during the study period. A total of 3288 documents were got indexed during a span of twenty years in Elsevier's Scopus database in the affiliation of University of Burdwan. Starting from 70 publications in 2001 it increases to 162 in 2010 and 262 in 2020, indicates that the numbers are almost doubled in every ten years. More than 250 papers were noted in four years, i.e. in 2014, 2015, 2019 and 2020 respectively.

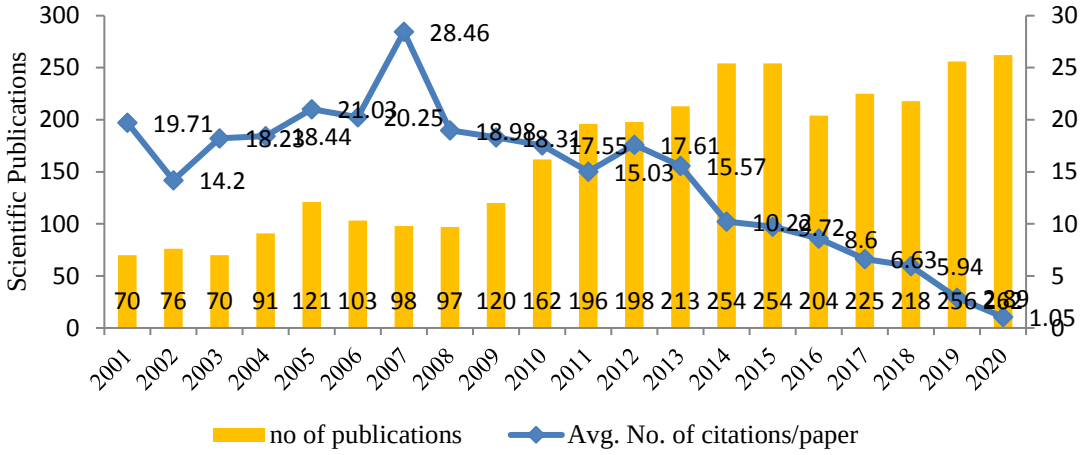

Figure 4a.3.1: Year-wise Publications of University of Burdwan

Table 4a.3.1 also shows the year-wise received citations against the number of publications in a year. Highest number of citations were noted 3487 for 198 publications at an average of 17.61 citation/paper in 2012. 2007 noted to be the highest average citation with 28.46, followed by 21.03 in 2005 and 20.25 in 2006. The citations relatively lower from 2014-15 onwards (Figure 4a.3.1), this is because these publications have not spent enough time after their publishing year. With time it is expected that the scenario of citation will change.

Table 4a.3.1: Growth of Literature: Year-wise distribution of Scientific Literature of University of Burdwan

Year	Publications	CP	%	Cited by	ACP
2001	70	70	2.13	1380	19.71
2002	76	146	2.31	1079	14.2
2003	70	216	2.12	1276	18.23

2004	91	307	2.77	1678	18.44
2005	121	428	3.68	2545	21.03
2006	103	531	3.13	2086	20.25
2007	98	629	2.98	2789	28.46
2008	97	726	2.95	1841	18.98
2009	120	846	3.65	2197	18.31
2010	162	1008	4.93	2843	17.55
2011	196	1204	5.96	2945	15.03
2012	198	1402	6.02	3487	17.61
2013	213	1615	6.48	3317	15.57
2014	254	1869	7.73	2596	10.22
2015	254	2123	7.73	2468	9.72
2016	204	2327	6.20	1755	8.60
2017	225	2552	6.84	1491	6.63
2018	218	2770	6.63	1294	5.94
2019	256	3026	7.79	740	2.89
2020	262	3288	7.97	274	1.05
Total	3288			40087	12.19

TP = Total papers; CP = cumulative publications; ACP= Average Citation per Publication

4a.3.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

It is observed from Table 4a.3.2 that the relative growth rates have decreased gradually over the time. The year Started with a downward rate in 2003 (-0.083) when the publication reduces from the preceding year. In the year 2010 recorded the highest relative growth rate (0.301) followed by 0.285 in 2005 and 0.263 in 2004. The whole study period has been divided into four block of five years each and the highest mean relative growth rate (0.147) has been recorded during the period of 2006 to 2010 and the lowest mean relative growth rate (0.09) noted during the period from 2011 to 2015.

Contrarily, the mean doubling time has increased from 3.87 in first five years to above 17 in the second and third five years block and it again decreases to near 7 in the last five years of the study period. There is an opposite trend of association between relative growth rate and doubling time has been noticed, when the relative growth rate is high then the doubling time will be less.

Table 4a.3.2: Calculation of Relative Growth Rate (RGR) and Doubling Time (Dt)

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	70	70	-	4.248	-		-	
2002	76	146	4.248	4.331	0.083		8.35	
2003	70	216	4.331	4.248	-0.083	0.143	8.35	3.87
2004	91	307	4.248	4.511	0.263		2.64	
2005	121	428	4.511	4.796	0.285		2.43	
2006	103	531	4.796	4.635	-0.161		4.30	
2007	98	629	4.635	4.585	-0.05		13.86	
2008	97	726	4.585	4.575	-0.01	0.147	69.3	18.15
2009	120	846	4.575	4.787	0.212		3.27	
2010	162	1008	4.787	5.088	0.301		2.30	
2011	196	1204	5.088	5.278	0.19		3.65	
2012	198	1402	5.278	5.288	0.01		69.3	
2013	213	1615	5.288	5.361	0.073	0.09	9.49	17.28
2014	254	1869	5.361	5.537	0.176		3.94	
2015	254	2123	5.537	5.537	0		0	
2016	204	2327	5.537	5.318	-0.219		3.16	
2017	225	2552	5.318	5.416	0.098		7.07	
2018	218	2770	5.416	5.384	-0.032	0.107	21.66	7.24
2019	256	3026	5.384	5.545	0.161		4.30	
2020	262	3288	5.545	5.568	0.023		30.13	
Total	3288				1.32 (0.7)		267.5 (14.08)	

CP = Cumulative Publications, RGR (P) = Relative Growth Rate of Publications, Dt (P) = Doubling Time of Publications

4a.3.3 Forecasting Research Productivity of University of Burdwan using Trend Analysis

Based on the previous data, projection of future growth is quite likely. In this regard, straight line equation under trend analysis is applied for the projection of next thirty years growth of publications of University of Burdwan.

Table 4a.3.3: Growth of Literature: Trend Analysis of research output in University of Burdwan

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	70	-10	100	-700
2	2002	76	-9	81	-684
3	2003	70	-8	64	--560
4	2004	91	-7	49	-637
5	2005	121	-6	36	-726
6	2006	103	-5	25	-515
7	2007	98	-4	16	-392
8	2008	97	-3	9	-291

9	2009	120	-2	4	-240
10	2010	162	-1	1	-162
11	2011	196	0	0	0
12	2012	198	1	1	198
13	2013	213	2	4	426
14	2014	254	3	9	762
15	2015	254	4	16	1016
16	2016	204	5	25	1020
17	2017	225	6	36	1350
18	2018	218	7	49	1526
19	2019	256	8	64	2048
20	2020	262	9	81	2358
	N=20	$\sum Y=3288$	$\sum X=10$	$\sum X^2=670$	$\sum XY=5797$

To assume the future growth of publications of University of Burdwan Trend Analysis has been introduced. In this regard, under Trend Analysis straight line equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 3288/20$

$a = 164.4$

$b = \sum XY / \sum X^2$

$b = 5797/670$

$b = 8.65$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 164.4 + (8.65 \times 14)$

$Yc = 164.4 + 12.1$

$Yc = 285.5$

Estimated number of publications in 2030, is when

$X = 2030\text{-}2011$ or, $X = 19$

$Yc = a+bX$

$Yc = 164.4 + (8.65 \times 19)$

$Yc = 164.4 + 164.35$

$Yc = 328.75$

Estimated number of publications in 2040, is when

$X = 2040\text{-}2011$ or, $X = 29$

$Yc = a+bX$

$Yc = 164.4 + (8.65 \times 29)$

$Yc = 164.4 + 250.85$

$Yc = 415.25$

Estimated number of publications in 2050, is when

X = 2050-2011 or, X = 39

Yc = a+bX

Yc = 164.4+ (8.65×39)

Yc = 164.4+ 337.35

Yc = 501.75

The straight-line equation is introduced to measure the future trend of research productivity of University of Burdwan. The calculation of trend analysis is based on table 4a.3.3 of University of Burdwan publication productivity.

Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next thirty years and the number of publications will be almost doubled in figure. It will be 285 in 2025, 328 in 2030, 415 in 2040 and 501 in 2050.

4a.3.4 Exponential Growth Rate

Starting from 2001 to 2020, the exponential growth rate of research publications of University of Burdwan has been shown in table 4a.3.4. During the period it is found that the growth rate was highest in the year 2010 with exponential rate of 1.35 and in 2005 it is 1.33. whereas the lowest rate recorded in the year 2016 (0.80). The growth rate was negative in the years of 2003 (0.92), 2006 (0.85), 2007 (0.95), 2008 (0.99), 2016 (0.80) and in 2018 (0.97). In these years the number of publications recorded lower than the preceding year, for rest of the years the growth rate was recorded positive. If the whole study period is divided into two decades, it is noted that the average growth rate during first ten years (1.11) is higher than the last ten years (1.06).

Table 4a.3.4: Exponential Growth Rate of Research Publications of University of Burdwan during 2001-2020

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	70	-	
2	2002	76	1.09	
3	2003	70	0.92	
4	2004	91	1.30	
5	2005	121	1.33	1.11
6	2006	103	0.85	
7	2007	98	0.95	
8	2008	97	0.99	
9	2009	120	1.24	

10	2010	162	**1.35 (H)**	
11	2011	196	1.21	
12	2012	198	1.01	
13	2013	213	1.08	
14	2014	254	1.19	
15	2015	254	1.00	
16	2016	204	**0.80 (L)**	
17	2017	225	1.10	
18	2018	218	0.97	1.06
19	2019	256	1.17	
20	2020	262	1.02	
Total		3288		

4a.3.5 Authorship Pattern

Authorship pattern helps to understand the overall collaboration scenario of the institution's researchers preferred. Under the affiliation of University of Burdwan a total of 3288 publications were got indexed in Scopus during the study period, and together all these publications consist total 12235 author occurrences at an average rate of 3.72 authors per paper.

Table 4a.3.5: Distribution of articles by authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	70	4	13	23	13	13	4	-	-	243	3.47
2002	76	5	18	15	14	14	10	-	-	272	3.63
2003	70	2	18	20	11	13	6	-	-	249	3.56
2004	91	6	24	16	12	16	15	2	-	378	4.15
2005	121	10	29	27	27	12	15	1	-	442	3.65
2006	103	8	22	28	21	13	10	1	-	381	3.70
2007	98	6	22	25	22	11	12	-	-	349	3.56
2008	97	11	26	27	12	11	10	-	-	316	3.26
2009	120	12	41	25	19	10	13	-	-	381	3.18
2010	162	6	43	43	19	26	24	1	-	630	3.89
2011	196	10	63	38	25	21	38	1	-	718	3.66
2012	198	7	65	42	20	23	40	1	-	739	3.73
2013	213	11	48	49	23	19	59	4	-	900	4.23
2014	254	16	66	69	34	16	53	-	-	931	3.66
2015	254	18	68	62	29	37	37	3	-	939	3.70
2016	204	10	62	41	39	21	30	1	-	744	3.65
2017	225	20	65	41	37	23	38	1	-	816	3.63
2018	218	22	56	44	35	29	30	2	-	806	3.70
2019	256	13	76	69	36	24	34	4	-	945	3.69
2020	262	8	83	53	36	22	55	5	-	1056	4.03

Total	3288	205	908	757	484	374	533	27	0	12235	3.72
%	100	6.23	27.62	23.02	14.72	11.37	16.21	0.82	0	-	-

Among all the publications, the most number of papers found as double authored paper, total 908 papers (27.61%) were in this category, followed by 757 papers (23.02%) published as three authored papers. Only 205 papers (6.23%) found as single authored paper, which indicates that the authors of this university are intends towards collaborative works rather individual publication.

4a.3.6 Degree of Collaboration of University of Burdwan Research Publications

The table 4a.3.6 represents the year wise number of multi-authored articles and their degree of collaboration. The analysis of degree of collaboration of all the years is almost same as the overall average value, i.e 0.94. The analysis also shows that during the study period of twenty years the multi authorship articles are higher and predominant than single authorship. Only 205 papers are recorded as single author paper. Highest 0.97 degree of collaborations noted in 2003 and 2020 and the lowest 0.89 in 2008.

Table 4a.3.6: Degree of Collaboration of University of Burdwan Publications

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC=Nm/Ns+Nm)
2001	4	66	70	0.94
2002	5	71	76	0.93
2003	2	68	70	0.97
2004	6	85	91	0.93
2005	10	111	121	0.92
2006	8	95	103	0.92
2007	6	92	98	0.94
2008	11	86	97	0.89
2009	12	108	120	0.9
2010	6	156	162	0.96
2011	10	186	196	0.95
2012	7	191	198	0.96
2013	11	202	213	0.95
2014	16	238	254	0.94
2015	18	236	254	0.93
2016	10	194	204	0.95
2017	20	205	225	0.91
2018	22	196	218	0.9
2019	13	243	256	0.95
2020	8	254	262	0.97
Total	205	3083	3288	0.94

4a.3.7 Citation Pattern

Citation is one of the many indicators by which impact of published literatures of a researcher or of any institution can be measured. During a span of twenty years a total of 3288 papers got indexed in Scopus under the affiliation of University of Burdwan (table 4a.3.7). At the time of data collection for this study, all these papers got together total 40087 citations at an average of 12.19 citations per paper. Among all the publications 615 documents (18.71%) were noted as zero citation whereas 145 documents found over 50 citations. There are 852 papers with citations ranging from 11 to 50. 2012 and 2013 were noted to be among the highest total received citations but in respect to highest average received citation 2007 is in the top with 28.46 average citations per paper. The citations for last few years are very low because the publications have not spent enough time after their published year.

Table 4a.3.7: Year-wise Citation Pattern of University of Burdwan Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	70	8	25	30	5	2	1380	19.71
2002	76	9	36	28	2	1	1079	14.2
2003	70	4	32	29	4	1	1276	18.23
2004	91	7	38	37	7	2	1678	18.44
2005	121	5	57	47	8	4	2545	21.03
2006	103	10	43	36	10	4	2086	20.25
2007	98	5	47	35	6	5	2789	28.46
2008	97	9	50	27	8	3	1841	18.98
2009	120	10	60	43	5	2	2197	18.31
2010	162	17	75	58	8	4	2843	17.55
2011	196	32	89	67	4	4	2945	15.03
2012	198	24	98	62	7	7	3487	17.61
2013	213	32	101	66	11	3	3317	15.57
2014	254	37	138	73	4	2	2596	10.22
2015	254	43	144	62	4	1	2468	9.72
2016	204	38	112	50	4		1755	8.60
2017	225	39	129	57			1491	6.63
2018	218	42	143	30	3		1294	5.94
2019	256	82	161	13			740	2.89
2020	262	162	98	2			274	1.05
Total	3288	615	1676	852	100	45	40087	12.19
%	100	18.71	50.97	25.91	3.04	1.37		

4a.3.8 Document Types

Five types of documents were considered for the present study and year wise distribution of these documents is presented in table 4a.3.8. Among all the documents most number of percentage belongs to Journal Articles (91.82%). Apart from the journal articles there are 108 book chapters, 95 reviews and 54 conference papers were also found. Maximum 241 journal articles were published in 2020, followed by 230 journal articles found in 2014. Highest number of Book Chapters i.e. 31 were recorded in the year 2019.

Table 4a.3.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	67	1	-	2	-	70
2002	74	1	-	1	-	76
2003	70	-	-	-	-	70
2004	88	-	-	3	-	91
2005	120	-	-	1	-	121
2006	100	2	-	1	-	103
2007	91	3	3	1	-	98
2008	92	1	1	3	-	97
2009	110	3	5	1	1	120
2010	154	3	-	4	1	162
2011	182	2	3	9	-	196
2012	183	4	3	8	-	198
2013	200	3	4	6	-	213
2014	230	6	10	6	2	254
2015	226	4	16	5	3	254
2016	186	3	9	6	-	204
2017	190	9	15	10	1	225
2018	196	3	6	10	3	218
2019	219	-	31	6	-	256
2020	241	6	2	12	1	262
Total	3019	54	108	95	12	3288
%	91.82	1.64	3.28	2.89	0.36	100

4a.3.9 Most Productive Channels of Communication

There were many journals with high impact factor where the publications of University of Burdwan authors preferred. Among the all top twenty most productive journals are listed in table 4a.3.9. The top three journals produced most number of articles are

published by Elsevier and out of top twenty nine of them are published by Elsevier. Three Springer journals are also there in the top. In the top twenty ten of them are impact factor of over 2. Chemistry, Physics and other science journals are top producing journals among the all, only one Humanities and Social Sciences journal is also there. Spectrochimica Acta (84 articles), Journal of The Indian Chemical Society (75 articles) and Polyhedron (64 articles) are the top three journals most number of articles.

Table 4a.3.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area/ Disciplines	Impact Factor	Frequency
1	Spectrochimica Acta	Elsevier	Molecular and Biomolecular Spectroscopy	4.098 (2020)	84
2	Journal of The Indian Chemical Society	Elsevier	Chemistry	0.284	75
3	Polyhedron	Elsevier	Chemistry	3.052	64
4	Indian Journal of Chemistry	CSIR-NISCAIR	Inorganic Physical Theoretical and Analytical Chemistry	0.491 (JCR 2020)	47
5	Journal of Molecular Structure	Elsevier ScienceDirect	Chemistry	3.196	37
6	Proceedings of The Zoological Society	Springer	Zoology	-	36
7	Inorganica Chimica Acta	Elsevier	Chemistry	2.545	34
8	Journal of Coordination Chemistry	Taylor & Francis Online	Chemistry	1.751 (2020)	31
9	Journal of Molecular Liquids	Elsevier	Physics, Atomic, Molecular & Chemical	6.165	29
10	Transition Metal Chemistry	Springer	Metal-based Molecular Compounds	1.588 (2020)	29
11	Dalton Transactions	Royal Society of Chemistry	Chemistry	4.052 (2018)	28
12	Chemical Physics Letters	Elsevier	Chemical physics, Physical chemistry	2.029 (2019)	26
13	Journal of Chemical Sciences	Springer	Chemistry	1.406 (2019)	26
14	Research on Chemical Intermediates	Springer	Chemical Intermediates	-	26
15	Space and Culture India	ACCB Publishing, England	Humanities and Social Sciences	-	26
16	Journal of Magnetism and Magnetic Materials	Elsevier	Magnetism, Magnet	2.993 (2020)	25
17	Journal of Optics India	Springer	Optics – Pure & Applied	-	25
18	Materials Chemistry and Physics	Elsevier	Materials Science	4.094 (2020)	25

19	Aip Conference Proceedings	American Institute of Physics	Physics	-	24
20	International Journal of Biological Macromolecules	Elsevier	Biochemistry	6.953 (2021)	22

4a.3.10 Most Productive Authors

During the period from 2001 to 2020 there were 3288 papers has been identified under the affiliation of University of Burdwan. 12235 author occurrences have been recorded to publish these publications at an average rate of 3.72 authorship per document. Among those, top twenty authors according to their number of published documents has been identified. The citations are counted according to their total publications during the whole life. During the study period the most productive authors are Ghosh, B.K. (125 publications), Chandra, G. (101 publications) and Bhattacharya, S. (95 publications), Das, D. (95 publications). Das, D. has in the fourth position according to the numbers of publications but he has the highest h-index with 44 for all his published documents.

Table 4a.3.10: Most Productive Authors during the study period under University of Burdwan Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	Ghosh, B.K.	7202485673	125	158	3301	29
2	Chandra, G.	7004990495	101	128	2531	26
3	Bhattacharya, S.	35478598800	95	116	1644	21
4	Das, D.	7402352987	95	271	6315	44
5	Chattopadhyay, P.	7102432547	87	138	3177	30
6	Ghosh, R.	35586111800	79	104	1273	21
7	Mondal, N.K.	8906059500	72	105	1756	22
8	Mukherjee, A.K.	56892559200	72	126	1916	24
9	Pradhan, S.K.	57192655816	67	191	3696	33
10	Ray, B.	7201965468	67	91	3352	33
11	Shaikh, A.A.	20436852600	65	90	587	13
12	Laskar, S.	7004040671	64	93	1018	19
13	Saha, B.	24459083100	63	137	3368	30
14	Sinha, C.	7102111901	60	392	6755	42
15	Banerjee, M.	7201743772	59	99	1045	17
16	Barik, A.	8382891900	59	72	765	17
17	Bhar, K.	31567467400	58	67	747	17

18	Mukhopadhyay, S.K.	36951870900	57	97	2522	30
19	Basu, S.	7403655983	53	84	610	13
20	Ghosh, A.K.	55448412700	53	78	374	11

4a.3.11 Subject area wise performance

Subject area wise distribution of published literature between 2001 to 2020 under the affiliation of University of Burdwan is shown in table 4a.3.11. Chemistry found to be the most productive subject domain with 1033 total papers in twenty years, followed by Physics and Astronomy (716 articles) and Agricultural and Biological Sciences (535 articles). Except Science based subjects, 219 Social Science, 146 Economics and only 82 Arts & Humanities publications are also noted.

Table 4a.3.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Chemistry	1033
2	Physics and Astronomy	716
3	Agricultural and Biological Sciences	535
4	Biochemistry, Genetics and Molecular Biology	479
5	Materials Science	424
6	Environmental Science	347
7	Mathematics	319
8	Social Sciences	219
9	Medicine	215
10	Pharmacology, Toxicology and Pharmaceutics	193
11	Immunology and Microbiology	175
12	Economics, Econometrics and Finance	146
13	Earth and Planetary Sciences	95
14	Business, Management and Accounting	83
15	Arts and Humanities	82
16	Energy	81
17	Multidisciplinary	60
18	Decision Sciences	48
19	Veterinary	21
20	Psychology	10

4a.3.12 Collaboration with Other Countries

The number of papers collaborated by the authors of University of Burdwan with the authors of other countries is presented in table 4a.3.12. A total of sixty-seven collaborative countries were identified during the period out of which top twenty are shown. There were countries also with very few papers collaborated with this university

authors. The highest collaboration found with the authors of Taiwan, where 79 documents were identified and all these documents received 1681 citations at an average rate of 21.28 citations per paper. Followed by United States and Spain with 66 and 60 documents respectively collaborated with University of Burdwan. The link strength describes the association among the collaborative countries in respect to number of contributed articles and number of received citations. there were countries like Saudi Arabia, Iran, Israel, Slovakia is also listed in the top list collaborated with the authors of this university.

