CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

In any research investigation, review of related literature is a primary component which enables the investigator to understand the earlier research interests, research patterns and the magnitude of the research output in a field of knowledge. As far as the field of ‘Scientometrics’ is concerned, the literature on the subject is constantly growing. A number of articles, books and conference volumes on the development of scientometrics have been published.

The first review on bibliometric empirical laws was done by Fairthrone in 1969. The second important one was published by Hjerppe in 1980, which contained more than 200 references on Bibliometrics. The most comprehensive historical review was published by Hertzel in the Encyclopedia of Library and Information Science in the year 1987.

The International Society for Scientometrics and Informetrics (ISSI) has been organizing a series of International Conferences on Bibliometrics, biennially since 1987. So far fourteen international conferences have been held across the Globe, which brought out the research productivity of the Bibliometricians.

In view of the huge amount of literature available in this field, in this Chapter an attempt has been made to review only the significant and the
recent literature on the various aspects of scientometric research under the following sub headings:

- Studies based on Databases
- Studies based on individual country’s out put
- Studies based on individual Journals
- Studies based on individual scientist’s works
- Studies based on the Authorship Pattern
- Studies based on Citation Analysis
- Studies based on Mapping the Literature
- Studies based on Bibliometric Laws
- Studies based on MEMS
- Studies based on uncited publication
- Recent studies

2.2 SCIENTOMETRIC STUDIES BASED ON DATABASES

Databases containing bibliographic references on published scientific literature are significant for quantitative studies.

The study of Indian literature on Information Technology and its applications in Library and Information Centres has been conducted by Bagawathi Sudha & Ramesh Babu (2000) based on “Indian Library and Information Science Literature” for the period 1990-1993. This study revealed solo research and most of the contributions were by practicing library professionals and published in journals.

Koehler et al (2000) examined the publications in CyberMetrics, Information Research, the Journal of Internet Cataloging, Libres, and the Journal of the American Society for Information Science. It was found that there exist differences among journals for distributions of authors by gender, and corporate authors by region.
Tsay et al (2000) investigated the growth of semiconductor literature based on the database Information services for the Physics and Engineering Communities (INSPEC). Well-established bibliometric techniques, such as Bradford’s, Zipf's plot and Lotka’s law have been employed to further explore the characteristics of semiconductor literature. Quantitative results on the literature growth, form of publication, research treatment, publishing country and language, author productivity and affiliation were reported. Further, from the Bradford-Zipf's plot, 25 core journals in semiconductor were identified and analysed.

Indian’s contribution to research in agriculture and related fields based on analysis of publications indexed in Chemical Abstracts (CAB) Abstracts published during 1990-1994 were analysed by Arunachalam (2000). The author attempted to map the agricultural research in India and tries to answer the questions such as which institutions are carrying out the research, in which journals the Indian research works got published.

Parameswaran & Smitha (2001) analysed the contents of Library and Information Science Abstract (LISA) during 1994-1998 which revealed that maximum number of articles are found to be published in the subject of Communication and Information Technology and majority of the publications are by single authors.

Marshakova Shaikевич (2001) analysed an issue dedicated to the memory of the Russian 'Father of Scientometrics', Vassily Vassilievich Nalimov (1910-1997). Aims to show some possibilities of bibliometric methods applied to the subject index of Chemical Abstracts and to the permuterm subject index of Science Citation Index.

Kumar & Gupta (2003) reviewed the different approaches for studying the growth of scientific knowledge, as reflected by publications.
They explored the applicability of selected models in the growth of world research output in the form of articles, patents and books in the field of Chemical Sciences.

Sangam & Keshava (2003) examined the growth of social science literature included in the Wilson Social Science Abstracts for the period of 1983-1998, which determined the relative growth rate, and doubling time for the publications.

To map semiconductor literature by author co-citation analysis and in order to highlight major subject specializations in semiconductors, Tsay et al (2003) identified authors and their relationships within these specialties and within the field. Data were collected from the Information Services for the Physics and Engineering Communities (INSPEC) database from 1978 to 1997.

Guan & Ma (2004) analysed and compared the research performance in computer science of four major Western countries, India and China, based on the data extracted from Information services for the Physics and Engineering Communities (INSPEC) database during the period 1993-2002.

Rajendiran et al (2005) analysed the global output of “fiber optics” research. Articles covered in the Ei-Tech Index database for the period of 1999-2003 has been studied. They analyzed the Growth of literature by year wise, country wise, authorship pattern, bibliographic forms, ranking of core journals and nature of research.

Kademani et al (2005) attempted and analysed quantitatively 475 papers published by the Bio-organic Division of Bhabha Atomic Research Centre (BARC) during (1972-2002) in various domains like
Synthesis, Biotechnology etc. They found that the highest number of publications was 38 in 2001. The average number of publications per year was 15.3 and the highest collaboration coefficient 1.0 was found in many years. The most prolific authors were found to be A. Benerji and V.R Mandapur.

Gil-Montoya et al (2006) studied the Spanish research in Dentistry, Oral Surgery, and Medicine retrieved from the Science Citation Index database of Institute for Scientific Information (ISI) of Philadelphia during the period 1974-2006. Scientometrics indicators relative to longitudinal production, authors and institutional productivity and authors' citation patterns are derived, which provided a background of the Internationalist production of this medical discipline in Spain.

Patra et al (2006) analysed the growth pattern, core journals in the field of Bibliometrics using data from LISA. Growth of literature does not show any definite pattern. Bradford’s Law of Scattering was used to identify the core journals and found “Scientometrics” as the core journal in this field. It is observed that author’s distributions do not follow original Lotka’s law. The Study also identified 12 most productive authors with more than 20 publications in this field of study.

Torro-Alves et al (2007) analysed the scientific bibliographic productivity using the Hirsch h-index, information from the Institute of Scientific Information database and the Curriculum Lattes (CNPq, Brazil) was performed at the Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo (FFCLRP-USP) that has four departments in Natural, Biological and Social Sciences.

Falagas et al (2008) compared the SCImago journal rank (SJR) indicator with the journal impact factor (IF) and retrieved relevant
information from the official Web sites hosting the above indices and their source databases. The SJR indicator is an open-access resource, while the journal IF requires paid subscription. The SJR indicator (based on Scopus data) lists considerably more journal titles published in a wider variety of countries and languages, than the journal IF (based on Web of Science data). Both indices divide citations to a journal by articles of the journal during a specific time period.

Kellner & Ponciano (2008) analyzed members of the Brazilian Academy of Sciences (BAS). The h-index of 402 members listed in 10 distinct categories by the BAS was determined, cross-checked with the curriculum vitae of each of them listed at the Plataforma Lattes database (CVL) and compared with each other.

Jacso (2009) used the Scopus database and Thomson-Reuters' (earlier known as ISI), Three citation databases (Science, Social Sciences and Arts amp; Humanities), both as implemented on the Dialog Information Services (Thomson ISI databases) and on the Web of Knowledge platform, known as Web of Science (WoS). There is no difference between the databases in the presence of publication year data - all of them include the element for all the records.

Jacso (2010) compared the journal impact rankings of the open access SCImago Journal & Country Rank (SJR) database and the subscription-based Journal Citation Reports (JCR). 7,000 scholarly and professional journals based on data licensed from Elsevier's Scopus database and compared it with the JCR database.

Osareh & Keshvari (2010) had visualized the structure of Iranian scientific output in Science Citation Index (SCI), accessible via Web of Science (WOS), during 2000-2006, they used scientometric techniques and
HistCite software. The number of Iranian documents indexed in SCI during the study period was 24480. Generally HistCite analyzes citation data on two different levels: based on citations in WOS (Global Citation Scale), and citations in collection of retrieved documents (Local Citation Scale). The results of the study showed that in the study period a total of 8 clusters have been formed on the two levels (GCS and LCS): Clusters 1 and 2 (with 3 sub-clusters) in GCS and clusters 3, 4, 5, 6, 7, and 8 in LCS.

Pouris (2010) reported the results of a scientometric assessment of the Southern Africa Development Community countries. The National Science Indicators database of Thomson-Reuters and the online ISI Web of Knowledge were utilized in order to identify the number of publications of the 15 countries over a period of 15 years; the activity and relative impact indicators of 22 scientific disciplines for each country and their collaborative patterns. It was identified that South Africa with 19% of the population in the region was responsible for 60% of the regional GDP and 79% of the region’s publications.

