CHAPTER II

REVIEW OF RELATED LITERATURE

2.0 Introduction

This chapter presents a review of related literature in the field of study. Scientrometrics is a new branch of knowledge, which uses bibliometric measurements for the evaluation of scientific developments, social relevance, and impact of the applications of science and technology.

Earlier studies in the field of research productivity using 'scientometric' or 'bibliometric' techniques to know the developments in the subjects, number of articles published in these subjects and related areas to assess the growth of science, to evaluate productivity of individuals, Departments, institutions and Country etc are given here. In the last two decades there is an unprecedented growth of such studies in different fields mainly because the Government and private organizations that invest large amount of money for research activities need accountability. Moreover funding agencies, scientists and policy makers etc. have required frequent assessment of research activities for varied reason. This chapter includes selected reviews, which seems most relevant in the context. It enables identification of specialization pattern in various branches of sciences.
Primary journals in Library and Information Science, LISA-CD ROM version of Library and Information Science Abstract and relevant websites were scanned to identify related studies.

The book “Bibliometric methods in assessing productivity and impact of Research” is the theme of a paper presented by Prof. F.W. Lancaster in connection with the seventeenth Sarada Ranganathan Lectures during 1991, under the auspices of the Sarada Ranganathan Endowment for Library Science. The book contains more than eighty reviews under the titles “Productivity and impact of research, individual productivity and impact, the ranking of journals, institutional productivity and impact, National analysis and problems and limitations of Bibliometric Methods.” This was also consulted to gauge the depth of the subjects.

The review of related studies is divided under the following headings.

2.1 Research productivity of Universities.

2.2 Institutional productivity

2.3 National Productivity

2.4 Individual productivity

2.5 Lotka's law and productivity

2.6 Subject wise study of research productivity
2.7 Factors of productivity

2.8 Research Collaboration

2.8.1 International Scientific Collaboration

2.8.2 Authorship pattern

2.9 Age and productivity

2.10 Conclusion

2.1 Research Productivity of Universities

Edem and Lawal (1999)\(^1\) have conducted a study to determine the influence of job satisfaction on the publication output of libraries in Nigerian Universities. Of the 6 dimensions of job satisfaction used in the study, only 3 such as achievements, responsibility and recognition had a significant influence on their publication output. Other dimensions including salary, university library policies and administration and supervision had no significant influence on their publication output.

Sehwarg and others (1998)\(^2\) in their article discusses the research output of the Danish Technical University. Papers published from 1992 to 1994 were grouped according to 20 clusters of research areas. Using citation techniques, the dynamics of citation frequencies and other features of research system such as self-citation research collaboration and relative impact on the international literature were studied. The
methods can be used to analyse institutional and national resources efforts and to monitor effects of changing policies.

Moed and others (1998)\(^3\) presents results of quantitative analysis of 340 research departments in the natural and life science at 3 Flemish Universities. The effects of changes in the funding structure of the Flemish Universities their research capacity, productivity and impact during the 1980's and early 1990's were studied. It concludes that if present trend continue to develop, a situation may emerge in which the basis normally provided by the university itself has become too small for externally funded research activities.

Haiqi (1996)\(^4\) in his study evaluates quantitatively the scientific output of key medical Universities in China using CBM disc, MEDLING and SCI databases. Results showed that the Tonji Medical University ranks first in terms of paper output in Chinese and English, while Beijing Medical University is placed second in output but first in citation impact. The study also reveals the fact that coverage of Chinese biomedical publications by western indexing services is very poor.

Colman and others (1995)\(^5\) brings out the research performance of 41 British University Politics departments through an analysis of articles published between 1987 and 1992 in 9 European politics journals with the highest citation impact factor. Annual performance scores were obtained by dividing each department's number of publication in these journals in each year by the corresponding departmental size. These scores were
consolidated to obtain a research performance score for each department over the period of assessment. They correlate significantly with research performance scores from 2 previous studies using different methodologies.

Contribution of Indian Universities to the mainstream scientific literature during 1987-89 is the subject of study of Nagpaul (1995) in his article reports the contribution of Indian Universities to the mainstream scientific literature during 1987-89 along 2 distinct, but interrelated dimensions of quantity and quality of research output. The quantity of output is assessed through the number of articles published in journals covered by science citation index and the quality of output is assessed through the impact factors of journals in which the articles are published.