Table 4a.3.12: Country wise collaboration of research output of University of Burdwan

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	Taiwan	79	1681	21.28	111
2	United States	66	1339	20.29	109
3	Spain	60	1424	23.73	96
4	France	45	3096	68.8	173
5	Italy	43	2526	58.74	159
6	United Kingdom	42	752	17.90	70
7	Germany	40	3308	82.7	175
8	South Korea	40	260	6.5	63
9	Malaysia	33	767	23.24	62
10	Japan	32	2633	82.28	150
11	Iran	31	574	18.52	79
12	Russian Federation	25	2383	95.32	157
13	Poland	22	2316	105.27	146
14	Saudi Arabia	19	163	8.58	38
15	Australia	18	178	9.89	45
16	Portugal	18	1824	101.33	129
17	Switzerland	18	2224	123.55	134
18	Czech Republic	17	1975	116.18	122
19	Israel	16	2237	139.81	125
20	Slovakia	14	147	10.5	16

Figure 4a.3.2 shows the countries collaboration according to their association. All these countries are associated with India, and here India belongs to only authors from University of Burdwan.

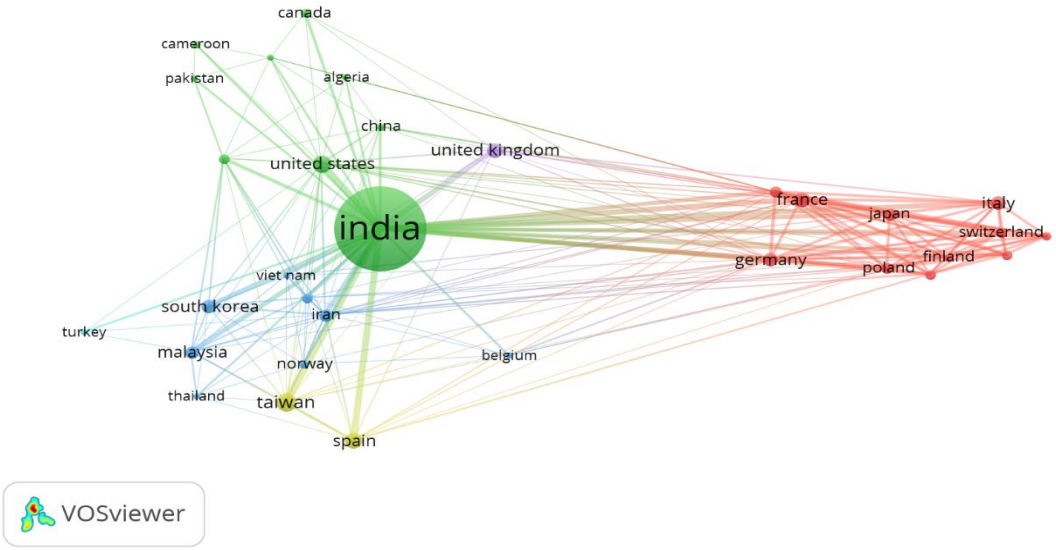

Figure 4a.3.2 Network visualization of Country wise Collaboration of University of Burdwan Publications

Minimum document of a country- 10, Minimum citation – 1, out of the 67 countries 32 meet the threshold and Six Clusters identified. Top five clusters are –

Cluster 1: 11 Countries	*Cluster 2: 9 Countries*	*Cluster 3: 8 Countries*	*Cluster 4: 5 Countries*	*Cluster 5: 3 Countries*
Czech Republic, Finland, France, Germany, Israel, Italy, Japan, Poland, Portugal, Russian Federation, Switzerland	Algeria, Cameroon, Canada, Pakistan, Saudi Arabia, South Africa, United States	Australia, Belgium, Iran, Malaysia, Norway, South Korea, Thailand, Vietnam	Taiwan, Spain, Norway, Belgium, Iran	United Kingdom, France, Germany

By considering minimum documents published with a country is 10 and minimum citation to be received is 1, out of total 67 collaborative countries 32 meet the condition and total six different clusters were identified based on their linking to each other. The cluster one (red) consists 11 countries, viz. Czech Republic, Finland, France, Israel, Italy, Japan, Poland, Portugal, Russian Federation and Switzerland. Cluster 2 consists with 9 countries (green), Cluster 3 consisting 8 countries (blue) are the most prominent in the visualization map indicating a strong association among each other.

4a.3.13 Collaboration with Other Organizations

Table 4a.3.13: Collaboration with other Organizations

Sl. No.	Affiliation Name	Publication Count
1	University of Calcutta	117
2	Indian Association for the Cultivation of Science	100
3	Bhabha Atomic Research Centre	96
4	Jadavpur University	77
5	Saha Institute of Nuclear Physics	73
6	Visva-Bharati University	56
7	University of Kalyani	51
8	National Institute of Technology, Durgapur	49
9	National Tsing Hua University	34
10	Hooghly Mohsin College	30
11	Universitat de Barcelona	27
12	Banaras Hindu University	26
13	Vidyasagar University	24
14	Durgapur Government College	23
15	Bankura Christian College	22
16	University Sains Malaysia	20
17	Academia Sinica Taiwan	20
18	M.U.C. Women's College	20
19	Raniganj Girls College	19
20	Academia Sinica, Institute of Atomic and Molecular Sciences	19

The authors of University of Burdwan published their research work in collaboration to authors of other various institutes. Among those University of Calcutta is in the top position with which total 117 publications were published by University of Burdwan's authors during the period. Followed by Indian Association for the Cultivation of Science (100 publications), Bhabha Atomic Research Centre (96 publications) and Jadavpur University (77 publications). Some other universities and research institutes from the state and outside the state are also in the top list collaborating with the authors of University of Burdwan. Among them, Banaras Hindu University, University of Kalyani, Visva-Bharati University, Vidyasagar University etc. are present. Few international institutes are also there in the top list of collaboration, viz. National Tsing Hua University, Universitat de Barcelona, University Sains Malaysia etc.

4a.4 University of Kalyani

4a.4.1 Growth of Literature: Year-wise distribution of Scientific Literature of University of Kalyani

University of Kalyani is one of the growing universities in West Bengal. Since its inception in 1960 the University had kept growing in all the sectors, viz by opening new departments, building infrastructure, growing number of students, progressing to higher degrees and so on. The table 4a.4.1 describes the year wise publications during the time span of twenty years from 2001 to 2020. During the period a total of 3396 publications got indexed in Scopus under the affiliation of University of Kalyani. Highest number of documents noted in the year of 2013 when 262 documents were published. From 2010 onwards the growth had taken a rapid shift maintaining approximately 200 or more publications every year.

Table 4a.4.1: Year-wise distribution of Scientific Literature of University of Kalyani

Year	Publications	CP	%	Cited by	ACP
2001	58	58	1.71	826	14.24
2002	103	161	3.03	1251	12.15
2003	92	253	2.71	2810	30.54
2004	90	343	2.65	2399	26.66
2005	94	437	2.77	1493	15.88
2006	109	546	3.21	1533	14.06
2007	114	660	3.36	1705	14.96
2008	139	799	4.09	2786	20.04
2009	157	956	4.62	2382	15.17
2010	195	1151	5.74	2875	14.74
2011	197	1348	5.80	3352	17.01
2012	197	1545	5.80	2636	13.38
2013	262	1807	7.71	3167	12.09
2014	255	2062	7.51	2357	9.24
2015	210	2272	6.18	1671	7.96
2016	220	2492	6.48	1537	6.99
2017	234	2726	6.89	1402	5.99
2018	218	2944	6.42	1127	5.17
2019	215	3159	6.33	638	2.97
2020	237	3396	6.98	297	1.25
Total	3396			38244	11.26

TP = Total papers; CP = cumulative publications; ACP= Average Citation per Publication

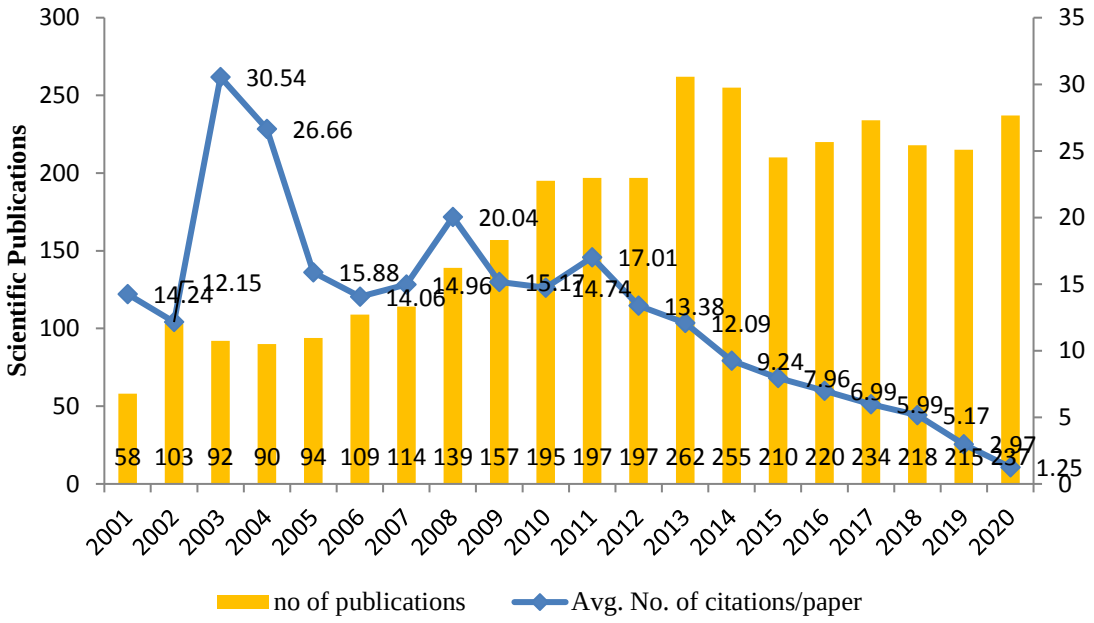

Figure 4a.4.1: Year-wise Publications of University of Kalyani

A total of 38244 citations had also recorded during the data collection of the study at an average rate of 11.26 citations per document. Highest total citations recorded in the year 2011 when 3352 citations were counted for 197 publications at an average rate of 17.01 citations per document. In 2013, 3167 citations were counted for 262 publications at an average rate of 12.06 citations per document. 2003 recorded as the highest average received citations with 30.54 average citation per document. Figure 4a.4.1 shows the year wise distribution of documents with it's average received citations. The average citation is decreasing over the years because the recent published documents has not reached yet to many researchers, who may cite these literatures in their work. So, with time it is obvious that the scenario of citation count will change with a growing trend.

4a.4.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

It is noted from Table 4a.4.2 that the Mean Relative Growth Rate of the publications of university of Kalyani have decreased gradually during the time 2001 to 2020. The year 2002 started with a high relative growth rate (0.575) when the publication increases from 58 to 103 in the following year. But the next two following years i.e. in 2003 and 2004 both are noted as negative rate of growth. The highest relative growth rate (0.575) is also in the 2002, followed by the second highest in 2013 (0.285). The whole study period has been divided into four block of five years each and the highest mean relative

growth rate (0.151) has been recorded during the period of 2001 to 2005 and the lowest mean relative growth rate (0.058) noted during the period from 2016 to 2020.

Table 4a.4.2: Calculation of Relative Growth Rate (RGR) and Doubling Time (Dt)

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	58	58	-	4.060	-		-	
2002	103	161	4.060	4.635	0.575		1.205	
2003	92	253	4.635	4.522	-0.113	0.151	6.133	10.99
2004	90	343	4.522	4.50	-0.022		31.5	
2005	94	437	4.50	4.543	0.043		16.116	
2006	109	546	4.543	4.691	0.148		4.682	
2007	114	660	4.691	4.736	0.045		15.4	
2008	139	799	4.736	4.934	0.198	0.146	3.5	6.49
2009	157	956	4.934	5.056	0.122		5.68	
2010	195	1151	5.056	5.273	0.217		3.194	
2011	197	1348	5.273	5.283	0.01		69.3	
2012	197	1545	5.283	5.283	0		0	
2013	262	1807	5.283	5.568	0.285	0.103	2.432	20.19
2014	255	2062	5.568	5.541	-0.027		25.67	
2015	210	2272	5.541	5.347	-0.194		3.572	
2016	220	2492	5.347	5.394	0.047		14.744	
2017	234	2726	5.394	5.455	0.061		11.361	
2018	218	2944	5.455	5.384	-0.071	0.058	9.761	18.5
2019	215	3159	5.384	5.371	-0.014		49.5	
2020	237	3396	5.371	5.468	0.097		7.144	
Total	3396				1.407 (0.074)		280.894 (14.78)	

CP = Cumulative Publications, RGR (P) = Relative Growth Rate of Publications, Dt (P) = Doubling Time of Publications

The mean doubling time is associated with relative growth rate in an inversely proportional relation, means when relative growth rate increases the doubling time will be decrease and on the decreasing of the relative growth rate will cause the increases of doubling time. During the first five years the mean RGR is 0.151 and the doubling time is 10.99 during the time. The lowest doubling time is seen during 2006 to 2010 when the doubling time measured 6.49 only but after that the time increases in the next two blocks of five years each when the highest time is seen during 2011 to 2016 with 20.19. There is an opposite trend of association between relative growth rate and doubling time has been noticed.

4a.4.3 Forecasting Research Productivity of University of Kalyani using Trend Analysis

To forecast the research productivity in the upcoming days the best possible technique is the application of straight-line equation under trend analysis. The future trend of the research productivity could be measured based on the past data available at a regular interval. Here based on the two decadal data (from 2001 to 2020), a projection of research growth of next thirty years has been calculated (Table 4a.4.3).

Straight-line equation Y= a+b is applied to give the future projection of the research growth of University of Kalyani.

Table 4a.4.3: Trend Analysis of research output of University of Kalyani

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	58	-10	100	-580
2	2002	103	-9	81	-927
3	2003	92	-8	64	-736
4	2004	90	-7	49	-630
5	2005	94	-6	36	-564
6	2006	109	-5	25	-545
7	2007	114	-4	16	-456
8	2008	139	-3	9	-417
9	2009	157	-2	4	-314
10	2010	195	-1	1	-195
11	2011	197	0	0	0
12	2012	197	1	1	197
13	2013	262	2	4	524
14	2014	255	3	9	765
15	2015	210	4	16	840
16	2016	220	5	25	1100
17	2017	234	6	36	1404
18	2018	218	7	49	1526
19	2019	215	8	64	1720
20	2020	237	9	81	2310
	N=20	$\sum Y=3396$	$\sum X=10$	$\sum X^2=670$	$\sum XY=5022$

To assume the future growth of publications of University of Kalyani, Trend Analysis has been introduced. In this regard, under Trend Analysis straight line equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 3396 / 20$

$a = 169.8$

$b = \sum XY / \sum X^2$

$b = 5022 / 670$

$b = 7.50$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 169.8 + (7.50 \times 14)$

$Yc = 169.8 + 105$

$Yc = 274.8$

Estimated number of publications in 2030, is when

$X = 2030\text{-}2011$ or, $X = 19$

$Yc = a+bX$

$Yc = 169.8 + (7.50 \times 19)$

$Yc = 169.8 + 142.5$

$Yc = 312.3$

Estimated number of publications in 2040, is when

$X = 2040\text{-}2011$ or, $X = 29$

$Yc = a+bX$

$Yc = 169.8 + (7.50 \times 29)$

$Yc = 169.8 + 217.5$

$Yc = 387.5$

Estimated number of publications in 2050, is when

$X = 2050\text{-}2011$ or, $X = 39$

$Yc = a+bX$

$Yc = 169.8 + (7.50 \times 39)$

$Yc = 169.8 + 292.5$

$Yc = 462.3$

The straight-line equation is introduced to measure the future trend of research productivity of University of Kalyani (table 4a.4.3). Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next thirty years and the publications will be almost doubled in figure. It will be 274 in 2025, 312 in 2030, 387 in 2040 and 462 in 2050.

4a.4.4 Exponential Growth Rate

It is observed from table 4a.4.4 that the exponential growth rate of University of Kalyani research is higher in between 2001 to 2010 than the following ten years i.e. from 2011 to 2020. The growth rate was highest in the year 2002 (1.78) and lowest in 2015 (0.82). The growth rate was negative in the years of 2003 (0.89), 2004 (0.98), 2014 (0.97), 2015 (0.82), 2018 (0.93) and in 2019 (0.99). In these six years the number of publications recorded lower than the preceding year. For rest of the years the growth rate was recorded positive. It was continuous growth has been there from 2005 to 2013, in these eight years there was no downward has been seen in the publications recorded by University of Kalyani.

Table 4a.4.4: Exponential Growth Rate of Research Publications in University of Kalyani

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	58	-	
2	2002	103	**1.78 (H)**	
3	2003	92	0.89	
4	2004	90	0.98	
5	2005	94	1.04	1.17
6	2006	109	1.16	
7	2007	114	1.05	
8	2008	139	1.22	
9	2009	157	1.13	
10	2010	195	1.24	
11	2011	197	1.01	
12	2012	197	1.00	
13	2013	262	1.33	
14	2014	255	0.97	
15	2015	210	**0.82 (L)**	1.03
16	2016	220	1.05	
17	2017	234	1.06	
18	2018	218	0.93	
19	2019	215	0.99	
20	2020	237	1.10	
Total		3396		

4a.4.5 Authorship Pattern

It is observed from table 4a.4.5 that the authors of this university are favoured to publish their documents in collaboration rather individually. Out of total 3396 documents only 142 publications (4.18%) found as single authored. The most number of papers found as double authored papers, where 962 publications (28.33%) is belongs to this category, following next three authored papers (823 publications) are the in the second highest position. There are 37 publications identified where more than 10 authors are used to publish a document. To publish these 3396 publications total 12770 author occurrences has also been identified at an average rate of 3.76 authors per paper. Most number of single authored papers found in the year 2013 when 13 single authored papers were recorded.

Table 4a.4.5: Distribution of Articles by Authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	58	5	31	10	7	3	2	-	-	152	2.62
2002	103	6	45	29	12	8	3	-	-	289	2.81
2003	92	12	28	24	14	6	7	1	-	282	3.07
2004	90	3	46	25	11	2	3	-	-	244	2.71
2005	94	1	32	34	10	5	11	1	-	321	3.41
2006	109	2	37	28	22	11	7	2	-	378	3.47
2007	114	5	26	43	17	10	11	2	-	409	3.59
2008	139	5	44	45	19	13	12	1	-	471	3.39
2009	157	7	49	43	28	15	15	-	-	523	3.33
2010	195	7	34	56	36	28	32	2	-	768	3.94
2011	197	10	71	36	33	14	30	3	-	716	3.63
2012	197	6	38	58	38	20	34	3	-	789	4.01
2013	262	13	71	56	45	29	46	2	-	986	3.76
2014	255	8	59	58	60	23	46	1	-	1003	3.93
2015	210	10	59	52	39	22	27	1	-	751	3.58
2016	220	9	66	47	36	29	33	-	-	804	3.65
2017	234	10	72	49	31	28	40	3	1	1018	4.35
2018	218	8	59	34	36	24	56	1	-	910	4.17
2019	215	8	52	30	46	29	46	4	-	913	4.25
2020	237	7	43	66	37	25	50	9	-	1043	4.40
Total	3396	142	962	823	577	344	511	36	1	12770	3.76
%	100	4.18	28.33	24.23	16.99	10.13	15.05	1.06	0.03	-	-

4a.4.6 Degree of Collaboration of University of Kalyani Research Publications

Degree of collaboration helps to understand the rate of collaboration of publications published by an institute, an individual or group of individuals in each subject field. Maximum rate of collaboration (0.99) identified in the year 2004 when only one single paper was identified out of 94 published literatures. Whereas, 2003 noted to be the lowest collaborative year with degree of collaboration of 0.87 denoting maximum number of single authored paper (12). The overall degree of collaboration identified 0.96 for all the years of the study period.

Table 4a.4.6: Degree of Collaboration of University of Kalyani Publications

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC)=Nm/ Ns+Nm
2001	5	53	58	0.91
2002	6	97	103	0.94
2003	12	80	92	0.87 **(L)**
2004	3	87	90	0.97
2005	1	93	94	0.99 **(H)**
2006	2	107	109	0.98
2007	5	109	114	0.96
2008	5	134	139	0.96
2009	7	150	157	0.96
2010	7	188	195	0.96
2011	10	187	197	0.95
2012	6	191	197	0.97
2013	13	249	262	0.95
2014	8	247	255	0.97
2015	10	200	210	0.95
2016	9	211	220	0.96
2017	10	224	234	0.96
2018	8	210	218	0.96
2019	8	207	215	0.96
2020	7	230	237	0.97
Total	142	3254	3396	0.96

4a.4.7 Citation Pattern

The table 4a.4.7 describes the citation pattern of publications of University of Kalyani during the period from 2001 to 2020. A total of 38244 citations recorded for 3396 papers at an average of 11.26 citations per paper. Highest percent of papers i.e. 1713 (50.44%) lies in between 1-10 citations, followed by 940 papers (27.68%) having citation ranges between 11-50. The percentage of highly cited papers was very low in

respect to total ratio, only 3.06 percent of the total papers recorded 50 or more citations. 2003 and 2004 recorded highest average citations with 30.54 and 26.66 citations per paper respectively.

Table 4a.4.7: Year-wise Citation Pattern of University of Kalyani Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	58	5	31	20		2	826	14.24
2002	103	12	53	36	1	1	1251	12.15
2003	92	5	40	35	8	4	2810	30.54
2004	90	6	49	31	1	3	2399	26.66
2005	94	6	49	33	4	2	1493	15.88
2006	109	6	60	40	3		1533	14.06
2007	114	15	53	40	4	2	1705	14.96
2008	139	13	58	55	8	5	2786	20.04
2009	157	14	67	68	8		2382	15.17
2010	195	22	87	76	8	2	2875	14.74
2011	197	22	86	79	6	4	3352	17.01
2012	197	25	88	75	9		2636	13.38
2013	262	42	120	90	7	3	3167	12.09
2014	255	45	131	76	3		2357	9.24
2015	210	35	121	52	2		1671	7.96
2016	220	42	131	46	1		1537	6.99
2017	234	60	131	41	1	1	1402	5.99
2018	218	44	142	31	1		1127	5.17
2019	215	73	130	12			638	2.97
2020	237	147	86	4			297	1.25
Total	3396	639	1713	940	75	29	38244	11.26
%	100	18.82	50.44	27.68	2.21	0.85		

4a.4.8 Document Types

Journal Articles, Conference Papers Book Chapters Reviews and Books are considered for this study (table 4a.4.8). Among these five categories almost 90% published as Journal Articles by the authors of University of Kalyani. There are only124 Review Articles, 105 Conference Papers, 102 Book Chapters and 19 Books were identified as indexed in Scopus during the time. Maximum number of Journal article (221 articles) recorded in the last year of the study i.e. in 2020.