Hennemann et al (2011) have chosen two databases - ISI Web of Knowledge Database (SCI-Expanded) and Chinese Chongqing VIP Database. Both data sources were analysed using a variety of bibliometric and network scientific methods. The structural and topological similarities of networks, built from co-authorship data, were apparent between the two databases. Konur (2011) explored the characteristics of the literature on the algae and bio-energy published during the last three decades, based on the database of Science Citation Index-Expanded (SCIE) and Social Sciences Citation Index (SSCI) and its implications using the scientometric techniques.

Garcia-Martinez et al (2012) examined world scientific production in Psychology based on bibliometric indicators (scientific production, production's percentage variation, average citations per document, normalized
citation, impact, etc.), for the period 2003-2008. The analysis was made by
country, by research institutions, and scientific journals, using the Scopus
(Elsevier), database of scientific literature.

Lou & Lin (2012) conducted a study to evaluate the global progress
and quantitative assessment of current research trends on family therapy,
using a bibliometric approach and exploring related literature in the Social
Science Citation Index (SSCI) database from 1992 to 2009.

Diem & Wolter (2013) investigated the fitness-for-purpose and
soundness of bibliometric parameters for measuring and elucidating the
research performance of individual researchers in the field of education
sciences in Switzerland. In order to take into account the specificities of
publication practices of researchers in education sciences, the analyses were
based on two separate databases: Web of Science and Google Scholar.

Konur (2013) explored the characteristics of the literature on the
attitudes towards disabled people published during the last three decades,
based on the databases of Science Citation Index-Expanded (SCIE) and Social
Sciences Citation Index (SSCI) and its implications using the scientometric
techniques. The results of the study revealed that the literature in the field had
grown steadily during the period reaching to 655 papers in total with
paralleling enormous changes in the research landscape.

Sagar, A et al (2014) studied the publication status and growth of
radioisotope research across the world and made quantitative and qualitative
assessment by way of analyzing various features of research output based on
Web of Science database during the period 1993-2012.
2.3 STUDIES BASED ON INDIVIDUAL COUNTRY’S OUTPUT

Spinak (2001) presents alternative views to interpret the current scientometric indicators, outcome from compilation of the Citation Index, published by the Institute for Scientific Information, and other similar databases. Particularly, hypothesis is presented aiming at explaining the bias of the Citation Index in favour of the publications that belong to the mainstream of the developed countries, against those publications of similar quality published by Third World countries.

Garg & Padhi (2002) analyzed laser research in India (1970-1994) which showed that India has improved in the area of research considerably during the period 1985-1994 as compared to that of 1970-1984. Further, the study indicated that the proposition of mega authored papers increased during 1990-1994 and international collaboration was mainly with the USA.

Markusova et al (2002) studied the literature in bio defence area. The goal of their project was to trace changes in bio defence research activities of its main players, Russia and the US. They found that during the ten year period (1999-2000), the growth of publications increased by 25%. They concluded that there was a sharp decline in Russian publications. The leading organizations in these areas were the former military research institutes, and then affiliated with the Ministry of Public Health of Russia. They also found these collaborative papers comprised of 16% of Russia’s Biological Weapons Papers. Of these collaborative papers, about 70% were with the US.

Zanetto (2002) examined the development of scientific and technological literature in Brazil in a 25-year period. It was found that the growth rate of Brazilian scientific production exceeded the international average, showing a six-fold increase in 25 years period before 2002. He
concluded that Brazil’s innovations capability was still unsatisfactory and in contrast to its scientific production and was failing to grow significantly.

AIDS Literature in Central Africa was analysed quantitatively by Macias – Chapula & Mijangos-Nolasca (2002), which indicated a high pattern of collaboration through multi authorship.

Wilson & Osareh (2003) examined the development of Iranian Scientist’s research work and the development of science and technology (S&T). A scientometric analysis of Iranian S&T publications using the Science Citation Index was presented and the possible short coming of this approach was discussed.

The Indian output on Air Pollution research was analysed quantitatively by Parameswaran et al (2003). The various bibliometric indicators have been used in the analysis, with regard to the Authorship Pattern, Relative Growth Rate, Doubling Time, Ranking of Core Journals and Core Research Institutions in India.

Bartol & Hocevar (2005) investigated the cities based on the author-affiliation data from Web of Science, Biosis Previews, CAB Abstracts, Chemical Abstracts, Compendex/Inspec, Francis, Medline, Pascal, and Sociological Abstracts databases. The study was carried out to analyze Specific cities publishing patterns and the trends with reference to particular disciplines. The Characteristics of city-data collection with regard to retrieval accuracy are investigated. Databases were compared on document coverage and input consistency. A city as an emerging super national unit was proposed as a scientometric object and indicator in its own right as a complement to the traditional notion of a country or a nation-state.

Jeenah & Pouris (2008) conducted a study on the performance of South Africa’s national system of innovation. It presented a scientometric assessment of research in South Africa in the context of the rest of Africa and in comparison with Brazil and India. South Africa has published a significant number of papers in all the 22 disciplines represented in the ISI's Essential Science Indicators.

Mahbuba (2010) compared two Health and Population Research Organizations, namely the International Centre for Diarrhoeal Disease Research in Bangladesh (ICDDR,B) and the National Institute of Cholera and Enteric Diseases (NICED) in India, during the period 1979-2008. Data were collected from the Web of Science (WoS) as well as from official records of these two organizations.

Sooryamoorthy (2010) studied South African publications on medical field using scientometric analysis. Extracting and analyzing medical publications for three decades and at regular intervals (1975–2005) from the SCI database, this paper pioneers an attempt to find out whether the reported pace of growth in the production of scientific papers in medicine was an effect of partnerships that scholars have with their counterparts within the organization, within the country, or with those in other countries.

Gupta & Bala (2011b) examined India's performance in S&T on several quantitative measures including India's global publication share, rank and growth rate, its publication share in various subjects in terms of national and global context using 15 years publications data (1996-2010) from the
Scopus database. It also determines the share of its international collaborative papers at the national level as well as across subjects, and analyses, the geographical distribution of its research output. In addition, it analyzes the highly productive institutions and characteristics of high-cited papers.

Pouris (2012) analyzed the scientometric research in South Africa and it discusses the sources of growth in the country's research literature in general. South Africa had been identified as having limited expertise in the field, revealed mainly during the last decade. However, the country was ranked 21st in the world among the countries publishing in the journal Scientometrics and it was the only African country with such a standing in the field. Identification of the forces affecting positively the growth in the number of research publications in the country indicates that the primary incentive fuelling the recent growth is the new funding formula in the country which subsidizes the universities by more than R100 000 for each publication by the academic community. The increase in the number of journals indexed in the ISI Thomson Reuters database and the incorporation of social sciences at the NRF have also affected the growth of research publications, but to a lesser extent.

Dutt & Nikam (2013) examined solar cell research in India as revealed by the publications indexed in Web of Science (WoS) for a period of 20 years from 1991 to 2010. It was seen that academic institutions contributed about half of the total output. Indian Association for the Cultivation of Science outperformed all other institutes in the country. Solar cell research by Indian scientists was well connected to international research trends in the field. The recent trends suggest more domestic and international collaborative research involving larger team sizes. It also suggested that more emphasis is being given to research on solar cells based on materials other than silicon.
Pouris & Ho (2014) attempted to provide by examining both patterns of collaboration at country and continental levels, the scientific disciplines emphasised. The findings indicated that the continent's research emphasised medical and natural resources disciplines to the detriment of disciplines supporting knowledge based economies and societies. Furthermore, the collaborative patterns in Africa were substantially higher than those in the rest of the world.

Montoya et al (2014) described the features of the contributions made by the Spanish institutions to the specialized literature in the energy field in the period 1957-2012. The sources considered had been the Scopus Elsevier database, together with bibliometric analysis techniques. All items provided by Scopus have been taken into account in the analysis (journal papers, conference proceedings, etc.).

### 2.4 STUDIES BASED ON INDIVIDUAL JOURNALS


Das (2001) observed the collaboration pattern in computer science research in India. The study covers 1408 research papers published in International Journals on Computer Science contributed by Indian scientists from 1991 to 2000. The domestic and international collaboration patterns have been studied and reported that USA, Canada and Germany were the collaborative countries. Among the Asian countries, India collaborated mostly with Japan, followed by Singapore and found that India had the potential of carrying out computer science research of international standard.
Cronin (2001) revealed the idea of a unified citation index to the literature of science was first outlined by Eugene Garfield in 1955 in the journal ‘Science’. Science Citation Index (SCI) has since established itself as the reasonable standard for scientific information retrieval. It has also become the database of choice for citation analysts and evaluative bibliometricians throughout the world.