Almena (1994) presents a study of the scholarly publications output of academic staff of the University of Ghana for the decade 1976-1986. Productivity rates were analyzed by department-wise, by faculty, co-authorship, journals, books and lectures, by gender and by geographical distribution of publisher. The study reveals the fact that a generally low output of scholarly publications at the University of Ghana during the period under study. The major problems have been lack of funding, equipment, non-availability of suitable journals and poor library facilities.

The study conducted by S.Kyvik (1994) gives an overview of the extent of popular science publishing and contributions to public debate, as compared to scientific publishing among faculty members at Norwegian Universities. Faculty publishes far fewer articles for the lay public than
publications for their specialist colleagues. The study states that the most productive researchers in terms of scientific publishing are also the most prolific in non-scientific publishing.

Plomp (1994) highlights the citation peculiarities of 324 research groups in the faculties of science and medicines of 8 universities in the Netherlands based on the citations in 1986 and 1987 of 3938 articles published in 1985. The results showed that the number of highly cited papers scored by professors and other senior scientists during their entire career is a much more reliable predictor of the performance of a research group than the number of short term citations of the articles published by the group within a short period.

Susan Bonzi (1992) analyzed the data collected from 411 senior faculty members of Syracuse University to examine trends in productivity over time. Overall productivity early in a career is a good indicator of later output. Professors increase productivity, to a greater extent than do Assistant Professor and Associate Professors. The study shows that increase in productivity among females is greater than among males, but males are more productive overall. Humanities and science/mathematics faculties increase productivity to a greater extent than social sciences and professional school faculties. Since journals are cited more than books, faculties do not publish in journals will not show a citation count.

In their article Ali and Young (1992) points out the use of CD-ROMS and the increase in the faculty publication output. The study
reports that there is a strong relationship between the use of CD ROMs and the faculty publication output. The study reports that the library's increase of access to the world's bibliographical information resources is due to the acquisition of CD ROM databases. It also noted that the use of CD-ROM technology in libraries has also improved the quality of the library users bibliographical citations.

The article "Scientific production of Spanish Universities in the fields of social sciences and languages" by Villagra Rubio and Villagra Rubio (1992) discusses in their article "Scientific production of Spanish Universities in the fields of social sciences and language" the characteristics of the scientific productivity of Spanish Universities in the field of social sciences and language from 1986-88. Quantitative methods are adopted to assess the University productivity rate, publications/authors ratio, and Co authorship, type of documents edited and their distribution. Suggests new lines of study for determining the factors that may explain the existing patterns of scientific production, and for identifying useful bibliometric measures aiming at an assessment of this type of literature.

Krauskopf (1992) explains the scientometric indicators as a means to assess the performance of state supported Universities in developing countries. The paper states that Chilean universities are responsible for more than 80% of the science literature produced in the country, which in the last 20 years, has grown more than 600%. One of the underlying problems of the governments of developing countries in
delineating suitable strategies for allocating efficiently the funds available has been the absence of clarity in distinguishing the individuals and centers committed to competitive scientific research. State funds are scarce because the region invests too little in science, do not always reach the right people and the right place, amplifying the existing problems for the good scientists who resist emigration.

Crew(1988)\(^{13}\) analyses the total publication and per capita publication rates of 52 UK politics Departments from 1978-84. The main findings are: i). The departmental per capita publication rates vary enormously; ii) a department’s relative productivity is strongly correlated across all types of publication; iii) a few departments are substantially more productive than the rest; iv) among highly productive departments, one can usefully distinguish between those with collective and those with individual strength; and v) a department’s productivity is not related to its size.

Through a preliminarily analysis Adamson (1981)\(^{14}\) presents the scientific productivity of six old Nigerian Universities, Ibadan, Ahmadu, Bello, Nigeria, Lagos and Benin over the period 1970-79. There is a real growth in scientific research in Nigeria as a whole. The analysis revealed that some of the universities have problems, which have their research efforts on a downward trend. And also report that a new order of scientific contribution by the universities seems to be emerging. The author
suggests that constant scientific growth analysis will help the new bodies involved in formulating and coordinating Nigerian science policy.