Table 4a.4.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	55	3	-	-	-	58
2002	97	-	-	6	-	103
2003	74	5	-	13	-	92
2004	85	1	-	4	-	90
2005	86	2	-	6	-	94
2006	105	1	-	3	-	109
2007	98	4	3	8	1	114
2008	131	3	-	5	-	139
2009	145	4	1	5	2	157
2010	175	12	5	3	-	195
2011	183	6	2	4	2	197
2012	175	12	2	8	-	197
2013	223	13	14	9	3	262
2014	224	1	23	6	1	255
2015	197	7	1	5	-	210
2016	196	13	3	7	1	220
2017	200	8	20	2	4	234
2018	187	9	11	10	1	218
2019	189	1	15	6	4	215
2020	221	-	2	14	-	237
Total	3046	105	102	124	19	3396
%	89.69	3.09	3.00	3.65	0.56	100

4a.4.9 Most Productive Channels of Communication

In twenty years of the study period there were quite a few journals have been used to communicate the research by the authors of University of Kalyani. Among all of them top twenty most productive in terms of number of documents published has been listed in table 4a.4.9. Out of those top Journals, publisher details, covered subject areas, Impact Factor of the journal's has also been there. It is noted that most of these journals are from basic science subjects, viz. Chemistry, Biochemistry, Physics etc. Elsevier and Springer journals are mostly preferred by the authors of this university and most of them are high impact factor journals too. In the top list there is only one Interdisciplinary Journal. i.e. *Current Science* has placed at the bottom of the table. *Tetrahedron Letters* (109 articles) and *Journal of The Indian Chemical Society* (83 articles) are the top two most productive journals from the field of Chemistry.

Table 4a.4.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area	Impact Factor	Frequency
1	Tetrahedron Letters	Elsevier	Organic chemistry	2.379 (2014)	109
2	Journal of The Indian Chemical Society	Elsevier	Chemistry	0.284	83
3	Synthetic Communications	Taylor & Francis	organic chemistry	2.007 (2020)	50
4	Polyhedron	Elsevier	Chemistry	3.052	47
5	Cytologia	Japan Mendel Society	Biology, Life Sciences and Basic Medicine	-	41
6	Aip Conference Proceedings	American Institute of Physics	Physics	-	39
7	Chemistryselect	Wiley-VCH	Chemistry	2.109 (2020)	39
8	Synlett	Thieme Medical Publishers	Chemistry	2.369 (2017)	33
9	Journal of Molecular Structure	Elsevier ScienceDirect	Chemistry	3.196	28
10	Molecular and Cellular Biochemistry	Springer	Biochemistry, Cell biology, Molecular biology	3.396 (2020)	28
11	Tetrahedron	Elsevier	Organic chemistry	2.379 (2014)	27
12	Inorganica Chimica Acta	Elsevier	Chemistry	2.545	26
13	Journal of Parasitic Diseases	Springer	Parasitology	1.21	24
14	Bulletin of Environmental Contamination and Toxicology	Springer	Air, Soil, Water, and Food contamination and Pollution	2.151 (2020)	23
15	Supramolecular Chemistry	Taylor and Francis	Chemistry	1.688 (2020)	23
16	Indian Journal of Physics	Springer	Physics	1.407 (2019)	22
17	Zeitschrift Fur Physikalische Chemie	Walter de Gruyter	Physical chemistry	1.356 (2014)	22
18	Indian Journal of Biochemistry and Biophysics	CSIR-NISCAI	Biochemistry and Biophysics	-	20
19	Transition Metal Chemistry	Springer	Transition metal-based molecular compounds	1.588 (2020)	20
20	Current Science	Current Science Association in collaboration with the Indian Academy of Sciences (India)	Interdisciplinarity	1.102 (2020)	18

4a.4.10 Most Productive Authors

A total of 12770 author occurrences has been identified for 3396 documents published during the period at an average of 3.76 authorship per document. Among all the authors top twenty most productive authors during the time has been listed in table 4.4.10. The table also highlights the total publications of these authors during whole life and for that all the published documents their total received citation and based on that citation data at the time of data collection h-index of the authors has also been calculated. Majumdar, K.C. with 229 documents is in the top position, followed by Khuda-Bukhsh, A.R. and Ghosh, K. are the next two top authors with 141 and 111 documents respectively. Majumdar, K.C. is in the top according to the other two indicators also that is based on total received citation and h-index, for his whole publications he received 7489 citations with h-index of 40. Chakraborti, T. (105 documents), Chakraborti, S. (91 documents) and Chatterjee, D. (90 documents) are the other most productive authors of this university. These top listed authors mostly are from the field of Basic Science subjects.

Table 4a.4.10: Most Productive Authors during the study period under University of Kalyani Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	Majumdar, K.C.	7101739371	229	379	7489	40
2	Khuda-Bukhsh, A.R.	7004060951	141	190	4573	39
3	Ghosh, K.	7201768385	111	168	3099	28
4	Chakraborti, T.	7004512762	105	129	3186	22
5	Chakraborti, S.	7006780923	91	155	3518	24
6	Chatterjee, D.	7102524767	90	110	4402	32
7	Santra, S.C.	7006693521	76	98	2077	26
8	Bandyopadhyay, P.K.	7102767187	74	85	406	10
9	Datta, A.K.	7402110534	69	85	567	13
10	Biswas, J.K.	56697928500	62	100	1354	21
11	Islam, S.M.	7202012997	62	160	3462	31
12	Lahiri, I.	7004250720	61	73	555	9
13	Bagchi, A.	9432485400	56	110	498	10
14	Kaviraj, A.	7003280599	52	77	1166	17
15	Chakrabarti, A.	7202579089	50	83	1238	19
16	Jana, B.B.	7006521710	50	131	1232	19
17	Datta, S.K.	7401498381	48	92	51	4
18	Roy, B.	8285516400	48	64	1105	18

19	Banerjee, A.	56843329000	47	101	336	10
20	Chattopadhyay, S.K.	7403001884	46	96	1800	22

4a.4.11 Subject area wise performance

Chemistry, Biochemistry, Genetics and Molecular Biology, Agricultural and Biological Sciences, Physics and Astronomy, Environmental Science, Mathematics these are the most productive subject areas produced maximum number of literatures from University of Kalyani authors. Social Sciences, Multidisciplinary, Economics and Arts and Humanities publications are less compared to the science-based subjects. Chemistry produced most number of papers (1032), followed by Biochemistry, Genetics and Molecular Biology (820) and Agricultural and Biological Sciences (510). There are only 94 publications found from social science and 28 from Arts and Humanities in Scopus indexed during the twenty years of study period.

Table 4a.4.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Chemistry	1032
2	Biochemistry, Genetics and Molecular Biology	820
3	Agricultural and Biological Sciences	510
4	Physics and Astronomy	485
5	Environmental Science	424
6	Mathematics	394
7	Pharmacology, Toxicology and Pharmaceutics	392
8	Materials Science	370
9	Medicine	297
10	Immunology and Microbiology	132
11	Earth and Planetary Sciences	118
12	Social Sciences	94
13	Multidisciplinary	80
14	Economics, Econometrics and Finance	57
15	Decision Sciences	49
16	Business, Management and Accounting	37
17	Energy	32
18	Health Professions	30
19	Arts and Humanities	28
20	Veterinary	17

4a.4.12 Collaboration with Other Countries

Authors of total 61 collaborative countries published their documents with the authors of University of Kalyani. Table 4a.4.12 shows the top twenty most collaborative countries contributing maximum number of documents during the time span of twenty years. Table also shows the received and average citations for the published documents in collaboration to a particular country. The link strength denotes the degree of association of the country with other countries. Authors from United States contributed maximum number of articles (148) with the authors of University of Kalyani, followed by Germany (96 publications) and France (55 publications) are in second and third position respectively. Papers published with United States authors has got the maximum number of citations with an average rate of 17.09 citation per document.

Table 4a.4.12: Country wise collaboration of research output of University of Kalyani

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	United States	148	2529	17.09	234
2	Germany	96	1634	17.02	187
3	France	55	1425	25.91	74
4	United Kingdom	48	1764	36.75	85
5	Australia	42	673	16.02	100
6	Sweden	42	1076	25.62	103
7	Spain	37	761	20.57	82
8	Taiwan	37	734	19.84	73
9	Italy	24	570	23.75	55
10	Switzerland	24	579	24.13	42
11	South Korea	23	476	20.69	61
12	China	22	375	17.04	61
13	Portugal	21	446	21.24	36
14	Japan	20	421	21.05	41
15	Poland	19	328	17.26	34
16	Turkey	16	276	17.25	31
17	Belgium	14	354	25.29	32
18	Canada	14	238	17	31
19	Russian Federation	11	202	18.36	29
20	Thailand	11	225	20.45	33

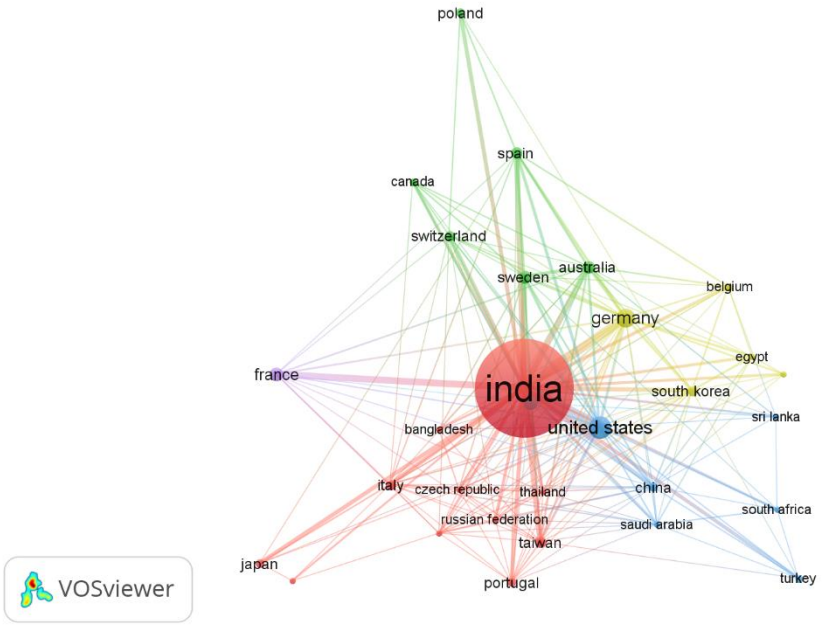

Figure 4a.4.2 Network visualization of Country wise Collaboration of University of Kalyani Publications

Minimum Document of Country- 10, Minimum Citation – 1, out of the 61 countries 31 meet the threshold and Six Clusters identified. Top four clusters are –

Cluster 1: 11 Countries	*Cluster 2: 6 Countries*	*Cluster 3: 6 Countries*	*Cluster 4: 5 Countries*
Bangladesh, Brazil, Czech Republic, India, Italy, Japan, Mexico, Portugal, Russian Federation, Taiwan, Thailand	Australia, Canada, Poland, Spain, Sweden, Switzerland	China, Saudi Arabia, South Africa, Sri Lanka, Turkey, United States	Belgium, Egypt, Germany, Greece, South Korea

The network visualization map (figure 4a.4.2) shows the clusters depending on the group of countries which are contributing by associating among themselves. Considering minimum document published by a country is10 and minimum 1 citation to be received, out of the total 61 countries 31 found fulfilling the condition. All total six clusters were identified among which 4 of them mentioned above. Cluster 1 consisting 11 countries, cluster 2 with 6 countries. The countries present in a cluster means there is a strong association in terms of collaboration among those countries.

4a.4.13 Collaboration with Other Organizations

University of Calcutta and Jadavpur University found as the most collaborative institution of Kalyani University publications. During the period 148 documents collaborated by the University of Kalyani authors with University of Calcutta authors and 99 documents published with the authors of Jadavpur University. Bidhan Chandra Krishi Viswavidyalaya, Indian Statistical Institute, Kolkata, Visva-Bharati University are the other most collaborative institutions. In the top list there are some research and technology intuitions as well with whom the authors of this university published their research works.

Table 4a.4.13: Collaboration with Other Organizations

Sl. No.	Affiliation Name	Publication Count
1	University of Calcutta	148
2	Jadavpur University	99
3	Bidhan Chandra Krishi Viswavidyalaya	65
4	Indian Statistical Institute, Kolkata	60
5	Visva-Bharati University	54
6	Indian Association for the Cultivation of Science	52
7	The University of Burdwan	51
8	Indian Institute of Chemical Biology	37
9	The Royal Institute of Technology KTH	33
10	Presidency University, Kolkata	29
11	Kalyani Government Engineering College	28
12	Indian Institute of Science Education and Research Kolkata	28
13	University of North Bengal	27
14	Saha Institute of Nuclear Physics	27
15	Bose Institute	26
16	B.P. Poddar Institute of Management and Technology	25
17	Rajbari	24
18	Universitat de Girona	23
19	Shibpur Dinobundhoo Institution College	23
20	Assam University	21

4a.5 University of North Bengal

4a.5.1 Growth of Literature: Year-wise distribution of Publications and Average Citations

Year wise distribution of articles and average citation is presented in figure 4a.5.1. it is noticed that the publications have taken a rapid shift from 2009 onwards and the curve of average citation is downwards from 2013. The cause of downwards of the average citations may be for many reasons but the most important is that these articles has not spent enough time to reach to the researchers. It may be expected that with time this scenario will change and the line of average citation will go upwards.

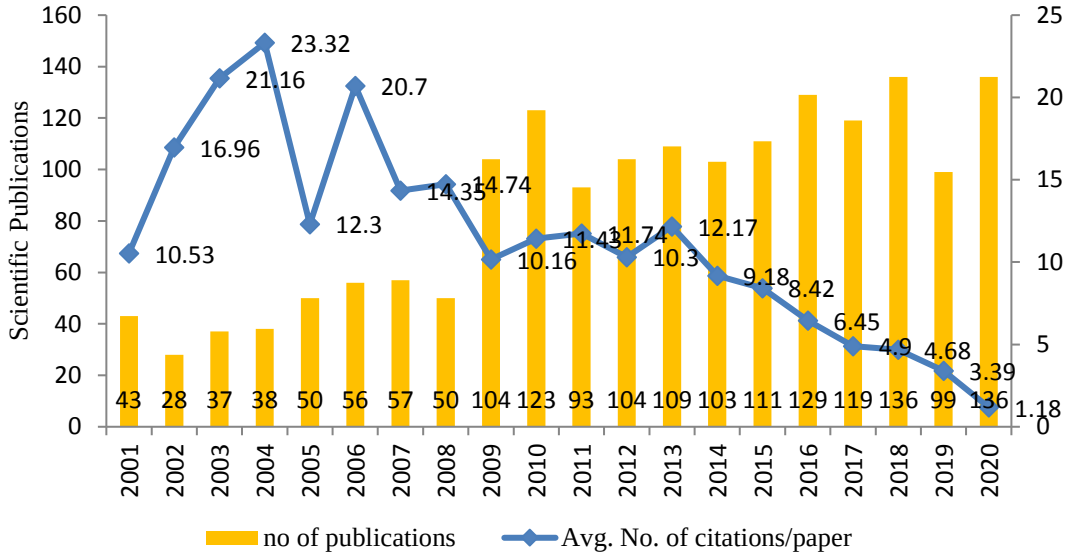

Figure 4a.5.1: Year-wise Publications of University of North Bengal

The table 4a.5.1 shows the exact number of publications identified during the period from 2001 to 2020 as got indexed in Scopus database under the affiliation of University of North Bengal. The year 2001 started with 43 publications but next three years it shows a decreasing rate and from 2005 onwards it was almost positive in every year. A rapid shift from 2009 has been noticed where 109 publications recorded in the year which is more than double from the previous year. The peak of the year of publications found in 2018 and 2020 when 136 publications recorded in both the years, followed by 129 publications in 2016 and 123 publications in 2010. A total of

16307 citations were identified at the time of data collection of the study for the 1725 articles published during the period at an average rate of 11.40 citations per document.

Table 4a.5.1 Year-wise distribution of Publications of University of North Bengal

Year	Publications	CP	%	Cited by	ACP
2001	43	43	2.49	453	10.53
2002	28	71	1.62	475	16.96
2003	37	108	2.14	783	21.16
2004	38	146	2.20	886	23.32
2005	50	196	2.90	615	12.30
2006	56	252	3.25	1159	20.70
2007	57	309	3.30	818	14.35
2008	50	359	2.90	737	14.74
2009	104	463	6.03	1057	10.16
2010	123	586	7.13	1406	11.43
2011	93	679	5.39	1092	11.74
2012	104	783	6.03	1071	10.30
2013	109	892	6.32	1326	12.17
2014	103	995	5.97	946	9.18
2015	111	1106	6.43	935	8.42
2016	129	1235	7.48	832	6.45
2017	119	1354	6.90	583	4.90
2018	136	1490	7.88	636	4.68
2019	99	1589	5.74	336	3.39
2020	136	1725	7.88	161	1.18
Total	1725			16307	11.40

TP = Total papers; CP = Cumulative Publications; ACP= Average Citation per Publication

4a.5.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

The Relative Growth Rate of the research productivity of University of North Bengal started with negatively in the year 2002 (-0.429) when the publications decreased to 28 in 2002 from 43 in the year 2001. Then, positive growth was seen till 2007 and from 2009 a steady growth has been noticed during the period. Highest Relative Growth Rate is noticed in 2009 (0.732). The average Relative Growth Rate of Publications of University of North Bengal is 0.186 over the period. The Doubling Time of the publications is correlated with the relative Growth Rate of Publications in an inversely proportion ratio. Means, when the growth rate is high then the doubling time of the publications will be low, based on the Relative Growth Rate during the middle period,

i.e. from 2006 to 2015 the Doubling Time is noted higher than the first and last five years of the study.

Table 4a.5.2: Calculation of Relative Growth Rate (RGR) and Doubling Time (Dt)

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	43	43	-	3.761	-		-	
2002	28	71	3.761	3.332	-0.429		1.615	
2003	37	108	3.332	3.611	0.279	0.202	2.484	6.46
2004	38	146	3.611	3.638	0.027		25.67	
2005	50	196	3.638	3.912	0.274		2.529	
2006	56	252	3.912	4.025	0.113		6.133	
2007	57	309	4.025	4.043	0.018		38.5	
2008	50	359	4.043	3.912	-0.131	0.232	5.29	10.1
2009	104	463	3.912	4.644	0.732		0.947	
2010	123	586	4.644	4.812	0.168		4.125	
2011	93	679	4.812	4.533	-0.279		2.484	
2012	104	783	4.533	4.644	0.111		6.243	
2013	109	892	4.644	4.691	0.047	0.114	14.745	9.02
2014	103	995	4.691	4.635	-0.056		12.375	
2015	111	1106	4.635	4.71	0.075		9.24	
2016	129	1235	4.71	4.86	0.15		4.62	
2017	119	1354	4.86	4.78	-0.08		8.663	
2018	136	1490	4.78	4.913	0.133	0.198	5.211	4.58
2019	99	1589	4.913	4.60	-0.313		2.214	
2020	136	1725	4.60	4.913	0.313		2.214	
Total	1725				0.186 (Avg.)		7.765 (Avg.)	

CP = Cumulative Publications, RGR (P) = Relative Growth Rate of Publications, Dt (P) = Doubling Time of Publications

4a.5.3 Forecasting Research Productivity of University of North Bengal using Trend Analysis

The future trend of the research productivity has been measured based on the past data available at a regular interval. To assume the future trend the best possible technique is the straight-line equation of trend analysis. Depending on published literature during 2001 to 2020 of University of North Bengal a thirty years projection of growth of literature of the institution has been made (Table 4a.5.3).

Straight-line equation Y= a+b is applied to give the future projection of the research growth of University of North Bengal.

Table 4a.5.3: Trend Analysis of research output of University of North Bengal

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	43	-10	100	-430
2	2002	28	-9	81	-252
3	2003	37	-8	64	-296
4	2004	38	-7	49	-266
5	2005	50	-6	36	-300
6	2006	56	-5	25	-280
7	2007	57	-4	16	-228
8	2008	50	-3	9	-150
9	2009	104	-2	4	-208
10	2010	123	-1	1	-123
11	2011	93	0	0	0
12	2012	104	1	1	104
13	2013	109	2	4	218
14	2014	103	3	9	309
15	2015	111	4	16	444
16	2016	129	5	25	645
17	2017	119	6	36	714
18	2018	136	7	49	952
19	2019	99	8	64	792
20	2020	136	9	81	1224
	N=20	$\sum Y=1725$	$\sum X=10$	$\sum X^2=670$	$\sum XY=2869$

To assume the future growth of publications of University of North Bengal Trend Analysis has been introduced. In this regard, under Trend Analysis straight line equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 1725 / 20$

$a = 86.25$

$b = \sum XY / \sum X^2$

$b = 2869 / 670$

$b = 4.28$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 86.25 + (4.28 \times 14)$

$Yc = 86.25 + 59.92$

$Yc = 146.17$

Estimated number of publications in 2030, is when

X = 2030-2011 or, X = 19

Yc = a+bX

Yc = 86.25+ (4.28×19)

Yc = 86.25+ 81.32

Yc = 167.57

Estimated number of publications in 2040, is when

X = 2040-2011 or, X = 29

Yc = a+bX

Yc = 86.25+ (4.28×29)

Yc = 86.25+ 124.12

Yc = 210.37

Estimated number of publications in 2050, is when

X = 2050-2011 or, X = 39

Yc = a+bX

Yc = 86.25+ (4.28×39)

Yc = 86.25+ 166.92

Yc = 253.17

The straight-line equation is introduced to measure the future trend of research productivity of University of North Bengal. The calculation is based on Table 4a.5.3 of trend analysis of University of North Bengal publication productivity.

Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next thirty years and the publications will be almost doubled in figure. It will be 146 in 2025, 167 in 2030, 210 in 2040 and 253 in 2050.

4a.5.4 Exponential Growth Rate

Table 4a.5.4 presents the exponential growth rate of the publications of University of North Bengal. The highest growth rate is recorded in 2009 (2.08) and lowest in 2002 (0.65). Table also shows the average decadal growth rate of publications and the analysis found that during the first ten years i.e., from 2001 to 2010 the growth rate is 1.12 which is slight ahead from the next ten years i.e., 1.03 during 2011 to 2020. The range of the growth rate is in between 0.65 to 2.08 which indicates that the rate of overall growth of publications is on the slower side. There are years when the growth

rate of publications noted less than 1, which indicates that in those years the number of publications decreased from the preceding year.

Table 4a.5.4: Exponential Growth Rate of Research Publications of University of North Bengal

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	43	-	
2	2002	28	**0.65 (L)**	
3	2003	37	1.32	
4	2004	38	1.03	
5	2005	50	1.32	1.12
6	2006	56	1.12	
7	2007	57	1.02	
8	2008	50	0.88	
9	2009	104	**2.08 (H)**	
10	2010	123	1.18	
11	2011	93	0.76	
12	2012	104	1.12	
13	2013	109	1.05	
14	2014	103	0.94	
15	2015	111	1.08	1.03
16	2016	129	1.16	
17	2017	119	0.92	
18	2018	136	1.14	
19	2019	99	0.73	
20	2020	136	1.37	
Total		1725		

4a.5.5 Authorship Pattern

Total 6484 authorship has been counted for publishing 1725 documents at an average rate of 3.76 authorships per document. Table 4a.5.5 presents year wise distribution of authorships of the contributed literatures. The highest number of documents found as three (452 documents) and two (442 documents) authored papers. These two categories together contributed more than half of the all papers, i.e., 52.17% of the total. There are only 126 documents (7.30%) published as single authorship and only 36 publications noted as more than 10 authors. Out of the twenty years of study period only five years has recorded more than 10 single authored paper i.e., in the years of 2009, 2010, 2012, 2015 and 2020. The results also highlight that dominance of multiple authored papers is there and out of the total 92.70% papers published as two or more than two authored. It also indicates that authors of these university preferred collaboration work rather individual work.