Garg & Padhi (2001) studied the publication trends in Laser Science, covering 3174 papers published in journals in the field of laser science and technology indicated that only 401 papers were single authored and the rest of 2773 were co-authored papers. Out of 2773 papers, 687 were written in local (inter-departmental), domestic (inter-institutional) and international collaboration.

Chen et al (2002) investigated an integrated approach to scientometric studies with emphasis on the use of information visualization and animation techniques. It was drawn upon citation and co-citation patterns derived from articles published in the journal Scientometrics (1981-2001).

Koley & Sen (2003) studied 457 citations appended to 26 research articles published in the four issues of the Indian Journal of Physiology and Allied Sciences. The ratio of Indian to foreign citations is found to be almost 1:6 of the total citations, 4.59 per cent were author self-citations and 2.84 per cent were journal self-citations of the citing articles, one is single-authored, 10 are two-authored, 9 three-authored, 4 four-authored, and one each five-authored and six-authored. No collaboration was noticed in the case of 23 citing articles. The remaining 3 articles were the results of collaboration from two-institution collaboration.

dynamics of the number of contributing authors and the number of published 
papers, distribution of the authors by the number of published papers, co-
authorship, the amount of biographical data (including jubilees and 
obituaries), and distribution of the authors by countries and organizations 
were analyzed. The results of this analysis are interpreted from the viewpoints 
of historical and sociological aspects of the development of Russian soil 
science.

Narnag (2004) analysed comparative study of articles published in 
Indian Journal of Pure & Applied Mathematics. The results indicated that the 
numbers of contributions are increasing in successive volumes. The study 
analysed the distribution of contributions, authorship pattern, citation 
analysis, geographical distribution of contributions and number of pages in 
each volume.

Jena (2006) conducted bibliometric study on the journal “Indian 
Journal of Fiber and Textile Research” for the period 1996-2004. The study 
focused on the trend of publications such as the year wise distribution of 
articles, bibliographical distribution of citations, authorship pattern, citation 
pattern, average length of articles, number of tables and figures used, time lag, 
geographical distribution of authors and subject analysis.

Davarpanah & Aslekia (2008) conducted a quantitative study of 
productivity, characteristics and various aspects of global publication in the 
field of Library and Information Science (LIS). A total of 894 contributions 
published in 56 LIS journals indexed Social Sciences Citation Index in (SSCI) 
during the years of 2000-2004 were analyzed. A total of 1361 authors had 
contributed publications during the five years.

Chang (2010) analysed scientometric methods to conduct an 
automatic content analysis on the development trends of science education
research from the published articles in the four journals- International Journal of Science Education, Journal of Research in Science Teaching, Research in Science Education, and Science Education from 1990 to 2007. The multi-stage clustering technique was employed to investigate topics, development trends, and contributions from various agencies that the journal publications constructed as a science education research field.

Davarpanah (2010) studied the Iranian and Malaysian Social Sciences publications between 1991 and 2008. Construction of a model is for measuring the strength and weakness of individual disciplines. The model was developed based on the balanced approach.

Tsay (2011) employed a citation analysis and compared the bibliometric characteristics and the subject relationship with other disciplines of the three leading Information Science Journals, Journal of the American Society for Information Science and Technology (JASIST), Information Processing and Management, and Journal of Documentation. The citation data were drawn from references of each article of the three journals during 1998 and 2008.

Cabanac (2012) studied the Journal of the American Society for Information Science and Technology and 76 other journals listed in the Information Systems category of the Journal Citation Reports-Science edition 2009 were analyzed. Besides, reporting usual bibliographic indicators, Demographic data about the 2,846 gatekeepers serving in Information Systems (IS) editorial boards were collected. He discussed various scientometric indicators supported by descriptive statistics. Pouris (2012) studied the scientometric research in South Africa and found the country was ranked 21st in the world among the countries publishing in the journal Scientometrics and it is the only African country with such a standing in the field.
Aswathy & Gopikuttan (2012) analyzed the article publications in the Journal of Spacecrafts and Rockets during 2006-2010 and covered 780 papers with 15648 references. They analyzed various parameters like growth pattern, authorship pattern, citation pattern, degree of collaboration and Lotka’s Law.

2.5 STUDIES BASEDF ON INDIVIDUAL SCIENTIST’S WORKS

Kim & Kim (2000) examined the research performance of Chemists at Seoul National University (SNU), the most prestigious university in Korea, using the numbers of articles appearing in journals and the numbers of citations received by those articles covered by Science Citation Index SCI CD-ROM, 1992-1998.

Amudhavalli & Florence (2001) analysed the publication data used in the identification of emerging research areas and in the evaluation of the research performance of individual scientists, research groups or organisations.

Kim (2001) explored the research performance of Korean Physicists, comparing Korean-authored papers versus internationally co-authored papers, indexed in SCI during 1994-1998 and using the number of citations received by internationally co-authored papers covered by the SCI CD-ROM.

Kalyane & Sen (2003) examined the researches on ‘eminent individual scientist’ as a unit of information generation has opened up diversified vistas in understanding the process of R&D innovation communications. Quantitative documentation on Tibor Braun encompasses his papers (single-authored 40 and multi-authored 140) during 1954-1995.
Kademani et al (2001) studied scientometric analysis of 246 papers by Ahmed Hassan Zewail, the Nobel Laureate in Chemistry (1999), published between 1976 and 1994 and also in diverse fields. Data was analyzed for authorship pattern with his 103 collaborators.

Swarna et al (2002) examined the technical reports as one of the media to record the scientific information generated by Scientists and Engineers, of Bhabha Atomic Research Centre (BARC) publications. The scientometric analysis of these reports has been carried out for physical bibliographic characteristics, authorship collaboration, inter-divisional collaboration, inter-institutional collaboration activities and content analysis.

Munnolli & Kalyane (2003) analysed 312 papers by Ram Gopal Rastogi published during 1954 to 1992 and reported the various domains of study, research collaborations, and highest productivity during the study period.

Koganuramat et al (2004) present the portrait of the Wolfgang Ketterle who was honoured with the Nobel Prize for Physics (2001) at 44 years of biological age and at 20 years of research publishing career. He had 115 publications during 1982 - 2002 in different domains, authorship pattern, collaborative coefficient, core journals. 'Bio-bibliometrics' is a method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes. Therefore, it is suggested that 'Scientometric Portrait' is the appropriate phrase for the studies on scientists and 'Informetric Portrait' for the studies pertaining to researchers in other disciplines such as Arts, Humanities, and Social Sciences.
Sangam et al (2005) sketched Prof. Peter John Wyllie with his scientific achievements. His research had had a great impact in the fields dealing with terrestrial magmatic phenomena and geology.

Kademani et al (2006) analysed 724 papers published by the Scientists of Analytical Chemistry Division at Bhabha Atomic Research Centre (BARC) during 1972-2003 in diverse domains. The highest number of publications was produced in 1997 and 2003. The most prolific authors were M. Sudersanan and P.K. Mathur. The core journals preferred for publishing were: Indian Journal of Chemistry and Journal of Electrochem Society of India. Top ranking journals ranking publishing analytical chemistry research were from India, UK and Switzerland.

Vinkler (2007) indicated the calculating scientometric indexes for individuals; self-citations should be excluded and the effect of the different bibliometric features of the field should be taken into account. The correctness of the indexes used for evaluating journal papers of individuals should be investigated also on the individual level.

Fritzsche et al (2008) analysed the contributions of the 15 primary member States of the European Union and selected non-European countries to pathological research between 2000 and 2006. Pathological journals were screened using ISI Web of Knowledge Database. The number of publications and related impact factors were determined for each country. Relevant socio economic indicators were related to the scientific output. Subsequently, results were compared to publications in 10 of the leading bio medical journals.

Vinkler (2009) suggested a new indicator (π-index) for comparative assessment of scientists active in similar subject fields. The π-index is equal to one hundredth of the number of citations obtained to the top square root of
the total number of journal papers (elite set of papers) ranked by the decreasing number of citations. The relation of the $\pi$-index to other indexes and its dependence on the field is studied, using data of journal papers of 'highly cited researchers.

Varaprasad et al (2010) studied quantitatively the growth and development of Chemical Science Research by J.S.Yadav during the period 1986-2009. During this period he has published 722 papers (702 Research Articles) in various domains. The data used was from Thomson/ISI Web of Science.