Schorr (1974)\textsuperscript{15} conducted a quantitative study on the scientific output of academic members of Tabriz University of Medical Sciences and Health Services (1988-1996). The study shows that 75.5 percent of these members were men and 24.4 percent women. 81.3 percent had a doctorate and 66 percent of them had the academic rank of assistant professor or higher. The population under study produced about 2166 scientific publications in the form of books, periodical articles and research report. The majority of these were articles (56 percent) and research reports (36 percent) while the books formed only 7% of the output. About 69.3 percent of researches were carried out by an individual researcher. The majority of papers and research reports (93.3%) appeared in domestic periodicals only and only 6.75 were published in international periodicals. The analysis pointed out that medicine is the most productive area among the 6 subjects studied (66.5 percent) and dentistry is the least productive one (1.5 percent). The number of publications during the period under study witnessed a sharp continuous growth.

2.2 Institutional productivity

Gupta and others (1999)\textsuperscript{16} conducted a study on the impact of professional and chronological age on the productivity of scientists in engineering science laboratories of council of scientific and industrial research. The mathematical models of ageing, desired from earlier
studies, were tested in the two types of scientific and technical output in order to determine the linear and non-linear trends and the productivity rates. The productivity of the scientists in the beginning of their career is slow in the case of patents compared to the research papers. Productivity of scientists in research papers reaches its peak between 26 and 30 years of experience then falls off after their late 50s. In the case of patents, lifetime productivity continues to increase with professional age, in contrast to an earlier study.

A bibliometric study was conducted by Ibrahim (1997/98)\textsuperscript{17} to determine the productivity of researchers in the Institute for Agricultural Research, Nigeria (IAR) and the National Productivity Research Institute, Nigeria. The study concludes that IAR and NAPRI have made remarkable impact not only on the agricultural sector but also in the agricultural economy in general. There is no significant difference between the two institutes.

Budd (1995)\textsuperscript{18} discusses the results of a survey of the level of publishing productivity of academic faculty for the years from 1991 to 1993 at 94 us institution with membership in the Association of Research Libraries (ARL). Data sources were the three citation indexes; science citation index, and Arts and Humanities index. Results indicate some relationship between publishing activity and other variables.

Herbst (1993)\textsuperscript{19} analysed the publication and citation records of a group of 34 senior members of the faculty of the chemistry Department
at Technikon-Israel Institute of Technology over the period 1980-1990. Results agreed with findings of the previous study and show that a few members (less than 20 percent) produce more than half the publications and receive more than half the citations of the group as a whole.

Maclean and Janagap (1993) argues that there were no correlation between scientific productivity and numbers of scientists in a center but there was a significant correlation between scientific productivity and budget, indicating higher efficiency in the larger centers based on a study conducted on 22 International agricultural centers.

Mulford (1993) and others focuses on work alienation and publication productivity of agricultural scientist in 2 international research centers. Results shows two perceptions of structure, centralization and formalization correlated with work alienation, but less so with publication productivity. Work alienation is correlated with publication productivity. Work alienation was less important than perceived centralization.

Sen and Shailendra (1992) in their paper presented at the international conference on science indicators for developing countries; Paris, 15-19 Oct 1990 describes a new method of evaluating scientific output by research laboratories. The analysis helps to generate performance indicators such as average impact factor and normalized impact factor for each scientist's laboratory and the research complex; spectral distribution of papers falling within various ranges of impact factors and normalized impact factors. By comparing the performances
over several years the trend of research activity of each laboratory can also be obtained.

An assessment of the research performance of Spanish Research Council using scientometric indicators were made by Aidamendez and Salvador (1992)\(^2\). The results show that very often costs, productivity and impact do not point in the same direction. The presence of highly cited articles at institutes with low productivity scores does not indicate a correspondance of quantity with impact. It suggests that the research group level would be a more reliable unit for analysis than the aggregated level of institute or research area.

Crew (1988)\(^2\) has suggested a sophisticated measure of institutional productivity, which takes account of the type of publications, produced and arrives at a numerical score for a group, or an average score per researcher, based on the weight assigned to each publication type. He gives a weight of 10 to a book authored, 2.5 to a book edited, 2 to an article in leading journals, and so on down to lower scores for other types of publication (e.g., pamphlets or occasional papers) and for received editions of works published earlier. The publication score assigned to a department, then, could be the average numerical score for the departmental members.

Garg and Rao (1988)\(^2\) have conducted a bibliometric analysis of scientific productivity of an Indian Laboratory in the field of physics. Science citation index (SCI) and non-SCI covered Indian and foreign
journals, during the period 1965-82 were taken to find out the pattern of productivity. Also points out the sub areas of physics in which the laboratory scientists have published maximum papers and the pattern of scientific co-authorship in the research work. Correlation coefficients between input variables (number of papers published, processes developed patents accepted) have been calculated.