Table 4a.5.5: Distribution of Articles by Authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	43	6	13	15	7	1	1	-	-	116	2.70
2002	28	6	8	8	5	1	-	-	-	71	2.54
2003	37	3	9	9	8	4	4	-	-	124	3.25
2004	38	7	12	14	3	-	2	-	-	104	2.74
2005	50	4	19	13	9	3	2	-	-	144	2.88
2006	56	2	18	17	8	7	4	-	-	186	3.32
2007	57	3	15	21	8	5	3	1	1	235	4.12
2008	50	2	14	11	7	8	8	-	-	181	3.62
2009	104	10	37	30	11	11	5	-	-	307	2.95
2010	123	12	39	37	19	9	6	1	-	386	3.14
2011	93	4	30	27	9	13	9	1	-	326	3.51
2012	104	12	27	30	11	16	7	1	-	350	3.37
2013	109	7	28	25	20	14	9	6	-	504	4.62
2014	103	3	39	29	14	8	9	1	-	330	3.20
2015	111	10	19	22	26	15	18	1	-	446	4.02
2016	129	7	24	31	23	15	23	6	-	570	4.42
2017	119	7	25	34	22	11	15	5	-	482	4.05
2018	136	4	32	35	24	18	19	4	-	545	4.01
2019	99	4	17	23	17	10	24	4	-	463	4.68
2020	136	13	23	21	24	20	31	4	-	614	4.51
Total	1725	126	448	452	275	189	199	35	1	6484	3.76
%	100	7.30	25.97	26.20	15.94	10.96	11.54	2.03	0.06	-	-

4a.5.6 Degree of Collaboration of University of North Bengal Research Publications

The degree of collaboration is the ratio of number of collaborative papers to the total number of papers published in a discipline or in by an institution over a time. Table 4.5.6 reveals that the average value of degree of collaboration is 0.93 which indicates that the maximum number of papers under University of North Bengal are published collaboratively. Highest collaboration (0.98) noticed in the year 2018 and lowest (0.79) in 2002. Out of the twenty years of study period sixteen years found the value of degree of collaboration is equal or more than 0.90, it indicates the dominance of collaborative research among the authors of this University.

Table 4a.5.6: Degree of Collaboration of University of North Bengal Publications

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC)=Nm/ Ns+Nm
2001	6	37	43	0.86
2002	6	22	28	0.79
2003	3	34	37	0.92
2004	7	31	38	0.82
2005	4	46	50	0.92
2006	2	54	56	0.96
2007	3	54	57	0.95
2008	2	48	50	0.96
2009	10	94	104	0.90
2010	12	111	123	0.90
2011	4	89	93	0.96
2012	12	92	104	0.88
2013	7	102	109	0.94
2014	3	100	103	0.97
2015	10	101	111	0.91
2016	7	122	129	0.95
2017	7	112	119	0.94
2018	4	132	136	0.97
2019	4	95	99	0.96
2020	13	123	136	0.90
Total	126	1599	1725	0.93

4a.5.7 Citation Pattern

A total of 16307 citations were recorded for 1725 publications of University of North Bengal retrieved for the period of 2001 to 2020 (Table 4a.5.7). 926 papers, the highest percentage (53.68%) of papers noted in between the citation range from 1 to 10. There were only 41 papers having citations of 50 or more, that means the percentage of highly cited papers is very low in respect to total publications. The percentage of uncited paper is also on the higher side, out of 1725 papers 334 remains uncited at the time of data collection in January 2021. Highest average citations noted in the year 2004 and 2003 with 23.32 and 21.16 citations per paper respectively.

Table 4a.5.7: Year-wise Citation Pattern of University of North Bengal Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	43	9	17	16	1		453	10.53
2002	28	1	15	11	1		475	16.96
2003	37	9	9	16	1	2	783	21.16
2004	38	4	15	16	1	2	886	23.32
2005	50	7	28	13	2		615	12.30
2006	56	4	22	24	4	2	1159	20.70
2007	57	7	24	24	2		818	14.35
2008	50	2	34	11	1	2	737	14.74
2009	104	28	40	32	4		1057	10.16
2010	123	20	59	41	2	1	1406	11.43
2011	93	13	41	36	3		1092	11.74
2012	104	23	42	38	1		1071	10.30
2013	109	17	50	39	2	1	1326	12.17
2014	103	8	66	27	2		946	9.18
2015	111	8	75	27	1		935	8.42
2016	129	22	87	18	2		832	6.45
2017	119	22	85	12			583	4.90
2018	136	35	82	19			636	4.68
2019	99	26	68	4	1		336	3.39
2020	136	69	67				161	1.18
Total	1725	334	926	424	31	10	16307	11.403
%	100	19.36	53.68	24.58	1.80	0.58		

4a.5.8 Document Types

The distribution of various types of documents reveals that Journal Articles occupy predominant position sharing 90.96% (1569) of the total during a span of twenty years. Other sources are Reviews (3.71 %), Conference Papers (3.01%), Book Chapters (1.74%) and Books (0.58%).

Table 4a.5.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	43	-	-	-	-	43
2002	27	1	-	-	-	28
2003	36	1	-	-	-	37
2004	35	1	-	2	-	38
2005	42	7	-	1	-	50

2006	54	2	-	-	-	56
2007	53	2	-	2	-	57
2008	44	3	-	2	1	50
2009	102	-	1	-	1	104
2010	117	2	3	1	-	123
2011	79	11	-	2	1	93
2012	91	2	4	5	2	104
2013	93	3	2	8	3	109
2014	93	-	4	6	-	103
2015	103	2	3	3	-	111
2016	112	7	3	6	1	129
2017	104	3	6	6	-	119
2018	125	4	1	6	-	136
2019	93	-	-	6	-	99
2020	123	1	3	8	1	136
Total	1569	52	30	64	10	1725
%	90.96	3.01	1.74	3.71	0.58	100

Most number of Journal Articles published in the year 2018 (125 articles) followed by 123 in 2020 and 117 in 2010. Other types of documents are very less as record indexed in Scopus under the affiliation to University of North Bengal. There are only 10 books and 30 Book Chapters found in twenty years which is very few for any reputed institution.

4a.5.9 Most Productive Channels of Communication

Based on the maximum numbers of articles published in journals, the top listed communication sources are presented in table 4a.5.9. In the list the first two journal, one from Physics and another from Chemistry background and both are published by Elsevier contributed 45 (*Journal of Molecular Liquids*) and 36 (*Journal of the Indian Chemical Society*) articles respectively. In the top list dominance of Science based journals has been noted. The predominant of the journals in the top list are mostly published by Elsevier, Taylor & Francis and Springer.

Table 4a.5.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area	Impact Factor	Frequency
1	Journal of Molecular Liquids	Elsevier	Physics, Atomic, Molecular & Chemical	6.165	45
2	Journal of the Indian Chemical Society	Elsevier	Chemistry	0.284	36
3	Physical Review Particles Fields	American Physical Society	Physics	5.296 (2020)	35

	Gravitation and Cosmology				
4	Physics and Chemistry of Liquids	Taylor & Francis	Liquid State	1.915 (2020)	30
5	Liquid Crystals	Taylor & Francis	Liquid Crystal Science and Technology	-	28
6	Tetrahedron Letters	Elsevier	Organic Chemistry	2.415	25
7	International Journal of Mathematical Analysis	Hikari	Mathematics	-	24
8	International Journal of Pure and Applied Mathematics	Springer	Mathematics	0.372 (2020)	23
9	Journal of Molecular Structure	Elsevier ScienceDirect	Chemistry	3.196	21
10	Chemistryselect	Wiley-VCH	Chemistry	2.109 (2020)	19
11	Acta Crystallographica Section E Structure Reports Online	International Union of Crystallography	Crystallography	-	18
12	Journal of Environmental Biology	Triveni Enterprises	Environmental Science	0.781	18
13	Phase Transitions	Taylor & Francis	Phase transitions in condensed matter	1.452 (2020)	17
14	Journal of Chemical Thermodynamics	Elsevier ScienceDirect	Thermodynamics	3.178 (2020)	16
15	Journal of Solution Chemistry	Springer	Physical Chemistry, Chemical Physics, Molecular Biology, Statistical Mechanics, Biochemistry, and Biophysics	1.677 (2020)	16
16	International Journal of Pharmacy and Pharmaceutical Sciences	Innovare Academic Sciences	Pharmaceutical Technology, Pharmaceutical/Medicinal Chemistry, Pharmacology, Pharmacy Practice, Clinical and Hospital Pharmacy etc.	-	15
17	Monthly Notices of the Royal Astronomical Society	The Royal Astronomical Society	Astronomy and Astrophysics	5.287	15
18	Physical Review	American Physical Society	Pure, Applied, and Interdisciplinary physics	15.762	15
19	Classical and Quantum Gravity	IOP Publishing (UK)	Gravitation and the Theory of Spacetime	3.528	14
20	Modern Physics Letters	World Scientific	Physics	2.066 (2020)	14

4a.5.10 Most Productive Authors

Table 4a.5.10: Most Productive Authors during the study period under University of North Bengal Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	Roy, M.N.	7402902493	128	194	2718	29
2	Ghosh, P.	57212696907	83	144	1159	20
3	Sen, A.	57202265770	80	103	1048	19
4	Bhadra, A.	7003532915	70	85	836	15
5	Chaudhuri, T.K.	57191862366	69	169	3793	26
6	Paul, B.C.	57203075374	65	88	891	17
7	Sinha, B.	9736003000	58	76	1126	16
8	Chakraborty, R.	7202348697	56	77	951	18
9	Nandi, K.K.	7003719331	56	90	1427	20
10	Mandal, P.K.	35565234400	54	88	750	13
11	Das, M.K.	55768998600	52	82	1340	19
12	Mukhopadhyay, A.	23091662600	49	71	495	13
13	Misra, A.	7402454204	47	79	810	16
14	Datta, S.K.	7401498381	45	92	51	4
15	Basu, B.	57198371490	42	80	1653	27
16	Dey, P.	36622069700	35	68	889	17
17	Mandal, P.	8932522200	34	40	262	8
18	Chakraborty, U.	6603811233	32	46	953	18
19	Nanda, A.K.	8255615400	32	35	683	15
20	Bandyopadhyay, P.	7102767420	29	75	848	17

The above table describes the list of the most productive authors of University of North Bengal during the period 2001 to 2020 as literatures indexed in Scopus except the subject categories like Engineering and Computer Science. The most number of articles i.e. 128 published by author named as Roy, M.N. whereas the total contribution during the whole career he has published 194 articles, followed by Ghosh, P. (83 publications) and Sen, A. (80 publications). Roy, M.N. with h-index of 29, Basu, B. with h-index of 27 and Chaudhuri, T.K. with h-index of 26 are the most impactful authors identified from the University of North Bengal by considering the value of h-index.

4a.5.11 Subject area wise performance

The subject categories producing most number of papers under the affiliation of University of North Bengal during the period 2001 to 2020 is highlighted in table 4a.5.11. Highest published literatures are from the subject areas like Physics and Astronomy (579 publications), Chemistry (566 publications) and Materials Science (301 publications). Other productive subject fields are Biochemistry, Agricultural and Biological Sciences, Mathematics, Medicine etc. The predominance is seen basically in the science and applied science based subject fields. There are only 72 publications in Social Sciences and 46 publications from Arts and Humanities.

Table 4a.5.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Physics and Astronomy	579
2	Chemistry	566
3	Materials Science	301
4	Biochemistry, Genetics and Molecular Biology	277
5	Agricultural and Biological Sciences	273
6	Pharmacology, Toxicology and Pharmaceutics	174
7	Mathematics	140
8	Medicine	125
9	Immunology and Microbiology	99
10	Environmental Science	91
11	Earth and Planetary Sciences	82
12	Social Sciences	72
13	Arts and Humanities	46
14	Multidisciplinary	43
15	Economics, Econometrics and Finance	29
16	Energy	12
17	Nursing	11
18	Health Professions	9
19	Decision Sciences	8
20	Business, Management and Accounting	7

4a.5.12 Collaboration with Other Countries

52 countries have been noted where from authors contributed in collaboration to the authors of University of North Bengal. Out of all the countries most productive twenty countries are highlighted in table 4a.5.12. United States dominated with 114 publications collaborated with the authors of this university which all together received

1363 citations at an average rate of 11.96 citations per paper. Poland (45 publications), Germany (39 publications), Russian Federation (35 publications) are the others top collaborative countries.

Table 4a.5.12: Country wise Collaboration of Research Output in University of North Bengal

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	United States	114	1363	11.96	181
2	Poland	45	358	7.96	58
3	Germany	39	857	21.97	70
4	Russian Federation	35	530	15.14	47
5	China	30	1051	35.03	53
6	Tunisia	27	372	13.78	66
7	France	17	199	11.71	38
8	Japan	16	266	16.62	24
9	United Kingdom	15	174	11.6	39
10	Canada	14	273	19.5	29
11	Saudi Arabia	14	130	9.28	31
12	Belgium	12	205	17.08	21
13	South Africa	12	179	14.92	17
14	Italy	11	153	13.91	26
15	Netherlands	10	142	14.2	17
16	Algeria	9	65	7.22	22
17	Nepal	9	90	10	18
18	Argentina	8	175	21.88	24
19	Spain	7	198	28.29	19
20	Malaysia	6	126	21	16

Considering the link strength as a measure of association among the countries in a collaborative work, the clusters are identified. By taking minimum documents published by a country is 5 and minimum 1 citation to be received out of 52 countries 25 meet the condition and six clusters are formed based on the degree of association. Cluster one formed with 7 countries, viz. Algeria, China,

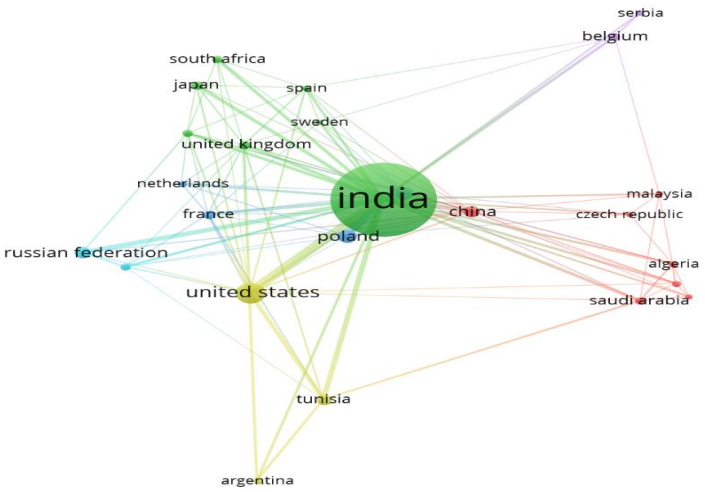

Figure 4a.5.2 Network visualization of Country wise Collaboration of University of North Bengal Publications

Czech Republic, Iran, Malaysia, Nepal, Saudi Arabia and cluster 2 consisting 7 countries viz. Canada, India, Japan, South Africa, Spain, Sweden, United Kingdom. These clusters are clearly visible in figure 4a.5.2. United States has the highest link strength of 181 denotes that this country is associated mostly with India as well as with other countries in terms of publishing documents.

Minimum document of a country- 5, Minimum citation – 1, out of the 52 countries 25 meet the threshold and six clusters identified. These clusters are –

Cluster 1: 7 Countries	*Cluster 2: 7 Countries*	*Cluster 3: 4 Countries*	*Cluster 4: 3 Countries*
Algeria, China, Czech Republic, Iran, Malaysia, Nepal, Saudi Arabia	Canada, India, Japan, South Africa, Spain, Sweden, United Kingdom	France, Germany, Netherlands, Poland	Argentina, Tunisia, United States

4a.5.13 Collaboration with Other Organizations

159 institutions have been identified from where the authors are contributed articles with collaboration to authors of University of North Bengal. Among all the collaborative institutions top twenty most number of documents published institutions are listed in table 4a.5.13. University of Calcutta with 41 papers is in the top, followed by St. Joseph's College, Darjeeling (39 papers) and Jadavpur University (35 papers). There are many State and Public Universities, Research Institutions, Colleges, Private institutions are in the top list of collaboration. The authors are collaborated mostly with the authors of institutions with the State of West Bengal.

Table 4a.5.13: Collaboration with Other Organizations

Sl. No.	Affiliation Name	Publication Count
1	University of Calcutta	41
2	St. Joseph's college, Darjeeling	39
3	Jadavpur University	35
4	Bose Institute	32
5	Siliguri Institute of Technology	32
6	Wojskowa Akademia Techniczna	31
7	Mizoram University	29
8	University of Kalyani	27
9	University of New Hampshire Durham	27
10	Bashkir State Pedagogical University	26

11	Chinese Academy of Sciences	25
12	Indian Institute of Technology Kharagpur	24
13	Assam University	22
14	Alipurduar College	21
15	Vidyasagar University	20
16	Bashkir State University, Sterlitamak Branch	20
17	Raiganj University	19
18	Indian Statistical Institute, Kolkata	19
19	UniversitA de Tunis El Manar	19
20	State University of New York at Fredonia	18

4a.6 Presidency University

4a.6.1 Growth of Literature: Year-wise distribution of Publications and Average

The literature affiliated to Presidency University increases in a consistent basis and it grows from 12 in 2001 to 201 in 2020. During the period a gradual growth has been witnessed. In these twenty years a total of 1482 publications were got indexed in the considered subject areas of the study. Altogether these 1482 publications received 15925 citations at an average rate of 10.75 citation per document. The last few years the average citations have decreased due to the lack of time spent after their publication date. This scenario will change over time with more reach to the authors. 25.61 is the highest average citation recorded in the year 2003 followed by 21.89 in 2002.

Table 4a.6.1: Growth of Literature: Year-wise distribution of Scientific Literature of Presidency University

Year	Publications	CP	%	Cited by	ACP
2001	12	12	0.81	203	16.92
2002	18	30	1.21	394	21.89
2003	31	61	2.09	794	25.61
2004	34	95	2.29	711	20.91
2005	40	135	2.70	558	13.95
2006	50	185	3.37	811	16.22
2007	32	217	2.16	575	17.97
2008	53	270	3.58	975	18.40
2009	44	314	2.97	922	20.95
2010	49	363	3.31	561	11.45
2011	77	440	5.20	1126	14.62
2012	79	519	5.33	959	12.14
2013	94	613	6.34	1161	12.35
2014	92	705	6.21	1571	17.08
2015	109	814	7.35	1285	11.79

2016	104	918	7.02	954	9.17
2017	100	1018	6.75	552	5.22
2018	119	1137	8.03	673	5.66
2019	144	1281	9.72	669	4.65
2020	201	1482	13.56	471	2.34
Total	1482		100	15925	10.75

TP = Total papers; CP = cumulative publications; ACP= Average Citation per Publication

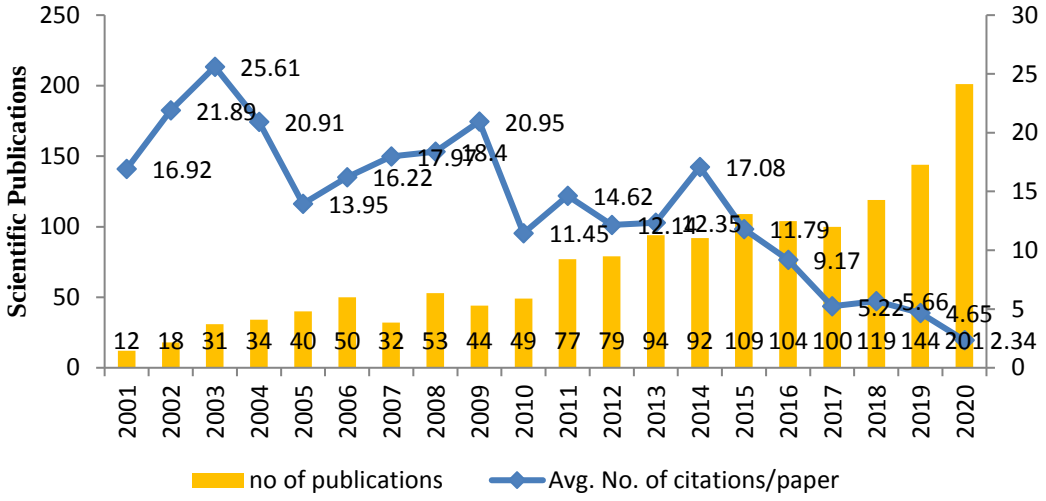

Figure 4.6.1: Year-wise Publications of Presidency University

Figure 4a.6.1 describes the year wise publications and average citations of the total publications in a year. It is clearly visible that the number of publications swift from 2010 onwards. The average citation was also higher the past years than the recent years, it is noted that before 2016 all the years has maintained an average citation of above 10 in every year. The trend of average citation is decreasing because of the less time spent by the recent published documents, with time this trend will change.

4a.6.2 Relative Growth Rate (RGR) and Doubling Time (Dt)

The Relative Growth Rate and Doubling Time of Presidency University publications is presented in table 4a.6.2. The whole twenty years period has been divided in four blocks of five years each, the mean RGR of publications calculated 0.24 during the period 2001 to 2005, in the next five years it increases to 0.29 and it decreases to 0.17 and 0.16 in the next two blocks. The corresponding Doubling Time gradually increased to 2.95 in first five years to 14.28 during 2011 to 2016. Again, it decreases to 7.84 in the last five years. It has been noticed that with the Relative Rate of Growth of

publications when decreased the corresponding Doubling Time of the publications will increase.

Table 4a.6.2: Calculation of Relative Growth Rate (RGR) and Doubling Time (Dt)

Year	Publications	CP	Log_e N1	Log_e N2	RGR(P)= Log_e N2 - Log_e N1/ T2-T1	Mean RGR(P)	Dt(P)= 0.693/ RGR(P)	Mean Dt(P)
2001	12	12	-	2.485	-		-	
2002	18	30	2.485	2.89	0.405		1.711	
2003	31	61	2.89	3.434	0.544	0.24	1.274	2.95
2004	34	95	3.434	3.526	0.092		7.533	
2005	40	135	3.526	3.689	0.163		4.252	
2006	50	185	3.689	3.912	0.223		3.108	
2007	32	217	3.912	3.466	-0.446		1.554	
2008	53	270	3.466	3.970	0.504	0.29	1.375	3.24
2009	44	314	3.970	3.784	-0.186		3.726	
2010	49	363	3.784	3.892	0.108		6.417	
2011	77	440	3.892	4.345	0.453		1.53	
2012	79	519	4.345	4.369	0.024		28.875	
2013	94	613	4.369	4.543	0.177	0.17	3.915	14.28
2014	92	705	4.543	4.522	-0.021		33	
2015	109	814	4.522	4.691	0.169		4.101	
2016	104	918	4.691	4.644	-0.047		14.745	
2017	100	1018	4.644	4.605	-0.047		14.745	
2018	119	1137	4.605	4.779	0.174	0.16	3.983	7.84
2019	144	1281	4.779	4.97	0.191		3.628	
2020	201	1482	4.97	5.303	0.333		2.081	
Total	1482							

CP = Cumulative Publications; RGR (P) = Relative Growth Rate of Publications; Dt (P) = Doubling Time of Publications

4a.6.3 Forecasting Research Productivity of Presidency University using Trend Analysis

To forecast the research productivity in the upcoming days the best possible technique is the application of straight-line equation under trend analysis. The future trend of the research productivity could be measured based on the past data available at a regular interval. Here based on the two decadal data (from 2001 to 2020), a projection of research growth of next thirty years has been calculated (Table 4a.6.3).