Braun (2010) attempted to survey the influence of Eugene Garfield on the journal Scientometrics. His contributions as editor, author, citing, cited and co-cited author, as well as eponymized scholar were taken into account. In all measures, he turns out to be a ubiquitous and imperative personality in the history of the journal -- and, of course, the research field it covers. Sangam and Savanur (2010) had drawn the portrait of Eugene Garfield. Kalaippan et al (2010) made a study of Prof. G.N. Ramachandran in the Subjects of Biophysics and Crystallography.

Munnolli et al (2011) studied the publication productivity of Harald zur Hausen, a renowned Scientist and Nobel Laureate in Physiology who was honoured with Nobel Prize for the discovery of human papilloma viruses causing cervical cancer. He had 285 publications during 1964 - 2009 in four domains: Adenoviruses (14), Epstein Barr and Herpesviruses (72), Papillomaviruses (122) and other associated disciplines (77).

Konur (2012) made a case study of Turkish Scientists, by way of using a scientometric biography of Prof. Dr. Ayhan Demirbas working in the area of Bio-energy since 1980s. He produced 454 articles and reviews in the inter disciplinary areas relating to the bio-energy between 1984 and 2010, and
379 of them were indexed by the SCI or the Social Sciences Citation Index (SSCI). He received 7,309 citations for his 454 papers giving a ratio for the "Average Citations per Item" as 16.1 and "H-index" over 39 as of July 2011, suggesting that the scientific impact of his research on the relevant literature has been significant.

Mukherjee (2013) studied the bibliometric characteristics including authorship pattern, citations received and relative performance of Prof. Lalji Singh, an eminent Indian scientist in the field of Genome Analysis, DNA Finger Printing, etc. The study was based on the publication data indexed in Web of Science and Scopus.

2.6 STUDIES BASED ON THE AUTHORSHIP PATTERN

Jacobs (2000) carried out bibliometric study on the publication patterns and impact of South African Scientists 1981-96, with special emphasis on the period 1992-96. The subject fields surveyed are: Physics, Chemistry, Plant and Animal Sciences, and Biochemistry/Microbiology. Scientists were selected from the ten Universities featuring the publication and citation, and pattern used by the Scientists during 1981-96. Further, the citation impact relative to the world, after a substantial drop in 1985-93 probably representing the international embargo period, in 1994-96 reaches the same level as observed in 1985-89. Also, the study shows that there was a direct relation between academic position, research experience and productivity among South African Scientists in the four scientific disciplines.

Farahat (2002) revealed the pattern of authorship in 19 Egyptian journals of Agricultural Science. Collaborated authorship was found to be the predominant trend in the field and co-authored papers accounted for 79% of the sample. The most common form for multiple authorship involved were three persons. Considerable variation was found
among sub-fields and co-authorship was found to be the most common in Social Science related agricultural disciplines.

Glanzel et al (2004) studied the basic regularities of author self-citations. The regularities are related to the ageing, to the relation between self-citations and foreign citations, and to the inter dependence of self-citations with other bibliometric indicators. The results of the paper confirmed the common notion of such effects only in part. The authors clarified that at the macro level multi-authorship does not result in any exaggerated extent of self-citations.

Yoshikane & Kageura (2004) discussed the pattern of research collaboration by observing co-authorship networks. Those studies mainly analyse static networks, and most of them do not consider the development of networks. On the basis of an analysis from two viewpoints, they compared the growth in the number of collaborating partners and change in the relationship strength with partners, the characteristics of four different domains, such as Electrical Engineering, Information Processing, Polymer Science and Biochemistry.

Surendra Kumar & Kumar (2004) examined the chronological documentation list prepared for the purpose along with author and subject indexes. In this study, productometric analysis of contributions of National Research Centre for Soybean, Indore, has been carried out for the period 1987-2001 in terms of number of research articles produced by its scientists.

The study highlights the authorship trend and collaborative research in chemistry in India during 1996-2000, quantitatively analysed by Kannappanavar et al (2004). The study found that team research is preferred in the field of chemistry rather than solo research. The degree of
collaboration was calculated and it is found that the collaboration varies from year to year.

Rao & Gupta (2004) explained the Indo-German collaboration in Science and Technology, through the co-authored publications during 1996-2000. The collaboration is under two broad streams, Bilateral and Multilateral. The study provides an analysis of co-authored papers by main fields and sub-fields and the impact of such collaboration in different fields of Science and Technology. The paper identifies the major institutions involved in collaborative research in the two countries. The study reveals the extent of commonality of subject interest between the two countries. The analysis showed that the bilateral papers were maximum in Physics followed by Chemistry, Biomedical Research, etc. However, the impact factor of bilateral papers was highest in Biomedical Research followed by Physics, Chemistry, etc.

Mahapatra & Padmanav (2006) discussed the growth of scientific research literature on Orissa published during 1985-2004. It includes 875 research papers from 40 different journals. They analyses the data by their authorship pattern, category of journals, place of origin, length of papers and productivity of journals.

Kretschmer et al (2007) examined Web hyperlinks and Web visibility indicators to establish their usefulness as indicators of collaboration and to explore whether similarities exist between Web-based structures and bibliographic structures. Three empirical studies of collaboration between institutions and individual scientists show that hyperlink structures at the Web will not reflect collaboration structures collected by bibliographic data. However, Web visibility indicators of collaboration were different from hyperlinks and can be successfully used as Web indicators of collaboration.
Glanzel (2009) conducted a study in the light of the h-index and the characteristic scores and scales. A statistical test for the h-core is presented and illustrated using the example of four selected authors. The mathematical relationship between the h-index and characteristic scores and scales were analysed. The results give new insights into important properties of rank-frequency and extreme-value statistics derived from scientometric and informetric processes.

Karpagam (2011) analysed the growth pattern of Nanoscience and Nanotechnology literature in India during 1990-2009 (20 years). The Scopus international multidisciplinary bibliographical database has been used to identify the Indian contributions on the field of Nano science and Nano Technology. The study measured the performance based on several parameters, country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Further, the study examined national publication output and impact in terms of average citations per paper, international collaboration output and share, contribution and impact of Indian Institutions and impact of Indian journals.

Aswathy & Gopikuttan (2013) analysed the publication pattern of faculty members of three universities in Kerala viz., University of Kerala, Mahatma Gandhi University and University of Calicut. They studied the Authorship pattern, Degree of Collaboration, the appropriateness of Lotka’s Inverse Square Law and year-wise and designation-wise distributions.

Santhanakarthikeyan et al (2014) analyzed the literature growth, author productivity, and authorship pattern, average length of articles and country collaboration of cancer research in India. The Indian Journal of Cancer, which shows the progress of ontological sciences in India, was established in 1963. Indian Journal of Cancer is the first and the only
periodical serving the needs of all the specialties of oncology in India. The journal is the official publication of the Indian Cancer Society and Indian Society of Oncology.

2.7 STUDIES BASED ON CITATION ANALYSIS

2.7.1 Citation Analysis

Verbeek et al (2003) analysed the geographic distribution of the science citation patterns in patents, singling out two fields of (different) technological development, namely Biotechnology and Information Technology. The approach allows exploring the associative patterns between science creation (as emerging from the scientific literature) and technology development (as emerging from the patent literature).

Bhattacharya et al (2003) examined the methodology for studying the interactions between science and technology. The approach rests mostly on patent citation and co-word analysis. In particular, this study aimed to delineate intellectual spaces in thin-film technology in terms of science/technology interaction. The universe of thin-film patents can be viewed as the macro-level and starting point of our analysis. Applying a bottom-up approach, intellectual spaces at the micro-level are defined by tracing prominent concepts in publications, patents and their citations of scientific literature.

Glanzel & Thijs (2004) analysed the role of author self-citations within the process of documented scientific communication. Two important regularities such as the relative fast ageing of self-citations with respect to foreign citations and the "square-root law" characterizing the conditional expectation of self-citations for given number of foreign citation have been found studying the phenomenon of author self-citations at the macro level. The analysis of citation based indicators for 15 fields in the sciences, social
sciences and humanities substantiates that at this level of aggregation there is no need for any revision of national indicators and the underlying journal citation measures in the context of excluding self-citations.

The application of bibliometric techniques in the social sciences attempts to clarify some of the topics mentioned against the application of the Social Sciences Citation Index (SSCI) for evaluation purpose by Van Leeuwen (2005). Further it covers topics like the existing publication and citation culture within the social sciences, the effect of variable citation windows and the (geographical) origin of citation flows.