Cohen (1981)\(^2\) in his article highlights the relation between publication rate and laboratory size. The study was based on three institutions such as National Cancer Institute (Bethesda), National Institute for Medical Research (London) and Rockefeller University (London). In these laboratories, ranging in size from 1 to 46 scientists, one additional scientist increases the expected annual number of publications of a laboratory by approximately 1.1 regardless of the size of the laboratory.

Knorr and Mittermeir (1980)\(^2\) examine the relation between publication and professional position. Attempts to explain the higher productivity of higher status scientist by pointing to their greater case of publication as far as acceptance of their work by journals and publishers is concerned were not supported by the data in recent studies. Position within a research organization does confer greater case of another or co-authorship; this is the major explanatory variable accounting for productivity differences within research laboratories.

The study conducted by Cohen (1980)\(^2\) reveals the publication rate as a function of laboratory size in biomedical research institutions. The
number of all publications of a research group in a year and the number of primary research publications of a group in a year were approximately proportional to the number of individuals in that group during the year.

2.3 National Productivity

Many studies have come out using bibliometric/Scientometric techniques to compare the productivity and impact of research conducted in various countries and region. When countries are ranked by number of science papers produced, the largest and most advanced countries will appear at the top of the list (India is the most productive among the under developed countries). How ever, different ranking emerge when other criteria are taken into account. For example science research in Israel comes out rather well when number of papers produced is plotted against such parameters as population, and number of telephones per capita. In other words, Israel produces a lot of research relative to its size, prosperity and stage of development.  

The study entitled Scientific productivity.... Where we do stand? explains the publication pattern and research productivity of Indian scientists. The study a bibliometric assessment of India’s scientific publications based on the science citation Index (1990 & 1994) by A. Basu and Nagpal (1999)\(^29\), NISTADS report no. Rep. 2448/98.

Cano (1999)\(^30\) reviews 17 years of research in Library and Information Science (LIS) in Spain. The total production of 2 major
Spanish periodicals publications in the field was analyzed from 1977-1994 according to productivity variables and thematic content. A total number of 354 articles were analysed. The Spanish research output seems to concentrate in the areas in information retrieval, description of services and studies of scientific communication. There are differences in the concentration of topics per journal studied. Authorship pattern shows that a preference for individual authorship.

Bibliometric indicators were used by Aman (1998)\textsuperscript{31} to examine the scholarly productivity of researchers and scientists in Kuwait. The ISI publications Arts and Humanities index, Social Sciences Index and Science Citation Index were surveyed to gather the data from 1986 to 1995. In addition to the number of times cited, the availability of the source journals in Kuwait University and the Kuwait Institute for scientific Research was also examined. He discusses the data in the light of theories of bibliometric and other laws of information science.

Guzman (1998)\textsuperscript{32} and others discuss the features of scientific production in the domains of vaccines for the period 1990-1995, including 8 Iberian-American countries. Indicators such as collaboration rate, activity index and representation techniques, were applied using a cluster analysis and multidimensional scaling. Similarities between countries are represented according to their activity index in the subject field. Results shows that a discontinuity in the scientific production over the years, where each country has a peculiar behaviour.
Makino (1998) presents the results of a detailed comparison of 2 research groups of theoretical astrophysics in Post World War 2 in Japan. It seems that one of the two groups gained a much higher reputation within the research community and little difference could be found between the two groups’ scores for the macroscopic indices such as the number of publications or the average citation index. The results suggest that widely used quantitative measures of productivity do not give a meaningful measure for the actual contribution of a research group to science.

Kshida and Matsui (1997) presents a report based on a scientometric analysis of social science literature. 40313 records collected from International Bibliography of the social sciences were examined by country and language. Result shows that a large number of monographs were published by a very small number of countries and in a few languages. It examines the correlation among the number of published monographs, GDP population and the number of people attaining a university education.

Nederhof and Van Wijk (1997) introduce a method to identify and map the internationally most visible research topics occurring in the social and behavioral sciences. The study describes methods and data relevant to a portfolio analysis of natural research efforts shows that the maps, enriched with scientometric indicators of strength and weakness of mankind research efforts, can be important tools for science policy.
findings indicate that the research front on many topics in both social and behavioral sciences was international in the late 1980s.