Straight-line equation Y= a+b is applied to give the future projection of the research growth of research publications of Presidency University.

Table 4a.6.3: Trend Analysis of research output of Presidency University

Sl. No.	Year	No. of Documents (Y)	X	X^2	XY
1	2001	12	-10	100	-120
2	2002	18	-9	81	-162
3	2003	31	-8	64	-248
4	2004	34	-7	49	-238
5	2005	40	-6	36	-240
6	2006	50	-5	25	-250
7	2007	32	-4	16	-128
8	2008	53	-3	9	-159
9	2009	44	-2	4	-88
10	2010	49	-1	1	-49
11	2011	77	0	0	0
12	2012	79	1	1	79
13	2013	94	2	4	188
14	2014	92	3	9	276
15	2015	109	4	16	436
16	2016	104	5	25	520
17	2017	100	6	36	600
18	2018	119	7	49	833
19	2019	144	8	64	1152
20	2020	201	9	81	1809
	N=20	$\sum Y=1482$	$\sum X=10$	$\sum X^2=670$	$\sum XY=4217$

To assume the future growth of publications of Presidency University Trend Analysis has been introduced. In this regard, under Trend Analysis straight line equation is applied to arrive at a projection in the year 2025, 2030, 2040 and 2050.

Straight line equation $Yc = a+b$

$\sum X = 10$

$a = \sum Y / N$

$a = 1482 / 20$

$a = 74.1$

$b = \sum XY / \sum X^2$

$b = 4217 / 670$

$b = 6.29$

Estimated number of publications in 2025, is when

$X = 2025\text{-}2011$ or, $X = 14$

$Yc = a+bX$

$Yc = 74.1 + (6.29 \times 14)$

$Yc = 74.1 + 88.06$

$Yc = 162.16$

Estimated number of publications in 2030, is when

$X = 2030\text{-}2011$ or, $X = 19$

$Yc = a+bX$

Yc = 74.1 + (6.29×19)
Yc = 74.1 + 119.51
Yc = 193.61

Estimated number of publications in 2040, is when

X = 2040-2011 or, X = 29
Yc = a+bX
Yc = 74.1 + (6.29×29)
Yc = 74.1 + 182.41
Yc = 256.51

Estimated number of publications in 2050, is when

X = 2050-2011 or, X = 39
Yc = a+bX
Yc = 74.1 + (6.29×39)
Yc = 74.1 + 245.31
Yc = 319.41

The straight-line equation is introduced to measure the future trend of research productivity of Presidency University (table 4a.6.3). Based on the previous twenty years publication productivity the projection has been made applying the straight-line equation in the years of 2025, 2030, 2040 and in 2050. The result of the projection noted that, an increasing trend will be there for the next thirty years and the publications will be above three hundred but not doubled. As per the calculation of the straight-line equation, it will be 162 in 2025, 193 in 2030, 256 in 2040 and 319 in 2050.

4a.6.4 Exponential Growth Rate

Exponential growth rate is one of the measures which helps to understand the growth rate of the present year compared to the preceding year. It is noticed that the average growth rate is higher during the first ten years (2001-2010) of the study than the second ten years (2011-2020). The highest growth rate has been recorded in the year 2003 (1.72) whereas the lowest in 2006 (0.64). The exponential growth rate recorded below 1.0 in a year denotes the decreasing rate of that year from the preceding year.

Table 4a.6.4: Exponential Growth Rate of Research Publications in Presidency University

Sl. No.	Year	Total Publications	Exponential Growth Rate	Average Growth Rate
1	2001	12	-	1.23
2	2002	18	1.5	
3	2003	31	**1.72 (H)**	
4	2004	34	1.10	

5	2005	40	1.18	
6	2006	50	1.25	
7	2007	32	**0.64 (L)**	
8	2008	53	1.66	
9	2009	44	0.83	
10	2010	49	1.11	
11	2011	77	1.57	
12	2012	79	1.03	
13	2013	94	1.19	
14	2014	92	0.98	
15	2015	109	1.18	1.17
16	2016	104	0.95	
17	2017	100	0.96	
18	2018	119	1.19	
19	2019	144	1.21	
20	2020	201	1.40	
	Total	1482		

4a.6.5 Authorship Pattern

Authorship pattern of the literatures published by Presidency University authors during the period from 2001 to 2020 is presented in table 4a.6.5. The study reveals that a total of 5894 author occurrences has been identified for 1482 articles with different frequencies. Among 1482 published literatures, only 175 articles (11.81%) are written as single author, 333 articles (22.47%) are written as two authors, 294 articles (19.84%) as three authors, 235 articles (15.86%) as four authors. Rest of the 281 articles are written by more than five authors. The average authorship counted for all the papers is 3.98. It can be seen that multi authors are predominated than single authors, which indicates that collaborative research work is favoured by the authors of this university.

Table 4a.6.5: Distribution of Articles by Authorship

Year	TP	Authorship Value								Occurrence of Authors	Average authorship
		1	2	3	4	5	06-10	11-50	Mega Authors ≥51		
2001	12	2	3	3	1	2	1	-	-	37	3.08
2002	18	4	2	4	4	2	2	-	-	58	3.22
2003	31	2	10	5	9	3	2	-	-	101	3.26
2004	34	-	13	11	6	1	3	-	-	106	3.12
2005	40	2	15	9	6	5	3	-	-	129	3.23
2006	50	4	12	13	10	4	7	-	-	170	3.4
2007	32	1	12	8	6	-	5	-	-	104	3.25
2008	53	6	14	16	6	4	7	-	-	175	3.30
2009	44	7	14	7	7	4	5	-	-	138	3.14

2010	49	11	11	9	3	10	4	1	-	161	3.29
2011	77	17	24	11	12	5	8	-	-	229	2.97
2012	79	14	18	17	12	8	9	1	-	264	3.34
2013	94	16	16	23	10	9	16	4	-	370	3.94
2014	92	9	18	21	18	6	16	4	-	372	4.04
2015	109	16	21	24	15	9	19	5	-	438	4.02
2016	104	11	25	17	16	13	20	1	1	458	4.40
2017	100	13	18	12	20	18	17	2	-	407	4.07
2018	119	15	25	27	9	16	23	4	-	471	3.96
2019	144	11	25	26	29	15	29	9	-	668	4.64
2020	201	14	37	31	36	30	36	17	-	1038	5.16
Total	1482	175	333	294	235	164	232	48	1	5894	3.98
%	100	11.81	22.47	19.84	15.86	11.07	15.65	3.24	0.07	-	-

4a.6.6 Degree of Collaboration of Presidency University Research Publications

Degree of Collaboration is the ratio between number articles published as multiple authors out of the total articles published in a year. Table 4.6.6 presents year wise degree of collaboration of the published literatures during a span of twenty years. The study reveals that the average degree of collaboration is 0.88 considering all the published documents during the study period. The higher value of degree of collaboration denotes that the percentage of multiple authored paper is also high in that particular year.

Table 4a.6.6: Degree of Collaboration of Presidency University

Year	Single Author (Ns)	Multi Author (Nm)	Total publications (Ns+Nm)	Degree of Collaboration (DC)=Nm/ Ns+Nm
2001	2	10	12	0.83
2002	4	14	18	0.78
2003	2	29	31	0.94
2004	-	34	34	1
2005	2	38	40	0.95
2006	4	46	50	0.92
2007	1	31	32	0.97
2008	6	47	53	0.89
2009	7	37	44	0.84
2010	11	38	49	0.78
2011	17	60	77	0.78
2012	14	65	79	0.82
2013	16	78	94	0.83
2014	9	83	92	0.90
2015	16	93	109	0.85
2016	11	93	104	0.89
2017	13	87	100	0.87

2018	15	104	119	0.87
2019	11	133	144	0.92
2020	14	187	201	0.93
Total	175	1307	1482	0.88

4a.6.7 Citation Pattern

Table 4a.6.7 describes the year-wise citation pattern of Presidency University over the period from 2001 to 2020. A total of 15925 citations for 1482 documents have been recorded at an average of 10.75 citations per documents. 776 papers i.e. 52.36% of the total share received citation in between 1 to 10 and 356 papers i.e. 24.02% recorded citations in between 11 to 50. The number of highly cited papers is on the very lower side, where only 53 papers has been identified as highly cited papers having citations of 50 or more. There are 297 papers having zero citation as recorded during the time of data collection in which last year of the study has recorded 104 papers without a citation. The citation is associated to time factor in which publication age is matter, so it is expected to decrease the number of uncited papers with the time.

Table 4a.6.7: Year-wise Citation Pattern of Presidency University Publications, 2001-2020

Published Year	Total Publications	Citation Patterns					Total Citations	Avg. Citations
		Zero Citation	Citations 1-10	Citations 11-50	Citations 51-100	Citations >100		
2001	12	2	4	5	1		203	16.92
2002	18		9	7	1	1	394	21.89
2003	31	1	11	15	4		794	25.61
2004	34	3	12	15	3	1	711	20.91
2005	40	3	20	16		1	558	13.95
2006	50	3	23	21	1	2	811	16.22
2007	32	2	18	8	4		575	17.97
2008	53	6	22	21	2	2	975	18.40
2009	44	5	18	17	4		922	20.95
2010	49	6	24	16	2	1	561	11.45
2011	77	12	32	29	4		1126	14.62
2012	79	4	45	27	2	1	959	12.14
2013	94	12	59	19	1	3	1161	12.35
2014	92	10	60	18	3	1	1571	17.08
2015	109	10	55	41	3		1285	11.79
2016	104	23	53	25	2	1	954	9.17
2017	100	18	65	17			552	5.22
2018	119	33	66	19	1		673	5.66
2019	144	40	87	17			669	4.65
2020	201	104	93	3		1	471	2.34
Total	1482	297	776	356	38	15	15925	10.75
%	100	20.04	52.36	24.02	2.56	1.01		

4a.6.8 Document Types

Five types of documents are considered for the study, among those like other Universities Presidency University authors are also preferred the Journal Articles than other types of documents. Total 1277 (86.17%) documents found as Journal Articles among all the documents published during the time. Conference Papers, Book Chapters, Reviews and Books are very less in percentage compared to Journal Articles published by the authors of this university. In 2020 maximum number of Journal Articles (169) noted and maximum 10 conference papers noted in the year 2018. There are among all only 16 Books and 56 Book Chapters were got indexed in Scopus written by the authors of Presidency University.

Table 4a.6.8: Document Types

Year	Document Types					
	Journal Articles	Conference Papers	Book Chapters	Review	Book	Total
2001	12	-	-	-	-	12
2002	17	1	-	-	-	18
2003	30	1	-	-	-	31
2004	33	1	-	-	-	34
2005	37	3	-	-	-	40
2006	44	3	1	2	-	50
2007	32	-	-	-	-	32
2008	48	3	1	1	-	53
2009	40	-	2	2	-	44
2010	45	1	1	2	-	49
2011	63	-	2	12	-	77
2012	71	-	1	7	-	79
2013	81	1	5	5	2	94
2014	84	1	2	4	1	92
2015	90	5	6	7	1	109
2016	79	6	7	12	-	104
2017	81	1	7	6	5	100
2018	95	10	7	4	3	119
2019	126	3	5	7	3	144
2020	169	1	9	21	1	201
Total	1277	41	56	92	16	1482
%	86.17	2.77	3.78	6.21	1.08	100

4a.6.9 Most Productive Channels of Communication

There are many journals in the list in which the authors of Presidency University published their research articles. Among them top twenty most preferred journals listed in table 4a.6.9. Most number of articles (40 articles) found in the journal titled as *Monthly Notices of The Royal Astronomical Society* published by The Royal Astronomical Society in the subject areas of Astronomy and Astrophysics, followed by 28 articles found in the *Journal of The Geological Society of India* published by Springer in the field of Earth Sciences. In the third position there is an Interdisciplinary subject area journal titled as *Journal of Earth System Science* of Springer in which 27 articles found. In the top list of the most communicated journals the subject areas covered mostly of Science based subjects like, Astronomy and Astrophysics, Earth Sciences, Physics and Geosciences. Elsevier and Springer published journals are dominated in the list than any other publishing house.

Table 4a.6.9: Most Productive Channels of Communication

Sl. No	Journal Title	Publisher	Subject Area	Impact Factor	Frequency
1	Monthly Notices of The Royal Astronomical Society	The Royal Astronomical Society	Astronomy and Astrophysics	5.287	40
2	Journal of The Geological Society of India	Springer	Earth Sciences	1.459 (2020)	28
3	Journal of Earth System Science	Springer	Interdisciplinary	1.371 (2020)	27
4	Current Science	Indian Academy of Sciences	Interdisciplinary Science Journal	1.102 (2020)	24
5	Journal of Chemical Physics	American Institute of Physics	Chemical physics	3.488 (2020)	20
6	Physical Review	American Physical Society	Physics	-	20
7	Journal of Luminescence	Elsevier	Physics	3.599 (2020)	17
8	Aip Conference Proceedings	American Institute of Physics	Physics	-	16
9	Astrophysical Journal	American Astronomical Society	Astronomy and Astrophysics	5.874 (2020)	15
10	Economic and Political Weekly	Sameeksha Trust	Social Sciences	-	12
11	Journal of Molecular Liquids	Elsevier	Physics, Atomic, Molecular & Chemical	6.165	11
12	Journal of Physical Chemistry	American Chemical Society	Physical Chemistry	2.6 (2019)	11
13	Precambrian Research	Elsevier	Earth Sciences	4.725	11
14	Journal of Applied Polymer Science	Wiley	Polymer science	3.125 (2020)	10

15	Journal of Cosmology and Astro Particle Physics	IOP Publishing and SISSA	Cosmology and Particle Astrophysics	5.839 (2020)	10
16	Gondwana Research	Elsevier	Geosciences, Multidisciplinary	6.051	9
17	Indian Journal of Geosciences	Geological Survey of India	Geosciences	-	9
18	Journal of The Indian Chemical Society	Elsevier	Chemistry	0.284	9
19	Physics Letters Section Nuclear Elementary Particle and High Energy Physics	Elsevier	Particle Physics, Nuclear Physics and Cosmology	4.771	9
20	Polymer International	Wiley Online Library	Polymer Science	2.990	9

4a.6.10 Most Productive Authors

Table 4a.6.10 highlights most productive authors of Presidency University during the period 2001 to 2020 as indexed literatures in Scopus multidisciplinary database. All total 5894 authorships have been identified for publishing 1482 articles. The table also shows the overall publications of the authors during all the years with total received citations and h-index. The Author Id in Scopus is also mentioned which will help to track the future progress of a particular author. Dey, A. (76 articles), Ghosh, S. (52 articles) and Mukhopadhyay, J. (36 articles) are the top three most productive authors during the period under the affiliation of Presidency University. Biswas, M. has published 164 articles in his whole career but only 30 publications found during the study period under the affiliation of Presidency University. Ghosh, U.C. received highest citations (2894) for his all the publications (78) during the whole career with h-index of 29.

Table 4a.6.10: Most Productive Authors during the Study Period under Presidency University Affiliation

Sl. No	Author Name	Author Id in Scopus	Total contribution during the study period	Total contribution of the author identified from Scopus	Total Citations Received	*h-index*
1	Dey, A.	36898179400	76	155	1449	19
2	Ghosh, S.	7404807070	52	92	1737	21
3	Mukhopadhyay, J.	7005380876	36	51	1219	20
4	Pandey, D.K.	56393936100	33	83	752	15
5	Bose, S.	8956150800	32	46	1092	19
6	Ghosh, U.C.	7006049331	32	78	2894	29
7	Biswas, M.	7102911947	30	164	2707	25

8	Pan, S.	55888364600	30	92	2591	32
9	Acharyya, M.	7003951569	29	71	1597	16
10	Ghosh, G.	55989034500	28	36	865	15
11	Bhattacharya, H.N.	6701313623	26	41	714	15
12	Dey, J.	7005737198	26	89	1385	16
13	Dey, M.	7005967694	26	78	1487	15
14	Das, B.	7403285850	24	96	1714	24
15	Ray, A.	7401641727	22	33	360	11
16	Nandy, S.	57207991545	21	37	415	9
17	Nayak, A.	57200708319	20	52	347	11
18	Sardar, P.S.	13805875800	19	32	385	12
19	Chakrabarti, B.	7102090197	18	75	594	13
20	Ghosh, P.K.	56654285700	18	62	1230	21

4a.6.11 Subject area wise performance

Predominance of Science and Applied Science subjects is seen in the publications of Presidency University during the period 2001 to 2020. Physics and Astronomy (579 publications), Chemistry (566 publications), Materials Science (301 publications) are the top three most productive subject areas. There are only 46 publications from Arts and Humanities and 43 Multidisciplinary publications found which are very less compared to other science-based subjects.

Table 4a.6.11: Distribution of Subject Areas

Sl. No	Subject Area	Frequency
1	Physics and Astronomy	579
2	Chemistry	566
3	Materials Science	301
4	Biochemistry, Genetics and Molecular Biology	277
5	Agricultural and Biological Sciences	273
6	Pharmacology, Toxicology and Pharmaceutics	174
7	Mathematics	140
8	Medicine	125
9	Immunology and Microbiology	99
10	Environmental Science	91
11	Earth and Planetary Sciences	82
12	Social Sciences	72
13	Arts and Humanities	46
14	Multidisciplinary	43
15	Economics, Econometrics and Finance	29
16	Energy	12

17	Nursing	11
18	Health Professions	9
19	Decision Sciences	8
20	Business, Management and Accounting	7

4a.6.12 Collaboration with other Countries

Authors from different countries collaborated with the authors of Presidency University and presented the top producing collaborative countries in table 4a.6.12. Total 54 countries were there out of which 16 countries published only one paper each in collaboration to Presidency University authors. The highest number of collaborations noted with the authors of United States (134 publications), United Kingdom (79 publications), and China (61 publications). The table also shows the country wise total received citations and average citation during the study period. It is noticed that average citations of the publications collaborated with countries like Australia, Norway, Spain, Greece, Switzerland, South Africa, Canada and Russian Federation recorded above 20.

Table 4a.6.12: Collaborative Countries

Sl. No	Countries	Frequency	Citations	Average Citation/Paper	Total link strength
1	United States	134	2474	18.46	303
2	United Kingdom	79	980	12.41	248
3	China	61	868	14.23	188
4	Japan	54	930	17.22	113
5	South Africa	52	1134	21.81	125
6	Germany	46	753	16.37	145
7	Italy	45	796	17.69	151
8	Canada	23	491	21.35	97
9	Brazil	22	244	11.09	64
10	France	21	406	19.33	95
11	Australia	21	646	30.76	91
12	South Korea	19	188	9.89	48
13	Sweden	19	301	15.84	84
14	Spain	17	469	27.59	54
15	Netherlands	13	147	11.38	75
16	Israel	12	110	9.17	32
17	Switzerland	10	247	24.7	43
18	Norway	10	303	30.3	32
19	Greece	9	248	27.56	43
20	Russian Federation	8	161	20.13	32

The network visualization map highlights the collaborative countries of Presidency University Publications with their link to other countries in respect to publishing documents collaboratively. In the figure 4a.6.2, India is denoted by the author frequency to the all authors of Presidency University. The higher link strength is seen by the higher dense linking line with the other countries. United States and United Kingdom predominated among all other collaborative countries with the total link strength of 303 and 248 respectively.

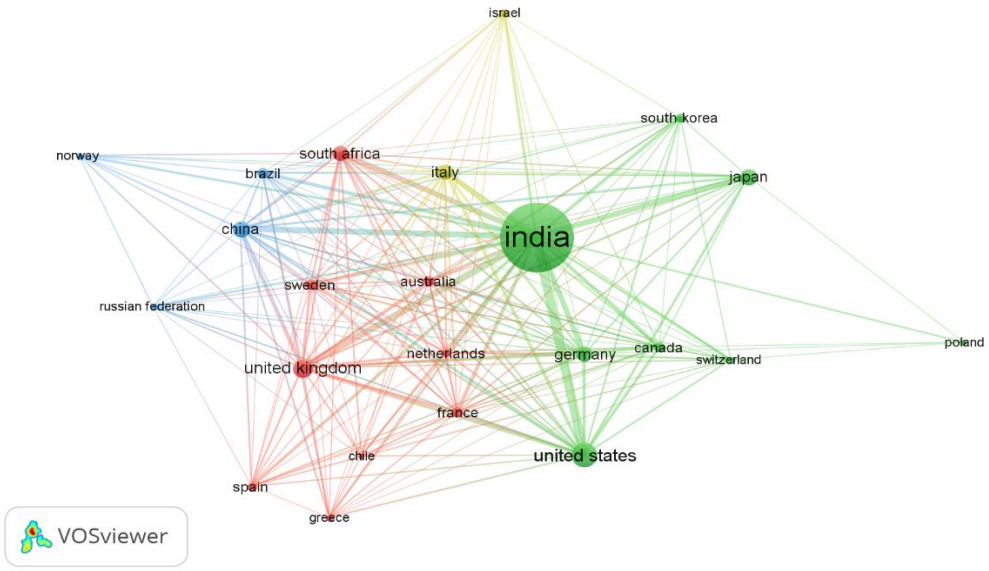

Figure 4a.6.2 Network visualization of Country wise Collaboration of Presidency University Publications

Minimum document of a country- 5, Minimum citation – 1, out of the 51 countries 23 meet the threshold and four clusters identified. These clusters are –

Cluster 1: 9 Countries	*Cluster 2: 8 Countries*	*Cluster 3: 4 Countries*	*Cluster 4: 2 Countries*
Australia, Chile, France, Greece, Netherlands, South Africa, Spain, Sweden, United Kingdom	Canada, Germany, India, Japan, Poland, South Korea, Switzerland, United States	Brazil, China, Norway, Russian Federation	Israel, Italy

The countries are linked based on their association of collaboration, each of the countries in the networked map is linked with the India, i.e. representing the authors of Presidency University. With the linking association among the countries there were 4

clusters identified. The first one consists by 9 countries (Red coloured), the second one is of 8 countries (Green Coloured).