Moed (2005) examined the differences in the structure of written communication system of different field of scholarships, the ISI’s databases and identifies why raw data from the databases cannot be used straightway in citation analysis.

Nederhof (2005) examined the research performance monitoring of the social sciences and the humanities using citation analysis. Main differences in publication and citation behavior between the (basic) sciences and the social sciences and humanities were outlined. Limitations of the SCI and A&HCI for monitoring research performance were studied.

Moya-Anegón et al (2006) presented a domain analysis of the Library and Information Science discipline using Author Co-citations Analysis (ACA) and Journal Co-citation Analysis (JCA). The techniques used were map construction of the self–organising map (SOM) neural algorithm, Ward’s clustering method and multi-dimensional scaling (MDS). The results of the study are compared with similar research developed by Howard White. This also showed the visualization.
Suleimenov (2010) has developed Kazakh publication citation indicator since 2005 to carry out scientometric analysis of scientific publications to determine their citation rate. At present, the Bibliographic Database (BDB) on citation includes information on the publication activities and citation index of approximately 30000 Kazakh scientists and specialists.

Ruch & Ball (2010) performed a study on 30 relevant scientists from the disciplines of "particle physics" and "neurology" to correlate between the citation rate Citation per Publication (CPP) and the H-Index. The foregoing discussions on the different correlations revealed that the form and degree of correlation do not just vary considerably between the individual comparisons but also amongst the disciplines. In the both the disciplines, the correlation between the citation rate CPP and the H-Index were relatively low.

Meneghini (2011) conducted a study to find out the total number of citations accounts for both the productivity of scientists and the impact of articles. It was found that 12 institutions of Physics (10 from Brazil, one from the USA and one from Italy) have been evaluated.

2.7.2 Uncited Publications

Stegmann & Grohmann (2001) studied publication and citation data for the thirty journals listed in the Dermatology & Venereal Diseases category of the 1996 edition of the Journal Citation Reports (JCR) on CDROM and seven dermatology journals not listed in the JCR-1996 were retrieved online from DIMDI and analysed with respect to short- and long-term impact factors, ratios of cited to uncited papers, as well as knowledge export and international visibility.

Van Dalen & Henkens (2004) examined the level of uncitedness and the impact of articles published in the years 1990-92 in 17 demography
After ten years 24 percent of the demography articles are still uncited and the average number of citations per article is seven. The ten-year citation history reveals two novel insights.

Lehmann et al (2005) explained that scientific communities are characterized by strong stratification. The highly skewed frequency distribution of citations of published scientific papers suggests a relatively small number of active, cited papers embedded in a sea of inactive and uncited papers.

Eysenbach (2006) found that Open Access (OA) to the research literature has the potential to accelerate recognition and dissemination of research findings, but its actual effects are controversial. OA articles are more immediately recognized and cited by peers than non-OA articles published in the same journal. OA is likely to benefit science by accelerating dissemination and uptake of research findings.

Wallace et al (2009) studied the prevalence of uncited papers or of highly cited papers, with respect to the bulk of publications, provides important clues as to the dynamics of scientific research. Using 25 million papers and 600 million references from the Web of Science (WoS) over the 1900-2006 period, it proposes a simple model based on a random selection process to explain the "uncitedness" phenomenon and its decline over the years.

Racki (2009) studied citation data accumulated on articles from the top and bottom 25% of impact factor (IF)-ranked international journals and compared them using 59 International Geoscience Journals from 1998 and 378 Polish geological papers from 1989-1994. MacRoberts and MacRoberts (2010) find that determine the influences on the production of a scientific article, the content of the article must be studied. They examined articles in
Biogeography and found that most of the influence is not cited, specific types of articles that are influential are cited while other types that are influential are not cited, and work that is "uncited" and "seldom cited" is used extensively. As a result, evaluative citation analysis should take uncited work into account.

Egghe (2010) found that the uncitedness factor of a journal is its fraction of uncited articles and determined the rank-order distribution of these uncitedness factors, using Central Limit Theorem which is valid for uncitedness factors since they are fractions, hence averages. A similar result was proved earlier for the impact factors of a set of journals.

Egghe et al (2011) conducted a study on Nobel Laureates and Fields Medalists and found they have a rather large fraction (10% or more) of uncited publications. They have examined 75 researchers from the fields of Mathematics (Fields medalists), Physics, Chemistry, and Physiology or Medicine (Nobel Laureates). The most remarkable result is a positive correlation between the h-index and the number of uncited articles. We also present a Lotkaian model, which partially explains the empirically found regularities.

Hsu & Huang (2012) studied the Impact Factor has become a well-known measure of the average citation number of articles published in a scientific journal. A journal with a high Impact Factor is assumed to have a low percentage of uncited articles.

Burrell (2012) commented on an earlier article by L. Egghe, R. Guns, and R. Rousseau (2011) and, noted that in a study of some eminent scientists, many of them had a fair proportion of papers which were uncited and found this to be surprising. Here, they have used the stochastic publication/citation model of Q.L. Burrell (2012) to show that the result might in fact be expected.
Burrell (2013) made study on empirical analysis of the relationship between the impact factor - as measured by the average number of citations - and the proportion of uncited material in a collection.

Prichard (2013) organization has published 569 papers in its 20 years. Of these 44% have been cited less than four times, and just on 9%, or 48 papers, have never been cited at all-not even by their own authors.

High share of uncited publications, which included those produced by top scientists, was repeatedly reported to exceed 10% of the total papers produced. Heneberg (2013) analyzed the uncitedness among two independent groups of highly visible mathematicians represented by Field Medalists, researchers in Physiology or Medicine represented by Nobel Prize Laureates. Over 90% of the uncited database records of highly visible scientists have been presented in progress reports, meeting abstracts, letters to the editor, discussion, personalia by errors of omission and commission of the Web of Science (WoS) database and of the citing documents. Only 0.9 and 0.3%, of the original articles and reviews were found to be uncited.

Uncitable documents were responsible for up to 30% of the total citations to the top-tier journals, with the highest values found for medical science journals (New England Journal of Medicine, JAMA, and the Lancet) and lower values found for the Science, Nature, and Cellseries journals. Self-citations to some of the top-tier journals reach values higher than the total citation counts accumulated by papers in most of the Web of Science indexed journals (Heneberg 2014). Ayanguasgil (2013) indicated that a perfect correlation between the times a paper is cited and peer recognition cannot be seen.

Hu & Wu (2014) found current literature on citation distribution gives more focus on the distribution of the percentages and citations of papers
receiving at least one citation, while there are fewer studies on the time-dependent patterns of the percentage of never-cited papers, on what distribution model can fit their time-dependent patterns, as well as on the factors influencing the non-citation rate.

Garg & Kumar (2014) identified that 6231 (17.5%) out of 35,640 Indian scientist papers published during the period 2008-2013 remained uncited. Most of the uncited papers were published by State Agricultural Universities and the Indian Council of Agricultural Research. The highest proportion of uncited papers was in the area of agricultural sciences followed by multidisciplinary and mathematical sciences. The Evidence report of Thomson Reuters has shown that there is a decrease in the percentage of papers emanating from India which do not receive citations.

2.8 STUDIES BASED ON MAPPING THE LITERATURE

The term scientigraphy according to Small and Griffith (1974) has not been widely adopted and it is a very apt label for the mapping of science. Science maps serve as a tool for navigating through the research literature by depicting the spatial relations between research fronts which are areas of significant activity.

Fergueson et al (1997) described the technique of multi-dimensional scaling (MDS) analysis and show how it might be applied to the individual structure their knowledge, does the structure vary as a function of training, individual implicit theories of personality, individual perceive their organizational psychologists.

The global output of Engineering Literature in different forms of publications including journals used by Indian Engineers and Researchers were analysed by Ravichandra Rao & Suma (2000). Further, journals
publishing Indian contributions, Indian institutions contributing to the engineering literature subject-wise, location-wise and document wise were also analysed.

Noyons (2001) discussed the bibliometric maps of science in a science policy context in the Nineteen Seventies; they have not been very successful yet. It seems, however, that only now they are becoming acknowledged as a useful tool. This is mainly due to the developments and integration of hypertext and graphical interfaces. Because of this, the strength of such navigation tools becomes obvious. The interface can provide suggestions to answer policy-related question, which is the initial purpose of such maps.

Martinsons et al (2001) analysed the authorship of scholarly knowledge and mapped over time by combining multivariate statistics and other techniques. Observed citation frequencies were fitted to a chi-square model of importance, receptivity and similarity, while cluster analysis is employed to map changes in journal relationships over time period.