Katz and Hicks (1996)\textsuperscript{36} in their article 'a systemic view of British science' analyses the publishing size and the number of publishing institutions in Britain for each sector using bibliometric techniques. It is a comprehensive analysis, which includes time series, institutionally based, sectoral level of national research output. Also assesses each sector's intra sectoral inter sectoral and international collaboration. The study examines the data by field, looking at sectoral publishing profiles across fields and at how the collaborative patterns vary between fields. The study concludes with a summary profile of each institutional sector.

Prpic (1996)\textsuperscript{37} in his article 'Characteristics and determinants of eminent scientist's productivity presents an analysis carried out on 385 eminent Croatian scientists to explore the patterns of and factors influencing their scientific productivity. The scientific productivity of the eminent scientists is not only several times larger than that of a survey conducted during 1990, but also shows greater collaboration and orientation towards the international scientific arena. The most important predictors, like the 1990 sample in the elite's productivity are qualificalional and organizational variables, but of a more selective nature.

Persson and Melin (1996)\textsuperscript{38} present a study of the productivity of scientific papers, co-authorship and R&D expenditures in the OECD countries. It discusses the distribution of papers in the journal 'Science' by
OECD country in comparison with ‘Science Citation Index’ papers as a whole and compares these to the distribution of R&D investments.

The paper presented by Arvanitis (1996)39 and others presented a paper at the workshop on ‘Bibliometric standards’ held in River Forest, Illinois 11 Jan 1995 expressed the experience with the National citation report database for measuring national performance a case study of Mexico. The study recommends that, in order to generate reliable and accurate indicators using these data files, these be handled by specialists well acquainted with ISI information products and with scientific set up of the country concerned.

Braun and Schubert (1996)40 pointed out and the indicators of research output in the sciences from 5 central European countries. The article summarizes the trends and patterns of research activities in Austria, the Czech Republic, Hungary, Slovakia and Slovenia during 1990-1994, as reflected in the primary journal literature covered by the science citation index database of the institute for Scientific Information.

Part of a special issue devoted to scientometrics and bibliometrics research in Latin America by Quesada-Allue and Gitlin(1995)41 presents a scientometric analysis of Argentinean Science output during 1966-83. The study focuses on authorship as a measure of Argentinean scientific size. Comparisons were made with more competitive countries such as Spain and Brazil. It reports a relative decline in the rate of author’s increase for Argentina and demonstrates the derived loss of positions in the publishing
Royle and Over (1994)\textsuperscript{42} throw their paper 'The use of bibliometric indicators to measure the research productivity of Australian academics' examines the appropriateness of using Institute for Scientific Information (ISI) database Science Citation Index (SCI) to measure the research productivity of Australian academics. It is shown from the analysis of publications listed in the research reports of 3 Australian Universities that only 27 percent of periodical article authored by academics in social science disciplines are captured by the ISI database, in contrast to 74 percent of journal articles generated by academics in science disciplines.

Using a performance indicator based solely on ISI source indexes or permitting universities or individuals to decide what constitutes a publication and hence is to be included in the count, raise additional concerns. The major problem in using frequency of publications as a measure of research productivity is to arrive at a valid definition of what constitutes a publication.

Brain drain is a common problem for developing countries. J.L.D. Arenas (1995)\textsuperscript{43} reports that First World issues and agendas influence research in these countries, whether or not they are relevant. The results of the bibliometric study suggest that Mexican researchers have been fairly successful in targeting English language articles at British and North American journals of high impact, But the efforts of Mexican health
sciences researchers are unfocused. Strategies to address the specific health research needs of Mexico are needed.

Kruauskopf (1992)\textsuperscript{44}, reports that Chillian Universities are responsible for more than 80\% of the science produced in the country, which in the last 20 years, has grown more than 60\%. Due to the unscientific financing, it does not reach the right people and the right place, amplifying the existing problems for good scientists who resist emigration. They also examine the research performance of state financed universities.

Pestana (1992)\textsuperscript{45} conducted an analysis of the scientific output from Spain and 5 other European countries on the basis of current Contents diskette (CCOD) life science (1989). The results of these studies showed an increasing share by Spain in the 6 countries output, especially in the sub field of organic chemistry and phytochemistry. It shows that the quality of the Spanish articles deduced from the journal impact factors (JRC-1989) is below the 6 countries average.