4a.6.13 Collaboration with other organizations

Table 4a.6.13: Collaboration with other Organizations

Sl. No.	Affiliation Name	Publication Count
1	University of Calcutta	102
2	Jadavpur University	56
3	Saha Institute of Nuclear Physics	50
4	Indian Institute of Technology Kharagpur	47
5	Indian Institute of Chemical Biology	35
6	Tata Institute of Fundamental Research, Mumbai	35
7	S N Bose National Centre for Basic Science	34
8	Lovely Professional University	34
9	Inter-University Centre for Astronomy and Astrophysics India	33
10	Indian Association for the Cultivation of Science	33
11	Bose Institute	32
12	University of Kalyani	29
13	Indian Statistical Institute, Kolkata	28
14	Indian Institute of Engineering Science and Technology, Shibpur	26
15	Hiroshima University	25
16	Liaoning Normal University	24
17	Indian Institute of Science Education and Research Kolkata	23
18	Vidyasagar University	22
19	University of Johannesburg	21
20	MMHS	20

The table 4a.6.13 presents the top institutions published documents with collaboration to Presidency University authors. All total 159 institutions were noted from where authors write articles with authors of Presidency University. Among them, many State and Central University, Research Institutions, Private Universities, and International Institutions are there. Authors from many colleges are also noted to collaborate with Presidency University authors. University of Calcutta (102 documents) and Jadavpur University (56 documents) authors were in the top in respect to publish documents with authors of Presidency University. The dominance of institutions in the top list is basically from West Bengal, but some international institutions are also there in the list.

Part-II

4b Factors Influencing Scholarly Publications: The Case of Six Top Universities in West Bengal

This chapter is an attempt to examine and determine the factors that influence the research productivity of higher education institutions, the study has been done based on the primary data collected from top universities of West Bengal. A total of 303 data were considered for this study which are collected from the Research Scholars, Assistant Professors, Associate Professors, and Professors of the selected universities. The scale has been formed using the factor analysis method and there are four scale has been formed in which three of them are found valid and significant. Binary logistic regression has been used to show the level of significance of scales in each of the models consisting of research scholars, assistant professors, associate professors and professors.

4b.1 Introduction

Scientific publications have been correlated with countries' intellectual wealth and economic development (Jaffe et al, 2020). The outcomes of scientific studies, which are published in scholarly journals, might be seen as research performance of any academic institutions. The publications appeared in indexed databases is the most frequently used metric to gauge research productivity, and it is a sign of excellence for institutions of higher education (Heng et al., 2020). To better understand how research performance within the university system could be enhanced, the study of the factors influencing research output has attracted interest on an academic and regulatory level (Bonaccorsi & Secondi, 2017). Many academics have been interested in the topic of research productivity in recent years. They have concentrated on the analysis and distribution of the number of publications as well as the factors that either directly or indirectly affect productivity. However, the findings about the elements influencing the research yield are still inconclusive. The analysis based on the secondary data retrieved from bibliographic database is not able to give clear direction about the influenced factors. To highlight on that this chapter has been introduced.

4b.2 Theoretical Framework

Research productivity refers to creative thoughts and ideas that, after being studied theoretically and practically, published as articles in journals, published as conference papers, as book chapters, books or as patent registration (Hedjazi and Behravan, 2011; (Ransdell, 2001). Zainab (1999) mentions research productivity is the registration or publication of research findings in the form of journal articles, conference papers, reviews, patents. Several influencing factors has been identified based on the previous studies which are basis of the growth of research productivity of any institution's faculty members and research scholars and other academy staffs. These factors are categorised as Individual factors, Institutional factors (Turner and Mairesse, 2003), and some demographic factors are also there.

4b.2.1 Demographic Factors

There are differences of publications has been identified according to the gender of the faculties or researchers, evidence has been there in the study of Turner and Mairesse, 2003 where they were identified that there are significant differences between males and females in terms of number of produced articles. In some other studies it was showed that women are less productive compared to men in scholarly production (Pfeiffer et al., 2016; Kyvik and Aksnes, 2015). It was noticed that scholars of the highly ranked institutions are more productive compared to a below ranked institution (Long et al., 2009; Amara et al., 2015). The work experience of the researcher and time spent on research both are considered as influential factors to enhance the publication productivity (Dhillon et al., 2015; Swihart et al., 2016; Fursov et al., 2016; Amara et al., 2015). Discipline wise variations has been observed in the production of publication, scientific disciplines always contribute more publication compared to social science, arts and humanities (Obemebe, 2012).

4b.2.2 Individual Factors

It was found that age and experience of the researcher increases the scholarly publications of individuals as well as institutions he/she belongs to (Fursov et al., 2016; Dhillon et al. 2015). Collaborative research works has always a positive and influential impact on research growth of individuals as well as of the country (Gomes et al., 2011;

Morris et al., 2011; Mamun and Rahman, 2015), collaborators or mentors always motivates the researchers and as a result of this the growth of publication increases (Ransdell et al., 2001). Apart from, international collaboration opens up the scope of publication for any researchers (Abramo et al., 2011; Fursov et al., 2016) and found it as a significant factor of publication growth (Ibegbulam and Jacintha, 2016). In some other studies it is found that, if the teaching load of the faculty members reduced then it effects in the publication productivity with increasing in numbers (Mamun and Rahman, 2015; Iqbal and Mahmood, 2011). The literatures published by Ibegbulam & Jacintha (2016); (Hoffman et al. (2017) and Isfandyari-Moghaddam et al. (2012) identifies some motivational factors which causes the rate of increasing of research productivity, such of these factors are researcher's own satisfaction to contribute to the field of which he belongs to and the other one is satisfaction by staying current in the field. Curiosity and creativity are also an important motivating factor of the growth of research productivity (Fennewald, 2008). According to a study by Ajegbomogun, F. O., and Popoola, S. O. (2014), candidates' self-efficiency during the hiring process as faculty should be given adequate importance in order to foster a favourable attitude toward boosting the research productivity. Apart from all these individual factors, positivity among the researchers about the research work is also plays a great deal in increasing the scholarly publication.

4b.2.3 Institutional Factors

Institutional factors positively associated with the publication output at individual level, institutional level as well as country level. These factors comprise of library infrastructure to support with relevant information, freely available of internet connections inside the campus, provision of accessing the latest books, journals and e-journals, remote access facility to access the e-resources subscribed by the institutions, scope of attending seminars, scope of publication in university's own journals, recognition for publication. A Study by Hollister and Schroeder (2015) found that adequate library infrastructure could play a role in increasing the number of publications by providing relevant information according to the researcher's need. Internet facility is also an important support to the researcher to find the e-resources from the subscribed resources of the university (Ajegbomogun and Popoola, 2014).

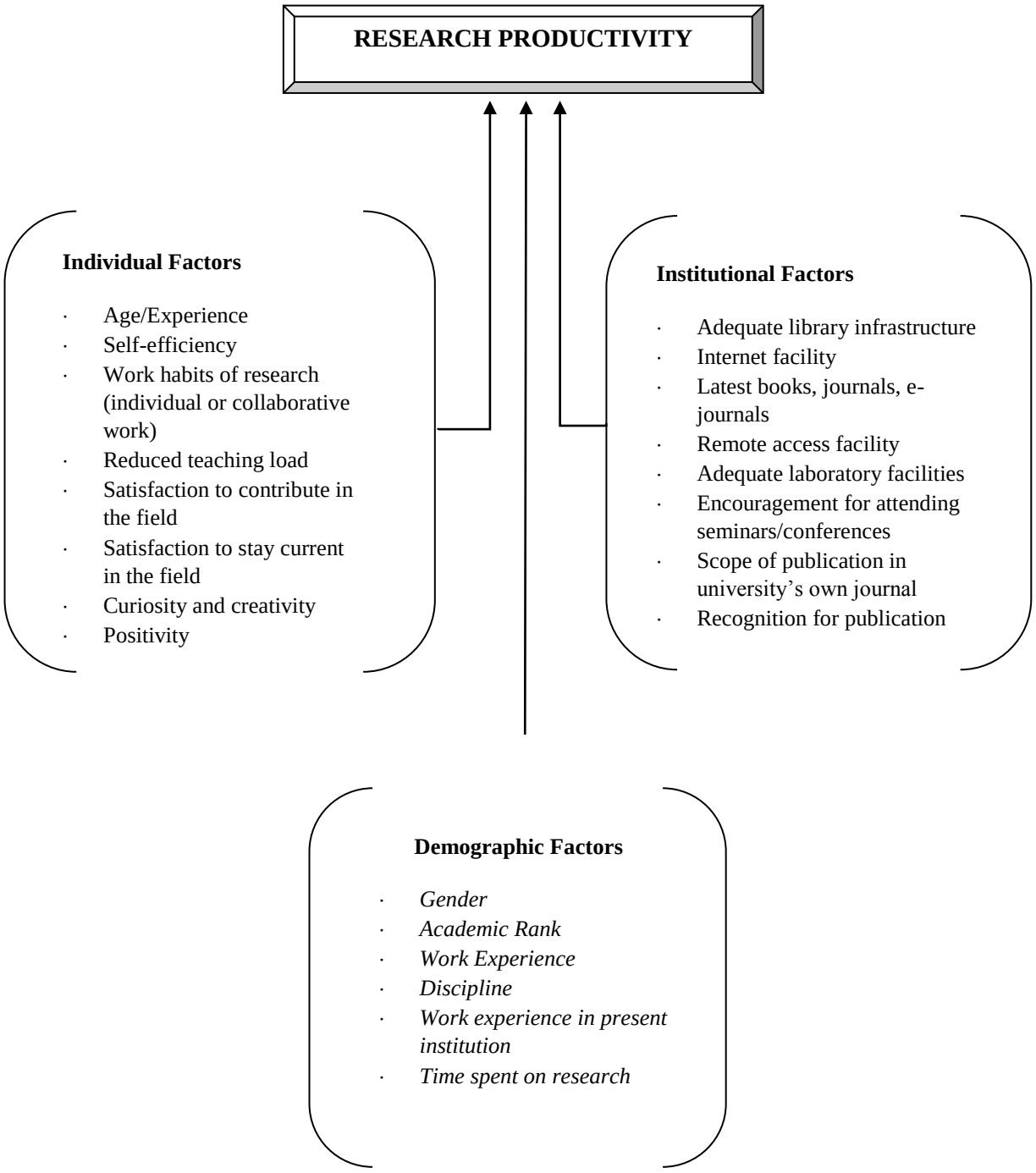

Figure 4b.1: Conceptual Framework of Factors Influencing Research Productivity

Provision of getting latest edition of books, journals and e-journals also enhance the research productivity (Iqbal and Mahmood, 2011). Remote access facility is one of the hybrid types of support where users can access the e-resources of the institution's subscribed collections from a remote place which also a supporting tool to enhance the publication productivity of the institution (Rafi, 2019 and Boukacem-Zeghmour et al., 2016). In the same way encouragement for attending seminars/conferences is also helps

to increase the number of publication (Obemebe, 2012). Except these facilities, a well-equipped laboratory facility for conduct lab-based research works and recognition for publication in highly impact or indexed journals are also important factors for enhancing the numbers of scholarly publication.

4b.3 Method of Statistical Analysis

4b.3.1 Data Collection and Sampling

The primary data were collected by using an online survey. The total population with full-time faculties and research scholars at the selected six universities are around 5000 (based on the data available in respective university websites, during the survey in the month of March-April 2022). Stratified random sampling with proportional allocation to each university were applied. A total of 1304 emails were sent out and we received 336 responses (the response rate was around 25%). Out of the total 336 responses, 33 responses have been excluded due to incompletion of the questionnaire, criteria like minimum one year completion in the affiliated universities and at least one publication by the respondents were considered for inclusion in the study, finally with all inclusions and exclusions 303 responses has been considered for the study. The faculty emails were obtained randomly from the websites of the selected universities. We obtained informed consent from the participants for their voluntary participation on the condition that the information provided through the form would remain anonymous and will be used strictly for academic purpose. Table 5.2 shows the demographic profile of the final sample.

The following Cronbach's formula has been used for the determination of the sample size.

$$n = \frac{z^2 (pq)}{e^2}$$

where,

z = 1.96

p = probability in sample (here, Authors with at least 5 publications are assumed to constitute 70% of the total population, hence the value of p = 0.7)

q = 1-p (1-0.7 = 0.3)

e = acceptable sample error (0.05)

According to the formula the actual sample size will be –

$$n = \frac{z^2 (pq)}{e^2}$$

$$n = \frac{1.96^2 (0.7\text{-}0.3)}{(0.05)^2}$$

n = 3.8416*0.21/ 0.0025

n = 0.806736/.0025

n = 322.6944 or 322 (Approx.)

4b.3.2 Survey Instrument

The questionnaire used in the study has been written in English. The questionnaire consists of 31 questions.

The main parts of the questionnaire are Part 1, General and demographic information of the researcher, where questions like name of the affiliated university, gender, academic rank, work experience, discipline etc. Demographic questions are self-explanatory; however, the remaining questions deserve explanation.

Part 2 has two sub sections. In sub section 2.1 there are 10 questions on behavioural characteristics of the researcher, questions on satisfactory level, curiosity about the research were asked for the measurement of individual factors influencing research productivity. In sub section 2.2 there are 9 questions on institutional level metrics are presented which are associated to the measurement of the factors influencing the research productivity. All these part 2 questions are designed on a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5).

In section 3 few close and open-ended questions (opinion and suggestions) are given to gather the view of researcher’s and faculty’s about the facilities and infrastructures to increase the rate of research productivity. The individual items in each scale can be found in Table 4b.1.

Cronbach's α coefficient has been applied prior to data analysis to check the reliability of the instrument (questionnaire). Overall, the scales have been found to be reliable as the value of Cronbach's α coefficient are above 0.6, indicating an acceptable level of reliability.

4b.3.3 Determination of Indices using Factor Analysis

Reliability and Validity of Constructed Scales: Cronbach's Alpha for each of the used scales demonstrates an acceptable level of internal consistency (correlation among the items), establishing dependability, assuming that 0.6 is the acceptable lowest value of internal consistency for scales with fewer than 20 items (Dall'Oglio, et al. 2010) (Table 4b.1). Additionally, each agency dimension's factor loadings in principal component analysis (PCA) shows that the underlying data match the proposed model reasonably well (Table 4b.1).

However, the factor loadings on individual motivational factors scale, Institutional factors scale and Research support scale are more reliable as compared to Academic environment scale.

Table 4b.1: Validity and Reliability Statistics of Various Scales

Scale Items	***Factor Loadings From PCA***	***Cronbach's Alpha***
Individual motivational factors		.655
Satisfaction to researchers own need to contribute to the field is important	.794	
Satisfaction to researchers own need to stay current in the field is important	.772	
Curiosity and creativity of the researcher produces more research	.620	
Positivity among the researchers to do well for the society with their research work is an important motivating factor	.621	
Academic environment		.397
Academic Rank of the institution plays key role in research	.716	
Work Habits (Individual or Collaborative nature of work) of the researcher is important for research output	.657	
Discipline wise scope of publishing research articles is a factor for high rate of production	.654	
Institutional factors		.869
Your University Library has adequate infrastructure for supporting Research	.808	
Accessibility and Utilization of Internet Resources in the campus is sufficient	.746	
Your university has provision for access to the latest books, journals and e-journals	.860	
Remote access facility to the university's e-resources is	.769	

adequate		
Adequate laboratory facilities to conduct research are present	.798	
University encourages to attend Seminars/Conferences	.679	
Research support		.709
There is provision to publish the research work in university's own journals	.760	
University provides ample scope for collaborative research work	.830	
University provides recognition for publication in high impact/UGC-Care listed journals	.802	

The above table describes the individual instrument of each of the scales formed using the Factor Analysis Method. Among the 19 questions asked to the respondents 16 found to be fit in four scales. The scale of institutional factors found as most significant than the other scales with the value of Cronbach's α coefficient of 0.869. The scale is formed with six components, viz. adequate library infrastructure, accessibility and utilization of internet resources in the campus, accessibility to the latest books, journals and e-journals, remote access facility to the e-resources etc. The second most significant scale is research support scale (Cronbach's α coefficient of 0.709), where questions like scope of publishing of research in university's own journal, provision of collaborative research and recognition for publication were there. The third most significant scale is the Individual motivational factors scale (Cronbach's α coefficient of 0.655), where questions on satisfaction for researcher's own need of contributing in the field and to stay current on the field, questions on curiosity, positivity was also there.

4b.3.4 Binary Logistic Regression

Binary logistic regression is one of the most widely used method in different fields, commonly for dichotomous dependent variables. Also, in higher education this method has been applied numbers of times to determine various aspects related to qualitative or quantitative issues. The determinants of the several dimensions of factors influencing research productivity have been estimated using binary logistic regressions.

The basic form of the binary logistic regression used is:

$$\mathbf{Log\ (p/1-p) = b0 + b1*x1 + b2*x2 + b3*x3 + b3*x3+... bk*xk}$$

Where,

b0 is the constant
b1, b2, b3... bk are the coefficients of the independent variables
x1, x2, x3.... xk. P is the estimated probability of the dependent variable assuming a value of 1.

A dichotomous dependent variable was created from the continuous variable 'number of publications', such that 5 and above publications for the respondent has been coded as '1' and below 5 publications has been coded as '0'.

4b.4 Results and Discussion

4b.4.1 Description of Sample Variables

The complete demographic characteristics of the primary samples collected for the study has been described in table 4b.2. Among the total 303 responses considered for the analysis 66% response is from male faculties and research scholars. Discipline wise distribution of the responses recorded from Science is the most with 43.56 % of the total, followed by Social Science (23.1%), Arts and Humanities (19.8%), Engineering & Technology (9.9%) and Interdisciplinary (3.63%).

Table 4b.2: Sample Characteristics

	Frequency	Percentage (%)
Gender		
Men	200	66
Women	103	34
Academic Discipline		
Science	132	43.56
Engineering & Technology	30	9.9
Social Science	70	23.1
Arts and Humanities	60	19.8
Interdisciplinary	11	3.63
Affiliated Institution of the Respondents		
Jadavpur University	127	41.91
University of Calcutta	50	16.5
University of Burdwan	51	18.83
University of Kalyani	28	9.24
University of North Bengal	25	8.25
Presidency University	22	7.26
Designation of the Respondents		
Professor	83	27.39
Associate Professor	32	10.56
Assistant Professor	82	27.06
Research Scholar	106	34.98
Years completed in the Institution		
>10 years	104	34.32
5years-10years	82	27.06
<5 years	117	38.61
Minimum Publications		
>50	83	27.39
10-50	106	34.98
<10	134	44.22

Among the universities most number of responses recorded from Jadavpur University followed by University of Burdwan and University of Calcutta. Response rate of the rest of the universities is very less compared to others. The designation wise distribution shows that most number of respondents are recorded from the pursuing doctoral and post-doctoral level scholars of these universities, total 106 scholars record has been included, with this 83 professors, 82 assistant professors and 32 associate professors from different domains has been responded. Among all the respondents 61.39% completed at least or more than 5 years in the present institution and 62.38% out of the 303 respondents published at least 10 or more articles.

4b.4.2 Scale wise response rates

Table 4b.3 describes the response rates of the constructed four scales of measuring factors influencing the productivity of an institution. Out of the four scales three of them agreed by more than 50% of the total respondents. The scale of Institutional factors received the highest number of positive responses where 169 (55.8%) of the total 303 respondents agreed that this factor has influential role on the growth of the productivity. Whereas, the scale of Research support has not found as an important factor of enhancing the productivity of research among the scholars and faculties of higher education institutions.

Table 4b.3: Response Rates of the Constructed Scales

Constructed Indices	Agree	%	Disagree	%
Index of Individual motivational factors	164	54.1	139	45.9
Index of Academic environment	167	55.1	136	44.9
Index of Institutional factors	169	55.8	134	44.2
Index of Research support	142	46.9	161	53.1

4b.4.3 Response rate of indexed materials

The table below (4b.4) describes the degree of response rate of agree/disagree to individual instrument of each of the scales formed using the Factor Analysis Method. Every instrument in a scale is measured by the given value of 1 to 5 using Likert Scale

where 1 denotes to the strongly disagree and 5 denotes to strongly agree. The calculation found that the value of the instruments in the scale of Individual motivational factors got the highest average value of 4.47 per respondents, which means that the respondents strongly agreed that each of the factors in this scale has very much important for the growth of the research productivity of the universities. Components of Academic environmental factors also received the response rate of 3.98 on average by every respondent, whereas the components of Institutional factors scored 3.65 on average per respondents. The lowest average score measured for the components in the scale of Research support where only 3.05 average score is recorded by the respondents indicating the less importance than the other scales.

Table 4b.4: Components wise Response Rate in each of the Index Materials

Index Materials	***1*** (strongly disagree)	***2***	***3***	***4***	***5*** (strongly agree)	***Total*value***
Individual motivational factors						
a. Satisfaction to researcher's own need to contribute to the field is important	-	4	27	97	175	1352
b. Satisfaction to researcher's own need to stay current in the field is important	3	3	29	107	161	1329
c. Curiosity and creativity of the researcher produced more production	1	1	16	62	223	1414
d. Positivity among the researchers to do well for the society with their research work is an important motivating factor	4	6	33	98	162	1317
Total	(Average degree of response rate of agree/disagree to each indexed component- 4.47)					5412
Academic environmental factors						
a. Academic Rank of the institution plays key role in research	23	35	108	84	53	1018
b. Work Habits (Individual or Collaborative nature of work) of the researcher is important for research output	-	06	23	90	184	1361
c. Discipline wise scope of publishing research articles is a factor for high rate of production	1	9	58	126	109	1242
Total	(Average degree of response rate of agree/disagree to each indexed component- 3.98)					3621
Institutional factors						
a. Your University Library has	13	39	81	101	69	1083

	adequate infrastructure for supporting Research						
b.	Accessibility and Utilization of Internet Resources in the campus is sufficient	7	22	63	107	104	1188
c.	Your university has provision for access to the latest books, journals and e-journals	12	32	62	111	86	1136
d.	Remote access facility to the university's e-resources is adequate	25	35	74	113	56	1049
e.	Adequate laboratory facilities to conduct research are present	13	43	98	97	52	1041
f.	University encourages to attend Seminars/Conferences	8	35	69	101	90	1139
	Total	(Average degree of response rate of agree/disagree to each indexed component- 3.65)					6636
Factors related to Research support							
a.	There is provision to publish the research work in university's own journals	98	67	55	47	36	827
b.	University provides ample scope for collaborative research work	24	44	99	71	65	978
c.	University provides recognition for publication in high impact/UGC-Care listed journals	39	47	80	72	65	970
	Total	(Average degree of response rate of agree/disagree to each indexed component - 3.05)					2775

Note: Scale ranging from "strongly disagree" (1) to "strongly agree" (5)

4b.4.4 Significant factors influencing research productivity: Results of Binary Logistic Regression Analyses

A Binary logistic regression analysis was conducted to test the significance of the determinants of factors influencing research productivity in different models. Table 4b.5 presents the results of the binary logistic regression analyses for different dimensions of factors associated with enhancing the research publications at institution level.