Boyack et al (2001) analysed the various efforts to map the structure of Science from Literature. The majority of these studies have been performed at the discipline or specialty level. Maps are often based on similarity between journal articles using citation analysis, co-occurrence or co-classification using keywords, topics or classification schemes, or journal citation patterns.

Ingwerson et al (2001) investigated the advantages of graphical mapping of national research publications and citation profiles from scientific fields in order to provide additional information with respect to research performance. By adopting Multi-dimensional scaling techniques, national
social science profiles from seventeen OECD Countries and two block periods 1989-1993 and 1994-1998 are mapped.

Moya-Angegon et al (2004) examined the generation of schematic visualizations as interfaces for scientific domain analysis. They propose the technique that uses thematic classification (classes and categories) as entities of co-citation and units of measure, and demonstrate the viability of this methodology through the representation and analysis of a domain of great dimensions. The main features of the maps obtained were discussed, and proposals are made for future improvements and applications.

Ramakrishnan & Rajendiran (2004) analysed the literature on Hepatitis B. For that purpose, three journals for a period of five years (1997-2001) have been considered, with citations counting and compared the coverage in three databases viz. MEDLINE, CINAHL and IPA. MEDLINE provided adequate indexing coverage of the cited journals and minimal coverage was provided by CINAHL and IPA.

The aggregated journal citation matrix was derived from Journal Citation Reports 2001 reported by Leydesdorff (2004). The technique was recently incorporated in software tools for social network analysis. The matrix can be assessed in terms of its decomposability using articulation points which indicate overlap between the components.

Mittal et al (2005) discussed Vidang, a well known drug in ayurvedic system of medicine, obtained from the medicine plant, Embelia ribes. Through citation mapping, a comprehensive bibliography has been compiled to study the research work done on this plant in India. Citation maps allow browsing through titles and provide the users with some directions into the information available. It may be useful for researchers to identify areas where there could be more scientific study.
Boyack et al (2009) examined the results of a prototype study that aims to map the structure and evolution of Chemistry research over a 30 year time frame. Information from the combined Science (SCIE) and Social Science (SSCI) Citations Indexes from 2002 was used to generate a disciplinary map of 7,227 journals and 671 journal clusters. Clusters relevant to study the structure and evolution of Chemistry were identified using JCR categories and were further clustered into 14 disciplines. The changing scientific composition of these 14 disciplines and their knowledge exchange via citation linkages was computed. Major changes on the dominance, influence, and role of Chemistry, Biology, Biochemistry, and Bioengineering over these 30 years are discussed.

Sagar (2010) performed a scientometric analysis of all Tsunami related publications as per the Scopus database during 1997-2008. A total of 4338 publications and 21107 citations to these papers were received. The parameters studied include growth of publication, country-wise distribution of publications, activity index of countries, most-frequently cited publications, authorship pattern, co-authorship index, and distribution of keywords. The United States of America, Japan, The United Kingdom, India and Australia produced 54.20% of the total output. A spurt in number of publications was observed after Indonesia's tsunami occurred on 26 December 2004.

Gupta & Bala (2011a) analyzed the research output of Asthma in India during the period from 1999 till 2008. It analyzes the growth, rank and global publications share, citation impact, share of international collaborative papers, contribution of major collaborative partner countries and contribution of various subject fields. It also analyzes the characteristics of most productive institutions, authors and high-cited papers. SCOPUS database has been used to retrieve the data on publication output in Asthma research.
2.9 STUDIES BASED ON BIBLIOMETRIC LAWS

2.9.1 Bradford’s Law

Wagner (1997) investigates time dependencies of Bradford distributions for 19th Century Mathematics and for 20th Century Logic. To facilitate comparisons, he uses ‘Pareto’s Law’ and Lorenz diagrams for the representation of empirical Bradford distributions. It shows that the character of Bradford distributions (including the core zone and the Gross droop) depends on the stage in the development of statistic field and that it varies with the time span considered.

Heine (1998) noticed the different ranking conventions which exist in the relationship between ‘journal productivities’ and ‘journal ranking by productivity’ of Bradford’s distributions. The writer suggested that a need accordingly rose for a standard ranking convention to assist comparisons between empirical data, and also comparisons between empirical data and theoretical models. Describes 5 ranking conventions including the one originally used by Bradford, along with suggested distinctions between ‘Bradford Data Set’, ‘Bradford Distribution’, ‘Bradford Graph’, ‘Bradford Log Graph’, ‘Bradford Model’ and ‘Bradford’s Law’.

Feicheng & Rui (1999) used the Frequency Rank Analysis of Bradford’s Law in a research on mechanism and model of scattering distribution of scientific information. Analysed the data from BIOSIS, INSPEC and COMPENDEX and verified the suitability and precision of Bradford’s Law in modern scientific and technological settings. It was found that the frequency rank analysis of Bradford’s Law was not suitable for their set of data.

Ramesh Kundra (1999) studied the behaviour of Bradford’s Law towards citation data on Indian Medical Journal. Three important properties
have been identified relating to size and frequency in five time periods. Though not very significant properties have been identified but some significant changes were seen.

Bogaert et al (2000) attempted to show how Bradford Curves, i.e. cumulative rank frequency function as used in informetrics, can describe the fragment size distribution of percolation models. The study also advances the claim that the percolation model can be used as a model to study (generalized) bibliographies. It also attempts to show how idea and techniques developed in scientometrics can be successfully applied in other fields of science and vice versa.

Lopez-Munoz (2003) performed a bibliometric study of the scientific publications referring to Selective Serotonin Reuptake Inhibitors (SSRIs). The database used was EMBASE: Psychiatry. They applied the principal bibliometric indicators: Price's and Bradford's Laws on the increase or dispersion of scientific literature, Lotka's law on the productivity of authors, the participation index (PaI) of countries, the productivity index (PI) of authors, and the collaboration index. By means of manual coding, documents were classified according to the type of study and to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSMIV) or non psychiatric categories. They analysed 3,622 original documents published between 1980 and 2000.

Pulgarin & Gil-Leiva (2004) studied a corpus of 839 bibliographic references about automatic indexing, covering the period 1956-2000. We analyse the distribution of authors and works, the obsolescence and its dispersion, and the distribution of the literature by topic, year, and source type. We conclude that: (i) there has been a constant interest on the part of researchers; (ii) the most studied topics were the techniques and methods employed and the general aspects of automatic indexing; (iii) the productivity
of the authors does fit a Lotka distribution (iv) the annual aging factor is 95%; and (v) the dispersion of the literature is low.

Patra & Mishra (2006) conducted a systematic analysis of the rise in bioinformatics literature. This study analyses the growth of the scientific literature in this area as available from NCB1 PubMed using standard bibliometric techniques. Bradford's law of scattering was used to identify core journals and Lotka's Law employed to analyze author's productivity pattern. The Study also explored publication type, language and the country of publication. Twenty core journals were identified and the primary mode of dissemination of information was through journal articles. Authors with single publication were more predominant (73.58%) contrary to that predicted by Lotka's law. The study provides useful information to scientists wishing to undertake further work in that area.

Nisonger (2007) overviewed the core concept applied to journals defines the relevant terminology and cites specific examples of core lists. Ten approaches for determining core journals (subjective judgment, use, indexing coverage, overlapping library holdings, citation data, citation network / co-citation analysis, production of articles, Bradford's Law, faculty publication data, and multiple criteria methods) were reviewed and the practical applications of core journals lists were explained. Theoretical and practical problems associated with the core concept and core journal lists were discussed and a taxonomy for classifying core journal lists is outlined.

Singh et al (2007) had undertaken a study with the purpose of finding out the growth and characteristics of Digital Library Literature. Over 1,000 articles for the period 1998-2004 were collected from LISA Plus and were analyzed to study authorship patterns, authors' productivity and prominent contributors, language-wise and year-wise distribution of articles,
country-wise distribution of journals, core journals in the subject area, and indexing term frequency.

Barrios et al (2008) studied bibliometric analysis of the area of Psychology of Tourism between 1990 and 2005. The evolution of scientific production during this period, Price’s, Lotka’s and Bradford's Laws and citation patterns were studied. The results show a significant growth in the literature on the subject, as well as an increase in co-authorship and institutional collaboration. Bibliometric laws and empiric regularities observed in other disciplines are also present in this new research field.