Sen and Gan (1990)\textsuperscript{46} argued that the science and technology situation of a country, organization or subject fields is best understood through the study of more important personalities engaged in research and development. Bibliometrics has been defined as a quantitative and analytical method for discovering and establishing functional relationship between biodata and bibliodate elements. The present study is a partial
bibliometric analysis of 28 Fellows (deceased) of the Indian National science academy.

Irivine and Martin(1989)\textsuperscript{47} have shown that France’s share of world publishing output is declining in most fields of science, and so is that of the United Kingdom, while the United States did not change much overall in the period 1980-1984, and Japan’s production increased in almost all fields. The study also reveals, however, that one must look at smaller areas of research to get a true picture of what is happening at the national level. For example, in some sub fields of biomedicine, the United Kingdom’s production is declining (eg. Ophthalmology 31% decline in papers in 1980-1984) whereas, in others, it is growing (e.g., a 43% increase in surgery papers in the same period).

A review of the scientific output of the state of Kuwait was carried out by Faiza Al Kharafi and others (1987)\textsuperscript{48}, on the occasion of the 25\textsuperscript{th} anniversary of its independence. Prior to 1970, only about 100 papers were credited to Kuwait institutions, mostly medical reports in local journals. The study shows that there is a considerable increase in the publication output of scientific papers and more than 80% are appearing in international journals.

Garfield (1984)\textsuperscript{49} prefers to use a form of impact factor in comparing the relative influence of papers produced by scientists from various countries. For example, in his analysis of Latin American researcher he shows that Chilean papers have the highest impact: of 312 papers
published by Chilean scientists in 1978 earned 1017 citations in 1978-1992, for an average impact of 3.3, whereas papers from Peru achieved an impact of only 1.5. In contrast, he points out, Scandinavian papers achieve an impact of 6.4 and US papers an impact of 5.7.

Lawani (1982)\textsuperscript{50} analysis of a sample of cancer research papers previously judged to be of high quality and of a random sample from the World literature, indicates that 19 countries are the key producers of cancer research literature. Quality papers were much less dispersed among countries than ordinary papers and there was a high and statistically significant correlation between the quantity and the quality of productivity of countries.

Sawai (1981)\textsuperscript{51} discusses the productivity pattern of university scientists of Japan by using 1978 edition of the current bibliographic directory of the Arts and science. The study was based on 394, 893 scientists, identified from 514, 318 journals citations and 50, 150 non-journal citations. Among them there were 12, 191 Japanese scientists affiliated to 344 universities and colleges. The field which had a large number of those contributing authors were life sciences, clinical medicine, physical and chemical science, and engineering and technology. It also reveals that university of Tokyo is the most productive in scientific research.
2.4. Individual Productivity

Rama Reddy (1999)\textsuperscript{52} and others in their article productivity of the university faculty members: A case study of university of Hyderabad, presents a citation analysis of a faculty member of the University of Hyderabad. The faculty member has published more than 100 articles and received in all 315 citations. There are at least 7 papers, which received more than 10 citations. The average number of citation per published paper is 3:7 and per cited paper is 5:4 verifies the author's productivity and impact over the years. Concludes that the author would be productive in coming years also.

Sen (1998)\textsuperscript{53} proposed a formula for the ranking of scientists based on diachronous citation counts. The paper generalized the fact that the citation generation potential (CGP) is not the same for all papers, it differs from paper to paper, and also to a certain extend depends on the subject domain of the papers. The method of ranking proposed in no way replaces peer review. It merely acts as an aid for peers to help them arrive at a better judgment.

Geetha and Varghese (1998)\textsuperscript{54} in their paper attempts to highlights the achievements of Prof. C. N. R. Rao in terms of his scientific productivity, particularly papers contributed in learned journals of international reputation and impact factor of source journals in which they have published. Prof. Rao, the pioneer in solid-state chemistry, entered the field in early 1950's and he was instrumental in developing it as a
mainstream area of chemistry. The authorship status and extent of collaboration are also identified.

Kalyane and Sen (1998)^55 reports scientometric indicators of 129 publications of C. R. Bhatia, geneticist and plant breeder, published between 1961 and 1994. The study discusses productivity coefficient, Publication rate, authorship pattern, etc., Domain-wise the maximum number of publications are in the area of mutation research and mutation breeding, followed by seed proteins, biotechnology, biochemical genetics etc.