Model-I (for Research Scholars): Model-I refers to research scholars, where work experience of the researchers found most significant factor for enhancing the publication, the value of the regression found significant for individual motivational factors (significance at <10% level) and research support (significance at <10% level). Other general variables like gender, time spent on research and among all the indices academic environment, institutional factors are not found to have any significant

association with the publication productivity of the researchers. Some other factors are also there for enhancing the numbers of publication.

Table 4b.5: Determinants of factors influencing research productivity

Variables	*Model-I* Exp (β)	*Model-II* Exp (β)	*Model-III* Exp (β)	*Model-IV* Exp (β)
Gender	0.51	0.4	0.43	0.49*
Work experience	1.57***	1.38***	1.32***	1.47***
Time spent on research	0.99	1.00	1.56	.99
Index 1: Individual motivational factors	2.95*	0.91	0.01*	1.53**
Index 2: Academic environment	0.51	7.34**	1.00	1.69
Index 3: Institutional factors	0.64	0.57	0.62*	0.66**
Index 4: Research support	2.52*	1.3	1.42	1.28
Constants	0.05***	0.22**	0.18***	0.14***

Note: * ** indicates significance at <1% level; ** ** indicates significance at <5% level; * * indicates significance at <10% level;
Model-I Research Scholar; Model-II Assistant Professor; Model-III Professor and Associate Professor; Model-IV: Overall research productivity of institution

Model-II (for Assistant Professors): In case of assistant professors the result of binary logistic regression indicates that variable like work experience has significance role on increasing the publication of the faculties, but factors like gender, time spent have not found significant in this regard. Among the four indexes constructed as par the factors loading using principal component analysis (PCA), the index of academic environment found to be most significant (significance at <5% level) for enhancing the publication of the faculties. Except these factors some other factors are also there influencing the productivity.

Model-III (for Professor and Associate Professor): In Model-III results has been shown for Professors and Associate Professors, where the regression analysis shows that work experience is more effective than any other factors to increase the publications and it is significant at <1% level. Among the four indexes Individual motivational factors and Institutional factors are also found significance at <5% level. Scale of academic support and research support are not found to have any significance role on increasing the publications. Though these factors are measurable, except these

some other constants are also there which have some positive impacts on enhancing the publications among the professors.

Model-IV (Overall research productivity of institution): Finally, the model-IV presents the results for the determinants of research productivity at institutional level which comprises research scholars, assistant professors, associate professors, and professors. The result of binary logistic regression shows that among the individual variables gender and work experience have significance role on enhancing the productivity of the individuals as well as of the institutions for which he/she works for. The other individual variable, i.e. time spent on research has not found significant according to the result.

Part-III

4c Correlating Research Impact using Citation Counts and Altmetrics Attention Score

With the conventional metrics of measuring research impact, nowadays Altmetrics, by which social visibility of an article is measurable and is very useful to analyse the research impact as well. The present section aims to measure the relationship between citation count and altmetric score of top cited articles from six top universities of West Bengal published during the period 2001-2021. The citation number of articles has been retrieved from Elsevier's Scopus database and identified 25 top cited articles from each of the six university. Out of the 150 articles, 55 articles (36.67%) found with at least 1 altmetric attention. The altmetric data were fetched through the dimension.ai database using doi of the top cited articles.

4c.1 Introduction

To assess the significance of scientific research, citation-based indices are used (Amath et al., 2017). These metrics have been used by the researchers for evaluating the quality of research for quite a long time. Generally, the data source for this type of studies is taken from citations databases like Scopus, Web of Science, Google Scholar. In 2010, a new type of metrics has been introduced for measuring the scientific impact of research publications with an emphasis on social media (Shema, 2014). The fundamental benefit of these measurements, which are referred to as altmetrics, is that they allow for the measurement of the impact of a document shortly after it has been released (Xia et al., 2016). Altmetrics has the scope to highlight different perspectives on impact, such as societal, educational etc. The goal of altmetrics is to supplement and overcome the drawbacks of web-based evaluations like webometrics and traditional assessment methods like bibliometrics, scientometrics.

Altmetrics data are freely available through the free tool "Altmetric it" of Altmetric.com or the data could be accessible through the dimension.ai database by using the doi or title of the research paper. Altmetric attention score provides the social impact of any article with that it also determines the number of readers by counting the readers in reference management tools like Mendeley and in CiteULike, a web-based

social bookmarking tool designed to encourage the dissemination of references to academic papers.

In the materials below, you may get the altmetric score and its several indications for tracking how much attention publications receive over a period. These are - Referenced in Patents, Referenced in Wikipedia Pages, In Facebook Pages, Tweeted by, In Facebook Pages, Blogged by, Referenced in Policy Sources, News Outlets, Readers in Mendeley, Readers in CiteULike.

Each of the listed resources has a weighted score that is utilised in an automatic process to determine the total altmetric score. The readers in Mendeley and CiteULike are counted separately and has no impact on total altmetric attention score. Authors or may be Journals with high repute, indexed in databases like Web of Science or Scopus used the social media platforms like Tweeter, Facebook, YouTube, Wikipedia pages, Blogs, referenced in policy sources and reference management tools like CiteULike, Mendeley are used to increase the publicity of the published articles. With this effort the published articles can easily reachable to the end users working on the field of her interests. So, in this way the importance of social platforms could be understood to increase the visibility and accessibility of the published literatures. As a result, Altmetrics can be used in conjunction with the number of received citations to evaluate the quality of the articles in these journals.

4c.2 Materials and Methods

4c.2.1 Selection of Data

Among the many central, state and private universities in the country, according to the NAAC accreditation six top ranked universities of West Bengal has been taken as per their published literature in all domains excluding engineering and computer sciences during the period from 2001 to 2020. The database has been used to retrieve the data was Scopus, from where top 25 articles has been taken from each of the university. Then, the doi of the papers has been used to identify the social impacts of the articles from dimension.ai. As a result total 55 articles found with altmetric attention score. With based these secondary data this study has been analysed.

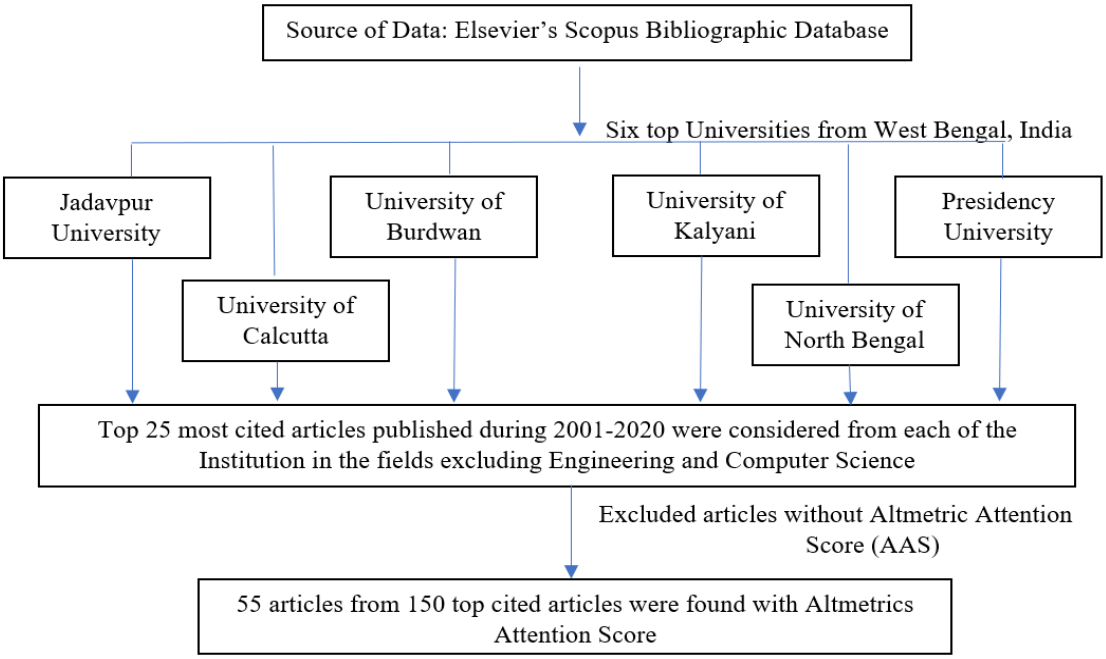

Figure 4c.1: Screening of Highly Cited Articles for fetching Altmetric Attention Score

4c.2.2 Statistical analysis

SPSS 20.0 has been used for measuring the Pearson's Correlation Coefficient between the variables like Citation Counts and Altmetric Attention Score, Citation Counts and Mendeley Readership.

4c.3 Analysis and Discussion

4c.3.1 Citation Counts in Scopus and Dimension with Altmetric attention Score

Table 4c.1 shows the differences of Citation counts in Scopus and Dimension for the same articles. Scopus citation counts is not freely available to all and Dimension is available freely if you know the title of the article or the DOI of the paper. According to the top 25 cited articles were analysed from each of the institute and listed only those which had at least one altmetric attention score. As a result, 55 articles were identified and citation comparison in both the databases were presented (Table 4c.1). The differences are not so much in both the databases for most of the universities, except in case of two universities where the difference is more than 1000. These two universities are University of Calcutta (difference of citation count is 1397) and other one is Presidency University (difference of citation count is 1025).

Table 4c.1: University wise distribution of Citation and Altmetric Attention Score

Paper's DOI	Citation in Scopus	Citation in Dimension	Recent Citation	FCR	RCR	AAS
Jadavpur University						
10.1016/j.ijpharm.2006.09.025	604	559	63	76	13	6
10.1016/j.phymed.2007.02.002	510	508	79	36	11	8
10.1289/ehp.5966	390	421	54	67	6.6	3
10.3390/molecules14051660	382	377	47	35	8.74	3
10.1016/S0039-9140(02)00270-9	367	380	29	41	5.72	10
10.1081/CLT-100108509	363	354	17	42	7.02	10
10.1126/science.1201180	343	446	78	46	9.07	10
10.1016/j.jep.2006.03.021	314	272	25	38	6.56	9
10.1021/jp0123029	303	312	27	28	-	3
10.1016/j.pcrysgrow.2005.10.001	287	289	25	30	-	9
10.1016/j.toxlet.2004.01.009	279	292	31	30	4.6	3
10.1002/ptr.1281	278	295	30	36	5.72	27
10.3389/fgene.2013.00283	254	362	92	32	10	9
10.1016/j.phymed.2011.10.003	249	291	65	57	7.93	20
10.1016/S1734-1140(10)70262-0	244	239	20	35	6.56	6
Total	5167	5397	682	629		136
Average	344.47	359.8	45.47	41.93		9.07
University of Calcutta						
10.2478/v10102-009-0001-7	1014	1700	631	-	26	578
10.1016/j.carbpol.2011.06.030	474	617	174	49	-	3
10.1016/j.lfs.2015.10.025	391	733	298	103	35	28
10.1007/s12088-008-0006-5	239	291	61	27	6.12	3
10.1021/es400521h	219	288	73	24	10	75
10.1016/S0091-3057(03)00110-2	200	195	26	18	3.8	4
10.1016/j.pmatsci.2013.01.003	197	230	45	25	-	3
10.1038/sj.cdd.4401435	179	188	21	9.98	4.29	3
10.1002/jobm.201100552	176	244	53	22	6.86	6
Total	3089	4486	1382	277.98		703
Average	343.22	498.44	153.56	30.89		78.11
University of Burdwan						
10.1080/00958972.2011.583646	372	438	132	48	-	1
10.1111/j.1365-2095.2012.00943.x	295	385	110	45	-	3
10.3389/fpls.2015.00420	279	428	160	52	13	2
10.1093/glycob/cwn092	265	298	50	30	7.39	9
10.1021/ic3019953	156	160	13	15		1
10.1016/j.phytochem.2004.07.025	142	144	14	10	1.91	1
Total	1509	1853	479	200	22.3	17
Average	251.5	3o8.83	79.83	33.33		2.83
University of Kalyani						
10.1023/A:1026028303196	912	924	42	48	20	3
10.1038/nature02638	903	954	104	83	13	6
10.1002/9783527634880	256	207	57	-	-	3
10.1007/s00775-008-0400-9	210	212	20	16	4.14	6
10.1016/j.chemosphere.2013.01.097	179	235	58	30	5.7	3
10.1016/S0301-4215(02)00311-7	178	181	18	42	-	3
10.1016/j.tet.2007.01.063	171	163	12	13	-	3
10.1007/s13225-017-0378-0	139	123	33	20	-	3
10.1016/j.saa.2004.06.054	116	116	11	9.9	1.14	3

Total	3064	3115	355	261.9		33
Average	340.44	346.11	39.44	29.1		3.67
University of North Bengal						
10.1086/425871	271	286	11	-	5.42	6
10.1103/PhysRevD.74.024020	136	159	34	32	-	6
10.1016/S0963-9969(02)00194-1	135	144	16	16	-	6
10.1103/PhysRevD.67.103009	134	141	16	29	-	3
10.1093/molbev/msj078	126	137	5	9.58	2.67	15
10.1038/hdy.2012.83	125	163	28	12	4.13	7
10.1093/molbev/msp213	113	152	34	10	3.19	17
10.3390/12102413	93	79	8	6.02	1.12	3
10.1002/jobm.200510050	89	125	35	12	1.65	3
10.1016/S0168-1605(02)00124-1	86	94	10	4.57	1.28	3
Total	1308	1480	197	131.17		69
Average	130.8	148	19.7	13.12		6.9
Presidency University						
10.1155/2014/701596	687	1100	404	124	20	3
10.1016/j.scitotenv.2020.139086	147	631	463	340	58	87
10.1093/mnras/stt401	112	142	35	39	-	1
10.1051/0004-6361/201526766	106	169	41	41	-	17
10.3389/fenvs.2015.00021	86	125	39	17	-	2
10.1007/s10701-009-9349-y	82	78	2	31	-	3
Total	1220	2245	984	592		113
Average	203.33	374.16	164	98.67		18.83

FCR= Field Citation Ratio, RCR= Relative Citation Ratio, AAS = Altmetric Attention Score

4c.3.2 Recent Citations, Field Citation Ratio and Relative Citation Ratio

- **Recent Citations:** The recent citations are the number of citations that were received in the last two years that have been recorded in indexed journals of Dimension database. Among the six universities maximum recent citations identified for 1382 for 9 publications of University of Calcutta at an average rate of over 153citations in last two years, followed by 984 citations by Presidency university and 682 by Jadavpur University publications. The total Altmetric attention accounted 703 by the University of Calcutta articles, whereas only 69 attention sore is there for the articles of University of North Bengal and as a result only 197 recent citations have been received by these articles in recent times. So, it's clear that if the artcles found well spread in social platforms it also effects in its citations too.

- **Field Citation Ratio (FCR):** According to the dimension definition "The Field Citation Ratio (FCR) indicates the relative citation performance of an article, when compared to similarly-aged articles in its subject area. The FCR is normalized to 1.0 for this selection of articles. A FCR value of more than 1.0 shows that the

publication has a higher than average number of citations for its group. Articles that are less than 2 years old do not have an FCR record in Dimension database. An article with zero citations has an FCR of 0." (Field Citation Ration, (n.a.)).

There are 53 top papers has the FCR value out of total 55, means all these articles published before two years. Highest field citation has been identified 340 for one article of Presidency University, followed by 124 again from Presidency, then 103 from University of Calcutta. Highest average Field citation ratio has been noted for Presidency University (98.67), then Jadavpur University (41.93) and University of Burdwan (33.33). Lowest FCR among the six universities noted in the publication of University of North Bengal (13.12)

- **Relative Citation Ratio (RCR):** According to dimension "The Relative Citation Ratio (RCR) indicates the relative citation performance of an article, when compared to other articles in its area of research. The RCR is normalized to 1.0 and calculated for all articles funded by the NIH in the Dimensions catalogue. An RCR of more than 1.0 shows that a publication has an above average citation rate for its group, when defined by the subject area citation rates of the articles that have been cited with it. Articles that are less than 2 years old, or do not have citations, do not have an RCR."

  Relative citation ration is associated with the measurement of the citation performance of an article within its area or research. Among the top cited articles from the selected universities highest RCR (26) recorded by article having doi-10.2478/v10102-009-0001-7, followed by 20 from one article of University of Kalyani (doi-10.1023/A:1026028303196).

4c.3.3 Active in different Social Platforms

A review of top cited articles of some top universities of West Bengal, India showed that out of total 150 articles 55 articles were traced at least once in social platforms (Table 4c.2), as readers in reference management sources or used as a reference, such sources are tweeter, Facebook pages, in blogging, news outlets, patents, Wikipedia pages, in Mendeley and CiteULike etc.

Table 4c.2: The most used social platforms by the top cited Articles of Universities in West Bengal

Sources of Attention	Number of Studied Articles	Number of Articles with Attention out of 55 (%)	Total attention Score	Mean Attention Per Article	Highest Attention	Rank Based on Attention Score
Referenced in Patents	55	24 (43.64)	87	3.63	26	3
Referenced in Wikipedia Pages	55	19 (34.55)	46	2.42	6	5
Referenced in Policy Sources	55	7 (12.73)	13	1.86	6	9
Tweeted by	55	18 (32.73)	104	5.78	48	2
Blogged by	55	5 (9.09)	13	2.6	6	8
In Facebook Pages	55	8 (14.55)	15	1.88	4	7
News Outlets	55	9 (16.36)	81	9	60	4
Readers in Mendeley	55	55 (100)	18470	335.82	3983	1
Readers in CiteULike	55	12 (21.82)	23	1.92	5	6

Table 4c.2 indicates that the articles received the attention score is mainly based on the readership count on Mendeley as it has been found for all the top cited articles with at least 1 AAS as per the source of the data. All the 55 articles (100%) together counted 18470 attention score in Mendeley Readership with an average of 335.82 per article. The highest readership found in Mendeley is 3983 from 1 article of University of Calcutta.

Tweeter share is in the second rank among all these articles according to the total attention score, it is counted 104. Only 18 papers (32.73%) were shared in tweeter. These articles were tweeted by 104 times and the highest number a paper were tweeted was 48 times. The average tweet for each of the articles was 5.78.

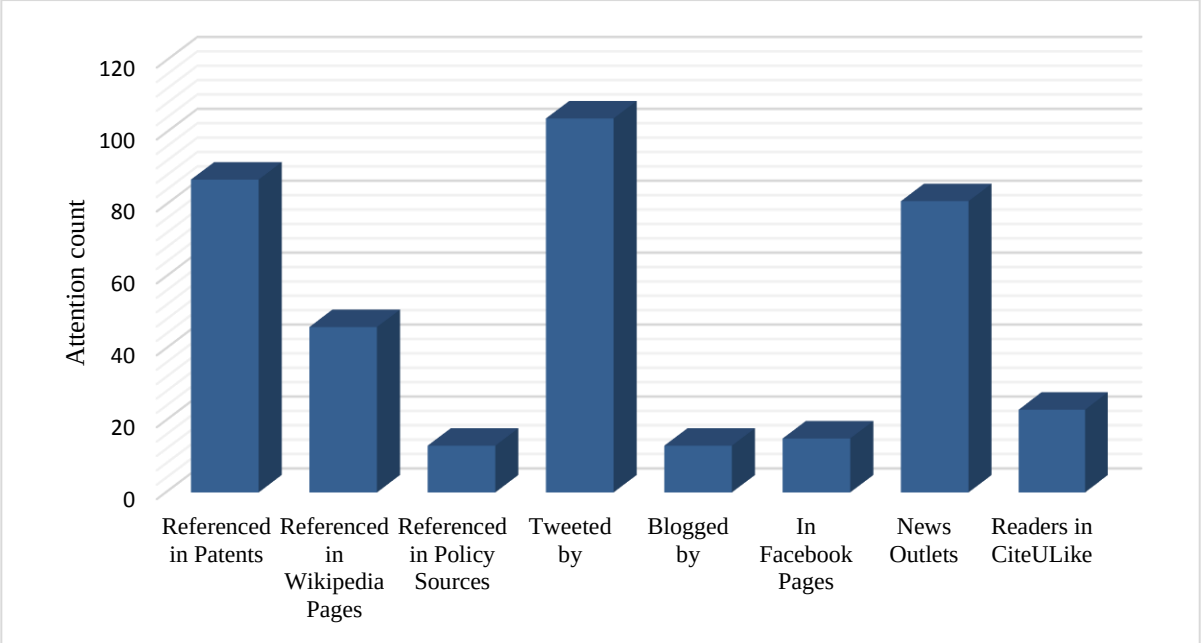

Figure 4c.2: Social Communication of top cited scholarly publications

Referenced in Patents scored 87 attentions for 24 articles (43.64%) with an average of 3.63 reference count. News outlets ranked 4 as per the table shows with an attention count of 81 for only 9 papers (16.36%) found with this category of sources. Followed by Wikipedia 46 attention for 19 papers, Readers in CiteULike 23 attention for 12 articles. The share in Facebook Pages, Blogging and in Policy Sources were found is very less in numbers for these top cited articles.

4c.3.4 Correlation between Traditional Indicators and Social Indicators

Table 4c.3: Result of Pearson's Correlation Coefficient

Pearson's Correlation Coefficient					
		Citation	AAS	Citation	Mendeley readership
Citation	Pearson Correlation	1	.466**	1.000**	.627**
AAS	Pearson Correlation	***.466***	1	.466**	.880**
Citation	Pearson Correlation	1.000**	.466**	1	.627**
Mendeley readership	Pearson Correlation	***.627***	***.880***	.627**	1

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation has been made on two different set of variables, where first one associated between citation count & altmetric attention score and the other one is between citation Count and Mendeley readership. The analysis showed a positive and significant correlation (r=0.466, significant at 0.01 level) between the number of citations and overall altmetric attention score of the highly citated research publications from six universities in West Bengal. A strongly positive and significant correlation is also found in between citation count and Mendeley readership (r=0.627, significant at 0.01 level).

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Chapter V

Findings and Conclusions

CHAPTER - V

FINDINGS AND CONCLUSIONS

The research performance of Universities in West Bengal has been analysed based on the available literature in Elsevier's Scopus Database for the period of 2001 to 2020. The study also highlights the influencing factors of productivity among the faculties and researchers of these universities. It was analysed and interpreted in the previous chapter. Based on the outcomes of the statistical measures, metric indicators and outputs of visualization tool, this chapter presents the findings as per the objectives of the study.

5.1 Findings of the Study

The inferences were made from the study and the findings are categorized under three parts as per the analysis chapter organized.

5.1.1 Findings Regarding Research Performance of the Universities based on the Secondary Data

- A steady growth in publications observed over the years for all the Universities under investigation. In Jadavpur University and University of Calcutta the growth of publications is on the higher side than the other universities. There are only few cases noted where the following year has lesser number of papers than the preceding year. There are fluctuations has been noted over the years in case of average citations received by the papers in a particular year. The peak year of publications is noted during the recent years for most of the universities.

- The result indicates that if the relative growth rate decreases the doubling time of the publication growth will increase in an inversely proportional ratio. If the rate of growth is found high then the doubling time of the publications will be low.

- The projection of trend analysis indicates that, a positive trend of growth for all the universities is noted and in next thirty years the publications will be doubled for most of the universities if present trend maintained.