Ahmed & Rahman (2008) presented the results of a Bibliometric Analysis of Nutrition Literature of Bangladesh. A list of periodical articles on various aspects of nutrition research of Bangladesh published during 1972 - 2006 was compiled for analysis. A total of 636 articles by 998 authors were identified. The articles were published in 100 local and foreign journals. The five-yearly distribution of nutrition literature shows that there is a rapid growth of nutrition literature from 1987 onwards. Lotka’s Law is found to be applicable to nutrition literature of Bangladesh. Bradford-Zipf distribution also appears to be applicable to the literature.

Vitzthum et al (2009) evaluated the scientific effects of Scoliosis Research both quantitatively and qualitatively. Large-scale data analysis, density-equalizing algorithms and scientometric methods were used to evaluate both the quantity and quality of research achievements of scientists studying Scoliosis. Density-equalizing algorithms were applied to data retrieved from ISI-Web. "BRADFORD, DS" is the most productive author (146 items), and "DANSEREAU, J" is the author with the highest scientific impact (h-index of 27).
Tsay & Lin (2009) explored the characteristics of transport phenomenon literature from 1900 to 2007 based on the Science Citation Index Expanded (SCI™ Expanded) database and its implication using two scientometric techniques, namely Bradford-Zipf's Law and Lotka’s Law. The study indicated that the journal literature on transport phenomenon confirms the typical S-shape for the Bradford-Zipf plot. The author productivity distribution, however, does not confirm with Lotka's Law by the Kolmogorov-Smirnov (K-S) Goodness of Fit Test.

Mishra et al (2010) studied the citation analysis of research publications of the National Metallurgical Laboratory (NML) during the period 1972-2007. It analysed 2830 most valuable citations spread over 561 publications made by the NML scientists and researchers indexed in Science Citation Index (SCI) retrieved through the Web of Science. A Bradford plot constructed to determine the core-citing journals shows that the curve is a typical S shape which indicates subject maturity.

Yin & Chi (2010) explored a bibliometric approach to quantitatively assessing research trend on ubiquitous computing, utilizing the related literature information in Ei database from 1993 to 2009. The result appeared that the literature production within ubiquitous computing title is fast growing. The distribution of cumulative numbers of literature on ubiquitous computing does confirm the typical S-shape for Bradford’s plot. Xu (2011) developed a standard procedure for Bradford Analysis: The methodology in the paper used to test the theory of Bradford’s Law of Scattering. Based on research work and experiments, a standard procedure for Bradford Analysis was developed.

Anil Kumar & Dora (2012) analyzed the citations of the 49 Doctoral Dissertations submitted at the Indian Institute of Management, Ahmedabad, during the period 2004 to 2009. The study reveals that journals
are the most cited sources, and based on the pattern of citations, a local ranking list of journals has been developed. The study applies Bradford’s Law to identify the groups of journals differentiated by their use. Results indicated that the top 48 journals that were ranked among the 30 most used journals contributed to more than 55% of the journal citations.

Jena et al (2012) studied to divulge the patterns of scholarly communication of The Electronic Library from 2003 to 2009 and to measure the coverage and quality of contributions of the journal towards LIS literature. The study also employed Bradford’s Law of Scattering.

Schaeer (2013) Studied conducted the area of applied informetrics which shows very promising effects by using long-known informetric and bibliometric methods like the analysis of power-Law distributions described by Lotka’s, Zipf’s or Bradford’s laws, or the application of co-occurrences analysis for entities like authors, journals or references of scientific literature.

2.9.2 Lotka’s Law

Kretschmer & Rousseau (2001) are of the opinion that using the normal or total counting procedure, Lotka’s Law breaks down when articles with a large, i.e. more than a hundred, number of authors are included in the bibliography. The explanation of this phenomenon is that the conditions for an application of the basic success-breeds-success models are not fulfilled any more. Studying articles with many authors means dealing with items (the articles) having multiple sources (the authors), hence, Egghe’s generalized success-breeds-success mode, leading to not necessarily decreasing distributions, explains the observed irregularities.

Alvarado (2002) reports the results of the application of Lotka’s Law to 10 subjects’ areas in Brazilian National Literature using minimum
square and maximum probability estimators. The subjects included medicine, iron and steel, library science and veterinary science and appeared to conform to different models.

Karisiddappa et al (2002) examined the Lotka’s Law on the scientific productivity of authors in theoretical population genetics from 1881 to 1980. The productivity distribution of authors in 10 time-year blocks and in three phases of the development (1921-50, 1951-65 and 1966-80) of theoretical population genetics was studied using Cohort type of approach. They also studied the extent of cumulative advantage acquired by the prolific group of authors over a time and finally analyzed the regularity in the distribution of productivity of various cohorts, having the same length of activity, but different periods of participation.

Huber (2002) developed a new model for a process that generates Lotka’s Law. Four relatively mild assumptions create a process that fits five different informetric distributions: rate of production, career duration, randomness, and Poisson distribution over time, as well as Lotka’s Law. By simulation, obtained good fits to three empirical samples that exhibit the extreme range of the observed parameters.

Newby et al (2003) applied Lotka’s Law to metadata on open source software development. Lotka’s Law predicts the proportion of authors at different levels of productivity. They examined metadata from the Linux Software Map (LSM), which documents many open source projects, and Sourceforge, one of the largest resources for open source developers. Authoring patterns found are comparable to prior studies of Lotka’s Law for scientific and scholarly publishing. Lotka’s Law was found to be effective in understanding software development productivity patterns, and offer promise in predicting aggregate behavior of open source developers.
Rowlands (2005) offered a practical insight into the application of Lotka’s Law of author productivity to the question of how likely it is that an author will return to a particular publisher (rather than make another contribution to a subject literature, which is its usual application). The question of author loyalty, especially repeat visits, is one which is of great interest to publishers. This paper showed, possibly for the first time, that the author productivity distribution predicted by Lotka’s Law for subject literatures also holds for publisher aggregates, in this case, all Emerald authors.

Bailon-Moreno et al (2005) study conducted a study using the information system of CoPalRed and with the treatment of 63,543 bibliographical references of scientific articles, the field of surfactants has been analysed in the light of the Unified Scientometric Model. It was found that the distributions of actors (countries, centres, and research laboratories, journals, researchers, key words of documents) fit Zipf’s Unified Law better than the Zipf-Mandelbrot Law. The model showed an especially good fit for relational indicators such as density and centrality. Using the Unified Bradford Law, the three zones fit were: core, straight fraction, and Groos droop. The fractality index was used to verify that Science can present fractal as well as transfractal structures. In conclusion, the Unified Scientometric Model is, for its flexibility and its integrating capacity, an appropriate model for representing Science, joining non-relational with relational Scientometrics under the same paradigm.

Patra & Mishra (2006) analysed the growth of the scientific literature in Bioinformatics as available from NCB1 PubMed using standard bibliometric techniques. Bradford’s Law of Scattering was used to identify core journals and Lotka’s Law employed to analyze author’s productivity pattern. Study also explored publication type, language and the country of
publication. Twenty core journals were identified and the primary mode of dissemination of information was through journal articles. Authors with single publication were more predominant (73.58%) contrary to that predicted by Lotka’s Law.

Yin et al (2007) proposed the model of scientific productivity of papers on clothing discipline in China. The quantitative distribution law between the papers and authors in the domain of clothing discipline was presented. When significance level \( \alpha = 0.01 \), the conclusion that the quantity of authors of clothing discipline conformed with Lotka distribution \( f(y) = 0.679 \frac{4}{x^{2.2303}} \) was obtained. At the same time, the conclusion was proved by statistical analysis.

Yin et al (2009) studied on the subject of "Ontology" on Social Sciences Citation Index (SSCI) database from 1956 to 2008. The result indicated that the literature productions related to ontology topic are still growing. The frequency indexes of author productivity distribution did not follow by Lotca’s Law. The applications of Ontology are mainly following by research aspects such as Philosophy; Computer Science and Information System; Information Science and Library Science; Psychology, Multidisciplinary; History and Philosophy of Science; Ethics and Sociology and so on. The literatures of Ontology are usually generated by multiple authorship.

Akakandelwa (2009) studied informetric analysis of 220 papers published by academic faculty at the University of Zambia from 2002 to June 2007, downloaded from the Thomson Scientific Database. The papers were analysed for authorship patterns and collaboration. The study also established a positive relationship between author productivity and author collaboration. The more collaborative an author is, the more productive that author is.
Hamadicharef (2010) presented the Bibliometric Analysis of the Brain-Computer Interface (BCI) Literature (1990-2008) from the Thomson Reuters’s Institute for Scientific Information (ISI) Web of Knowledge. The study explored the growth of BCI Literature, to assess if it follows Lotka’s Law of Scientific Productivity, to identify authors, groups and countries contributing the most to BCI, citation analysis and finally, to determine the core journals. Results indicate that BCI Literature follows a power law growth, has an average author count of 3.9 and an average page count of 7.09. More than half (52.73%) of the BCI Literature is never cited, and 14 papers have been cited more than 100 times. The 3 most productive authors are leading BCI research groups, in Austria, Germany and the USA.

Tsai & Chiang (2011) surveyed e-commerce (EC) technology trends and forecasts using bibliometric analysis from 1989 to 2009 with topic as "e-commerce" in Social Sciences Citation Index (SSCI) Database. The Bibliometric Analytical Technique is used to examine the topic in SSCI journals from 1989 to 2009, based on the scope of 2655 literatures of EC. This paper implemented and classified EC literatures using the seven categories for different distribution status in order to explore how EC technology trends and applications have developed in this period. Also, the paper will perform K-S test to verify the reliability of Lotka’s Law. The analysis provides a roadmap to guide future research and abstract the trend information so that EC researchers can save some time since core knowledge will be concentrated in core categories. This implies that the phenomenon "success breeds success" is more common in higher quality publications.

2.9.3 Zipf’s Law

Sen et al (1998) reported the results of a study on the validity of Zipf’s Law related to the word length and the frequency of its use in the case
of Library and Information Science Literature. Results obtained from the analysis of six different samples accept Zipf’s Law in all the cases.

Egghe (1999) studied the probabilities of the occurrence of multi-word phrases in relation to the probabilities of occurrence of the single words. He gives two independent proofs that Zipf’s Law is not valid in multi word phrases. Then he examined the fractal argument of Mandelbrot in the case of second phrases.

Rousseau & Rousseau (2000) developed a computer program for fitting a power law distribution such as Lotka’s. It basically follows Nicholl’s methodology: using a maximum likelihood approach to estimate parameters, and a Kolmogorov-Smirnov test for goodness-of-fit. When input data are converted (from rank-frequency to size-frequency) this program can also be used to Test Zipf’s Law.

Jiang et al (2002) found that developing the probability function to describe rank-size Zipfian phenomena has been an important problem in scientometrics and informetrics. They present a new rank-size distribution of Zipf’s Law and apply it to an actual distribution of scientific productivities in Chinese Universities.

Kot et al (2003) analysed the Usenet Newsgroups that provides a popular means of scientific communication, and demonstrates striking order in the diversity of Biology newsgroups. Submissions to newsgroups accept a form of Zipf’s Law, a simple power Law for the frequency of posts as a function of the rank, by posting, of contributors. The study shows that a simple stochastic process accounts for this pattern and reproduces many of the properties of newsgroups. This model successfully predicts the relative contribution from each poster in terms of the size, the number of posters and total posts of the newsgroup.
Saxena et al (2003) studied Zip’s Law in a random text from English with a new ranking method. It studied the properties of this text and compares the product of rank and frequency for three ranking procedures. It also analyses the performance of data in the extreme regions of the Zip’s curve. It was observed that ranking procedure and type of text have definite bearings on the performance of Zip’s curve.

Tsay & Ku (2005) explored the characteristics of photocatalysis literature based on the theoretical perspectives of the bibliometrics, such as literature growth, document type and language, author affiliation productivity and journal productivity. The distribution of journal articles and core journals were examined by Bradford’s Law, Bradford-Zipf’s Law and the impact factor of ISI’s Journal Citation Reports (JCR).

Alvarado (2009) analyzed the authors who make up the elite in a sub-area of the bibliometric field: the author’s productivity is also known as the "Lotka’s Law". The units of analysis were taken from 376 different authors producing of 390 articles, book chapters, and works presented in congresses, from 1922 up to 2003. The conclusion is that the elite was made up by 17 authors who had each one participated at least in the production of five or more documents totalizing a contribution of over a third of all documents.

Slovenia’s Current Research Information System (SICRIS) currently hosts 86,443 publications with citation data from 8359 researchers working on the whole plethora of social and natural sciences from 1970 till present was studied by Perc (2010).

Lu et al (2010) analysed to provide a clear picture about the relation between the Zipf’s Law and Heaps’ Law without the help of any specific stochastic model, namely the Heaps’ Law is indeed a derivative phenomenon from the Zipf’s Law. The presented numerical method gives considerably
better estimation of the Heaps’ exponent given the Zipf’s exponent and the system size. This analysis provides some insights and implications of real complex systems. For example, one can naturally obtain a better explanation of the accelerated growth of scale-free networks.

Pulgarin (2012) examined whether the characteristics of the Lotka distribution of publications (in particular, the changes that the two parameters, \( n \) and \( c \), undergo) constitute an indicator of the structure of influence in a scientific field. A quasi-experimental method was used to estimate the parameters of Lotka’s Law in a number of scientific areas (by means of a series of searches in the Scopus database). The study was performed on 90 sets of author productivity data (resulting from a combination of 10 areas, 14 countries, and 3 time periods). Both the exponent of the law, \( n \) (i.e., the slope of the log-log plot), and the constant \( c \) (the fraction of authors with only a single publication) were found to depend on the state of development of the scientific area, on its productivity, on the country, and on the time period being studied. A characteristic that distinguished the so-called "hard sciences" from the "social sciences and humanities" was the level of co-authorship, with the average number of authors per publication being greater in science than in the social sciences and humanities. The empirical results show a picture of the behaviour of the Lotka distribution in different situations, due to different causes. This could be interesting as a better understanding of these regularities may allow them to be incorporated into the theoretical context.

2.10 STUDIES BASED ON MEMS

Avila-Robinson & Miyazaki (2013) integrated bibliometric indicators, social network analysis and multivariate statistical methods on scientific publications, and their citing and cited references on the emerging technology in MEMS/NEMS. A total of thirteen MEMS/NEMS technologies are evaluated for the purposes. Overall, the results provided a quantitative
framework for discerning technological emergence through the evaluation of the dynamics of scientific knowledge bases.

2.11 STUDY BASED ON UNCITED PUBLICATION

In the MEMS literature too, number of uncited articles as like that of other subjects fields. The studies on uncitedness of journals - Journal of American Chemical Society (Ghosh & Neufeld 1974), Nature (Ghosh 1975); discipline - Library and Information Science (Schwarts 1997), Physics, chemistry, biological sciences, geosciences, engineering and medicine (Hamilton 1990); index database – ISI (Hamilton 1991); countrywise (Hamilton 1990, Pendlebury 1991); MEMS literature (Bathrinarayanan et al 2015) are the few.

2.12 RECENT STUDIES

Garg & Kumar (2014) identified that 6231 (17.5%) Indian scientist papers out of 35,640 papers published during the period 2008-2013 remained uncited. High share of uncited publications, which include those produced by top scientists, was repeatedly reported to exceed 10% of the total papers produced, Petr Heneberg (2013). Uncitable documents was responsible for up to 30% of the total citations to the top-tier journals, with the highest values found for medical science journals (New England Journal of Medicine, JAMA, and the Lancet), Petr Heneberg (2014).

2.13 INFERENCES

From the above review of literature, the following inferences could be drawn:

1. The review of literature has been based on several groupings such as studies based on databases; studies based on Individual journals; studies based on individual country’s output; studies based on individual scientist’s works; studies based on citation
analysis; Studies based on mapping the literature and studies based on bibliometric laws.

2. The early research on scientometric studies were mostly by single authors. In the recent years there seems to be a collaborative endeavor.

3. The research contribution by Indian authors on scientometric shows an increasing trend.

4. The research analysis on scientometrics has been increasingly adopting advanced statistical tools and techniques as revealed by the review. Probably the use of software package for the analysis of data has facilitated such a kind of analysis.

5. It is observed that most of the studies are database oriented and individual journal oriented.

6. It is also observed that there are studies of analyzing the individual scientists’ contributions by Library and Information Science professionals mostly in the field of special libraries.

7. The studies on mapping are also seen in the recent years.

8. It further reveals that the research in the field of scientometrics is marching ahead not only in India but also in other parts of the world.

9. It is found that there was no stand on the subject of Biodiversity research productivity literature at data base oriented or at journal oriented or at individual countries output study.

Therefore, in the next chapter an overview of Micro-Electro-Mechanical Systems (MEMS) and its needs, types, devices, applications etc. are provided.