- The researchers, faculty members of the Universities favoured the collaborative research work rather individual publications. The average authorship indicates

that the researchers of these Universities used at least three or more authors to publish a paper on average. The percentage of single-authored papers is very less in number in all the universities which also indicates that the researchers are not preferred to do their research work individually. The high degree of collaboration in all the University's publications also indicates the same.

- The channels of communication preferred by the authors of the universities in West Bengal are dominated by the journals of high impact factor covering main stream Science based subjects in most of the cases. It is found that Social Science and Arts & Humanities journals are very less in the top list. Springer, Elsevier, Taylor & Francis found as the top publishing agencies in which most number of articles published by the top university authors of West Bengal.

- It is found from the analysis that all the universities under investigation had published total 30934 documents during the period 2001 to 2020. Among all these publications 1829 publications (5.94%) found as recorded zero citations. The highest percentage of papers recorded citations in between 1 to 10 at the point of data collection of the study. Among all the publications 265 highly cited papers identified which papers recorded 100 or more citations. Most number of highly cited papers recorded by Jadavpur University (158) for the publications during the period. Jadavpur University also recorded the highest number of total citations for the publications during the period followed by University of Calcutta.

- It is also found that the faculties, researchers of these Universities are interested to publish their work more in Journals, while the interests of publishing in conferences, seminars or review articles is very few. The percentage share of indexed books and book chapters is also very less in number.

- By analysing the countries collaboration in the Universities publications, it is found that the authors are tends to do their collaboration with the developed countries more than the developing countries.

- Among the subject areas considered for the study some of the main stream science subjects contributed way ahead than the Social Science, Arts & Humanities subjects.

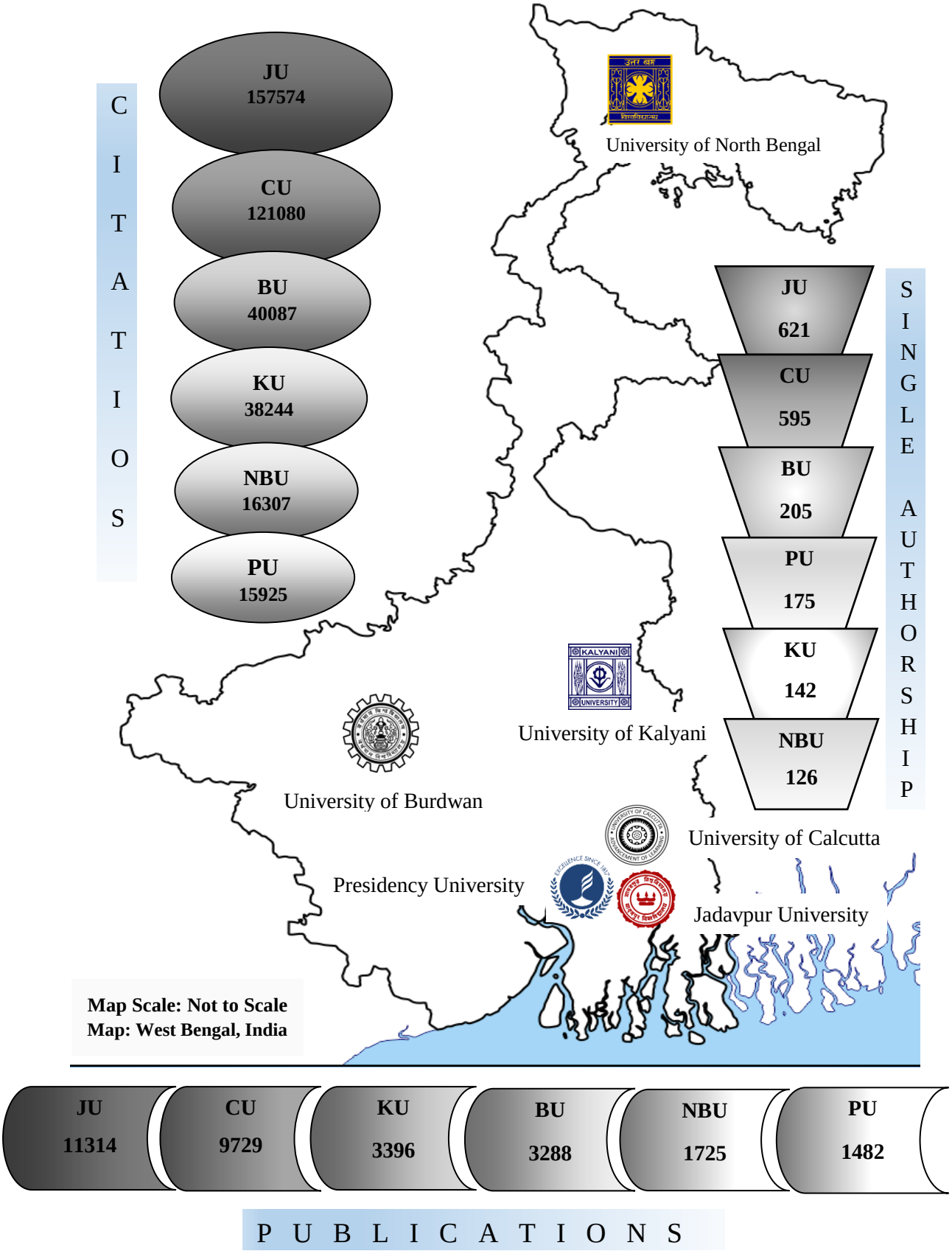


Figure 5.1 Location wise Research Outputs of Universities in West Bengal, 2001-2020

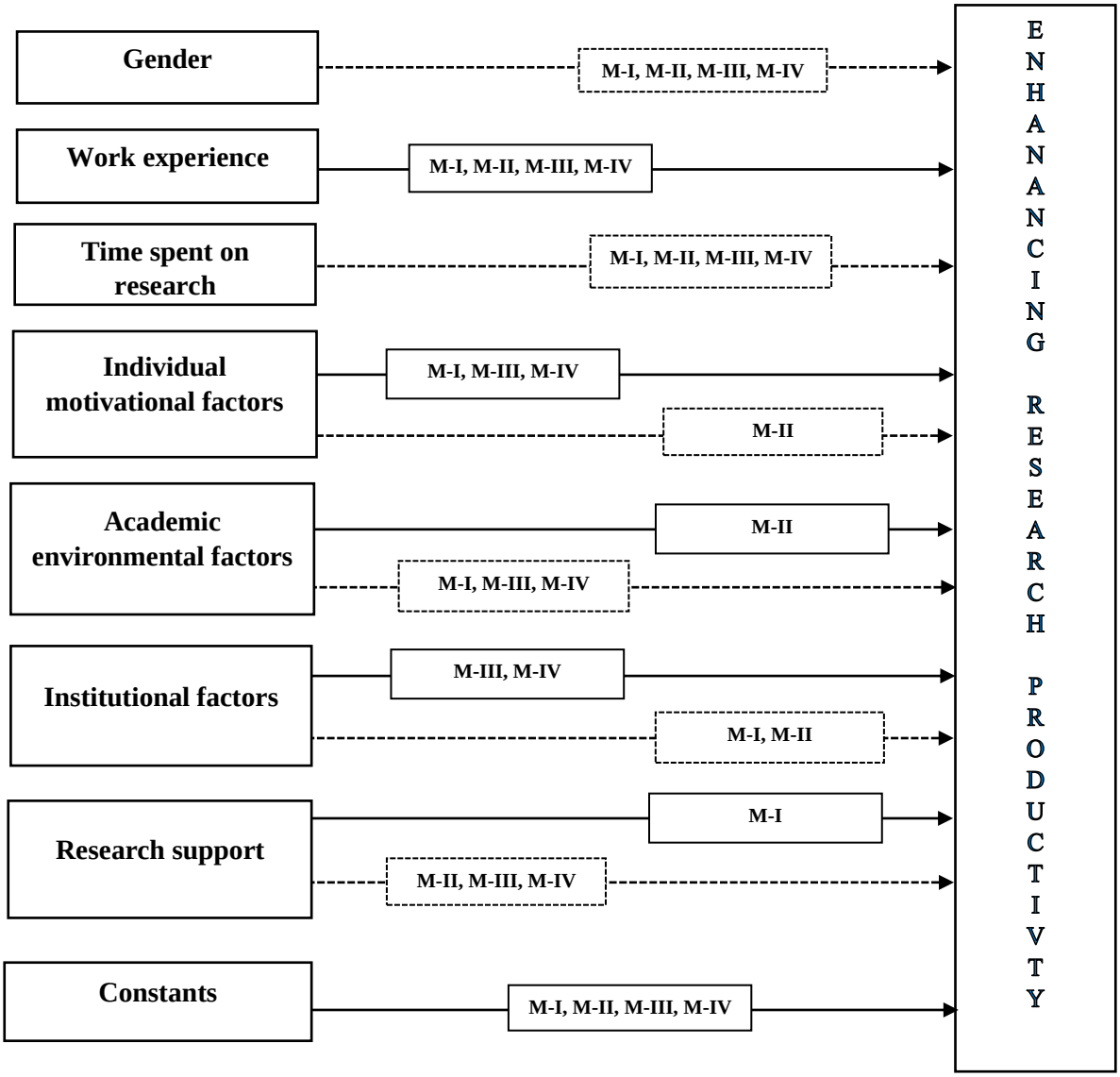
5.1.2 Findings Regarding Major Factors Influencing Research Productivity

Results of the part II of the analysis, where factors influencing research productivity has been measured which reveals that several factors have a substantial impact on the rise of publication productivity among the research scholars and faculty members of Universities in West Bengal. The results have been described under four models, in which the Model-I is associated with the Research Scholars, where work experience of the researchers found most significant factor for enhancing the publication, the value of the regression found significant for individual motivational factors (significance at <10% level) and research support (significance at <10% level). The Model-II describes the factors for the Assistant Professors, where the result found that work experience has significance role on increasing the publication of the faculties, but factors like gender, time spent have not found significant in this regard. Among the four indexes constructed as par the factors loading using principal component analysis (PCA), the index of academic environment found to be most significant (significance at <5% level) for enhancing the publication of the faculties of this level.

The Model-III associated with the factors influencing for the growth of productivity among the Associate Professors and Professors, where the regression analysis shows that work experience is more effective than any other factors to increase the publications and it is significant at <1% level. Among the four indexes, Individual motivational factors and Institutional factors are also found significance at <5% level. Scale of academic support and research support are not found to have any significance role on increasing the publications. Though these factors are measurable, except these some other constants are also there which have some positive impacts on enhancing the publications in all the models described.

The overall research productivity of institutions is described in Model-IV and the result found that among the individual variables gender and work experience have significance role on enhancing the productivity of the individuals as well as of the institutions for which he/she works for. The other individual variable, i.e. time spent on research has not found significant according to the result.

Based on the results of the Binary Logistic Regression the proposed framework has been developed describing the significant factors influencing Research productivity among the scholars and faculty members of Universities in West Bengal.



M-I: Research Scholar;
M-II: Assistant Professor;
M-III: Professor and Associate Professor;
M-IV: Overall Research Productivity of an Institution.

Figure 5.2: Significant Factors Affecting Research Productivity in Different Models

The four indexes formed which together consists with 16 individual questions associated with the number of publications of any higher education institutions. The scale on individual motivational factors have found significance (level of significance at <5%) for increasing the numbers of publications. Also, the institutional factors consist by items such as adequate library and laboratory facilities, internet services in the campus, access to latest books, journals, e-journals etc. are also found significance (level of significance

at <5%) for enhancing the number of publications. Despite of these two scales, the scale of academic environment and research support have not found significant role in the matter of increasing the numbers of research of any institution.

5.1.3 Findings Regarding Social Impact of Highly Cited Publications

A positive and significant correlation was observed between the number of citations and the Mendeley readership with Pearson's correlation coefficient (r) value of 0.627 and there was a positive and significant correlation also observed between the citation counts and overall altmetric attention score with Pearson's correlation coefficient (r) value of 0.466. Altmetrics represents the social communication of the scholarly publications, the citation counts of any articles could be increased thorough the social communication, as it increases the visibility and accessibility of the work more than anything else.

The counts of Altmetric Attention Score of the top cited articles are mostly based by the use in platforms like Mendeley, Twitter, Facebook, as referenced in Patents, Wikipedia pages, in News Outlets etc.

5.2 Suggestions

- Self-esteem of a researcher is the most important characteristics; striving for excellence is an important driver, so Universities need to look organise more programs for the development of such characters among the researchers.
- Young teachers need to be motivated for doing project works by giving a seed money from university fund. This will enhance research output, interaction with scholars, field survey, data collection based on which papers can be written.
- Good research can take place if teachers are not appointed in bureaucratic jobs. Research takes a backseat since a lot of time is taken away by regular teaching which in most situations do not follow the UGC workload division and administrative jobs.
- An environment of collaboration and cooperation amongst the departments under a university given the rise of interdisciplinary and multidisciplinary research activities.

- Research output must be circulated among the other researchers, faculty members and peer group as well as society for further technological advancement.
- Institutional recognition to good researchers and smooth administrative support to research projects would ensure quality research.
- The respective universities need to encourage the scholars and faculty members in Social Sciences, Arts and Humanities and Interdisciplinary research as the number of quality research from these fields still lacking compared to Science based subjects.
- Faculty exchange and students exchange program with famous institutes of the country and globe; compulsory foreign visit by the financial support of the university; yearly research fund support will help to increase the productivity of any institutions.
- Research Advisory Committee of every department should be well updated regarding the latest research across the globe so that they can embrace and encourage new research issues without any pseudo-disciplinary narrow outlook.
- Higher Education Institution's ranking bodies are recommended to consider altmetrics in addition to traditional indicators when assessing scientific outputs.

5.3 Future Research Scope

- In this type of research, where the main aim is to highlight the research productivity of institutions of higher education, it is recommended to do the same by using bibliographic databases, like Web of Science, Scopus etc. individually or by considering both the databases.
- A stream-wise comparative research performance analysis is also recommended.
- Comparative analysis with the other top universities regarding research performance can be analysed.
- Indexes formed for different levels can be measured in respect to other university's research performance also.

5.4 Conclusions

The research performance of six top state universities of West Bengal has been analysed based on the literature available at Elsevier's Scopus database for a span of twenty years from 2001 to 2020. Based on the analysis of the secondary data, it is concluded that a gradual growth of publications was there among the universities of West Bengal and it is likely to be doubled in the next thirty years. Among the six universities, in terms of numbers of publications and received citations Jadavpur University and University of Calcutta is far ahead from other universities of the state.

It is also observed that the highly cited papers have been well spread among the social platforms, such as in twitter, Facebook pages, in Wikipedia pages, in blogs and used as reference in patents, policy sources and these articles are also active in news sources. It means highly cited works has also the high social impact. Citation and Altmetrics Attention or Mendeley Readership could not be replaced by each other, they can only complement each other. With citation, Altmetrics could be used as a supplement for assessing the impact of publications. So, it is recommended to the researchers to active in all the social platforms where his research can be share, it will increase the visibility of the work to the public more and will create some social impact which will result as to get more citation as well.

The factors influencing research performance has been analysed based on the primary data and it is found that the individual variables, viz. gender and work experience have significance role on enhancing the productivity. With this, Individual motivational factors and Institutional factors are also found significant (significance at <5% level) for the growth of research publications of an institution. The results also found that research support, academic environment is still not sufficient to influence the research activities in these universities. To overcome the problems more funding should be expected from the governments to this kind of top universities of the states.

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APPENDICES

Appendix I: Questionnaire for Survey on Factors in Influencing Scholarly Publication

Heading of the section: Factors influencing scholarly publication productivity among University Professors and Researchers: The Case of Six Top Universities of West Bengal

Respected Professors/Fellow Researchers,

I would like to request your assistance in helping me collect the following data for my study, 'Research Performance of Universities in West Bengal: A Comprehensive Metric Study.' The purpose of this brief questionnaire is to identify the major factors that influence the Individual Research Output of University Professors and Researchers, which also help me out to configure the major factors affecting research productivity of your respective University.

I would appreciate your cooperation in this and assure you that the information you provide shall be kept confidential. Your name will not be revealed in any of the reports.

Thanking You,
Arijit Das
PhD Research Scholar
Department of Library and Information Science
Jadavpur University
Kolkata 700 032

I have read the purpose of the research and willingly agree to participate

Yes ☐

No ☐

1. General and Demographic Information-

a. Name of the University -

Jadavpur University ☐

University of Calcutta ☐

University of Burdwan ☐

University of Kalyani ☐

University of North Bengal ☐

Presidency University ☐

b. Current Academic Rank

Research Scholar Assistant ☐

Assistant Professor ☐

Associate Professor ☐

Professor ☐

c. Work Experience (In Years)

_____

d. Discipline

Science ☐

Engineering & Technology ☐

Social Science ☐

Arts and Humanities ☐

Interdisciplinary ☐

e. Years completed in this Institution –

_____

f. Number of hours of work time you spent on Research (in a week)-

_____

g. Total Number of Publications –

_____

2.1 Individual Factors Influencing Research Productivity According to You -

[Please evaluate the impact of Individual Factors influencing research productivity to you using a scale of 1 to 5, with 5 being "Strongly Agree" and 1 being "Strongly Disagree".]

a. Age / Experience of researcher is important for producing more research

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

b. Self-Efficacy of the researcher is important

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

c. Academic Rank of the institution plays key role in research

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

d. Work Habits (Individual or Collaborative nature of work) of the researcher is important for research output

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

e. Reduced teaching load of the faculty members or full-time researchers will benefit the research productivity

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

f. Satisfaction to researcher's own need to contribute to the field is important

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

g. Satisfaction to researcher's own need to stay current in the field is important

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

h. Curiosity and creativity of the researcher produces more research

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

i. Discipline wise scope of publishing research articles is a factor for high rate of production

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

j. Positivity among the researchers to do well for the society with their research work is an important motivating factor

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

2.2 Institutional Factors Influencing Research Productivity According to you -

[Please evaluate the impact of Individual Factors influencing research productivity to you using a scale of 1 to 5, with 5 being "Strongly Agree" and 1 being "Strongly Disagree".]

a. Your University Library has adequate infrastructure for supporting Research

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

b. Accessibility and Utilization of Internet Resources in the campus is sufficient

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

c. Your university has provision for access to the latest books, journals and e-journals

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

d. Remote access facility to the university's e-resources is adequate

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

e. Adequate laboratory facilities to conduct research are present

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

f. University encourages to attend Seminars/Conferences

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

g. There is provision to publish the research work in university's own journals

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

h. University provides ample scope for collaborative research work

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

i. University provides recognition for publication in high impact/UGC-Care listed journals

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

3. Opinion and Suggestions

Suggestions for increasing the rate of research productivity among researchers and faculty members according to you -

a. To what extent do you believe that your research contribution will achieve/has achieved the standard of your institution

	1	2	3	4	5	
Not achieved at all	◯	◯	◯	◯	◯	Fully achieved

b. To what extent do you believe your research contribution will achieve/has achieved your own satisfaction

	1	2	3	4	5	
Not achieved at all	◯	◯	◯	◯	◯	Fully achieved

c. Select the facilities that you consider important to increase research output (multiple selection is allowed)

Increased funds for research activities	◯
Provision off accessing the latest books and e-journals	◯
Remote access facilities to University's subscribed databases	◯

d. What do you think will lead to increase the research output (multiple selections allowed)

Arrangements off national and international seminars and conferences	⬭
Arrangements off workshops on technical writing, research methodology, manuscript construction and other research ethics	⬭
Arrangements off research orientation	⬭

e. Any other suggestions

Thank you for your kind response

Appendix II: University wise distribution of Altmetric Attention Score of Top Cited Documents

Jadavpur University									
Altmetric Indicator →	**Readers in Mendeley**	**Readers in CiteULike**	**Tweeted by**	**Referenced in Patents**	**Referenced in Wikipedia Pages**	**In Facebook Pages**	**Blogged by**	**Referenced in Policy Sources**	**News Outlets**
Paper's DOI ↓									
10.1016/j.ijpharm.2006.09.025	89			5					
10.1016/j.phymed.2007.02.002	542	1	2	1	1				
10.1289/ehp.5966	266			1					
10.3390/molecules14051660	144	1			3				
10.1016/S0039-9140(02)00270-9	177								1
10.1081/CLT-100108509	179								1
10.1126/science.1201180	251	4	1						1
10.1016/j.jep.2006.03.021	287	1		4					
10.1021/jp0123029	175			1					
10.1016/j.pcrysgrow.2005.10.001	321			5					
10.1016/j.toxlet.2004.01.009	136							1	
10.1002/ptr.1281	215		10	3	4	4			1
10.3389/fgene.2013.00283	185		3	1	1				
10.1016/j.phymed.2011.10.003	708		2	3	1				1
10.1016/S1734-1140(10)70262-0	199			2					
University of Calcutta									
10.2478/v10102-009-0001-7	3983	1	48	1	4	2	6	6	60
10.1016/j.carbpol.2011.06.030	950	1							
10.1016/j.lfs.2015.10.025	1281	5							
10.1007/s12088-008-0006-5	411				2				
10.1021/es400521h	185		3			2			9
10.1016/S0091-3057(03)00110-2	259		1	2		1			
10.1016/j.pmatsci.2013.01.003	144			1					
10.1038/sj.cdd.4401435	84			1					
10.1002/jobm.201100552	456			2					
University of Burdwan									
10.1080/00958972.2011.583646	427		1						

10.1111/j.1365-2095.2012.00943.x	404			2					
10.3389/fpls.2015.00420	413		2			3			
10.1093/glycob/cwn092	216			1			1		
10.1021/ic3019953	42		1						
10.1016/j.phytochem.2004.07.025	138					1			
University of Kalyani									
10.1023/A:1026028303196	397	3		1					
10.1038/nature02638	452				1			1	
10.1002/9783527634880	83				1				
10.1007/s00775-008-0400-9	129			2					
10.1016/j.chemosphere.2013.01.097	474		3						
10.1016/S0301-4215(02)00311-7	124							1	
10.1016/j.tet.2007.01.063	41			13					
10.1007/s13225-017-0378-0	109				1				
10.1016/j.saa.2004.06.054	55			26					
University of North Bengal									
10.1086/425871	161	3		2	6				
10.1103/PhysRevD.74.024020	4				3				
10.1016/S0963-9969(02)00194-1	117							2	
10.1103/PhysRevD.67.103009	4				1				
10.1093/molbev/msj078	72	1			2				
10.1038/hdy.2012.83	162	1	4		3				
10.1093/molbev/msp213	128	1	7		6	1	1		
10.3390/12102413	29			2					
10.1002/jobm.200510050	91			5					
10.1016/S0168-1605(02)00124-1	64							1	
Presidency University									
10.1155/2014/701596	1286				4				
10.1016/j.scitotenv.2020.139086	1026		8		1		4	1	6
10.1093/mnras/stt401	11		1						
10.1051/0004-6361/201526766	48		4				1		1
10.3389/fenvs.2015.00021	114		3			1			
10.1007/s10701-009-9349-y	22				1				
Total	18470	23	104	87	46	15	13	13	81