Kalyane and Kedamani (1997)^56 portrait the research productivity of Barbara McClintock (1992), the winner of Nobel prize in physiology for 1983. Her discovery that transposition is a vital part of genetic mutation was a veritable breakthrough in experimental genetics. By analyzing the publications of Barbara McClintock, the present paper identifies her peak period of publication productivity, her collaborating authors and the extend of collaboration, the scattering of her publications in various sources and the keywords used for the totes of her papers. Typical characteristics of her personality and implications of her achievements are illustrated by citing incidents from her life.

Kalyane and Munnolloi (1995)^57 conducted an analysis of the research productivity of the analytical chemist T.S. West using scientometric indicators. The study reports the details such as distribution of articles among journals and other channels of communication, ranking
of journals, quienquennial collaboration coefficient, productivity coefficient, most prominent collaborators, publication density, publication concentration etc.

Kademani (1994) and others reports the details of a scientometric analysis of the publication output of Indian nuclear physicist P. K. Iyengar. Year wise publication, research domain, collaboration pattern, channel of communication used and frequency of keywords were analysed. The most productive period with highest publication activity was 41-45 years of age. The result indicates that he can be considered as a role model for younger researchers to follow.

2.5 Lotka’s Law and productivity

A. N. Joshi and B.S. Maheswarappa (1996) discuss concepts, types and problems in measuring scientific productivity, reviewing studies since 1926. Examines theoretical developments in relation to the frequency distribution of Lotka’s law of scientific productivity. The study revealed the fact that various studies are mainly non-comparable and inconclusive owing to substantial differences in the analytical methods applied. The study points out the need for methodological standardization and co-ordination of research efforts in this area through empirical validation and generalization of bibliometric models.

Lemoine (1992) discusses Lotka’s approach to the frequency distribution of scientific productivity and draws attention to the fact that not
all empirical frequency distribution of scientific productivity fit Lotka’s model. Productivity was measured in terms of research papers and patents produced by each of the CSIR researchers. Discusses some preliminary ideas based on the characteristics of the data and on Indian cultural heritage in order to explain the results.

Ravinder Nath and Wade M Jackson (1991) discuss the result of the study conducted based on articles published in 10 periodicals between 1975 and 1987 in the subject field of management information system. It shows that while Lotka’s law relating to the number of authors of papers written by each author does not apply, a generalized version of Lotka’s law, referred to as the inverse-power law fits remarkably well.

Kyvik (1989) examines whether productivity differences among individual researchers are larger in some fields of leaving than in others, productivity patterns in natural sciences, medical sciences, social sciences and the humanities are compared by the use of unweighted and weighted publication counts. The study shows that about 20% of the tenured faculty at Norwegian Universities produces 50% of the total output and the most prolific of the researchers account for almost 85% of the output. The results are discussed in relation to Lotka’s law

A database consisting 336 items were analysed by Devendra Kumar Gupta (1985) to study the authorship trend and applicability of Lotka’s inverse square law. Two stages of development were identified—
exponential rate of growth during the rest three years and which is expected to continue in later years of 1970s. Lotka's law in its original form as inverse and square law does not apply to this set of data but however, it does apply in its generalized form with a calculated value of exponent $\alpha=2.7$. Which establishes the fact that law productivity of authors in case of an emerging speciality in related with the increasing value of $\alpha$. Two statistical tests Chi-square Test and K-S Test were also applied.

Lotka’s law and productivity pattern of ecological research in Nigeria from 1900-1973 was analyzed by Gupta (1987)$^{64}$ to test the applicability for different files were generated. Publications of all the authors, and co-authors. Lotka’s law in its original form as inverse square law does not apply to any of the 4 data sets. However, it does apply in its generalized form with the calculated values of characteristics exponent. The values were found to be 1.9, 1.8, 2.2 and 2.4 for the four different data sets.

Subramanyam (1981)$^{65}$ discusses the applicability of Lotka’s law to library science literature and tested by collected authorship data from library literature (1979 cumulated annual volume) and by crediting works of multiple authorship to only the first named author. The data was found to conform to an inverse cube law more closely than an inverse square law.
2.6 Subject-wise study of research productivity

M. Vijayakumar (2000) and others attempted to bring out the information use pattern by library professionals through a study based on the references appended to eighty post graduate library and information science dissertations, submitted to the Department of Library and Information science, Kuvempu university. The paper identifies forms, average number of citations per dissertation, year-wise distribution of literature, area-wise distribution of distribution of dissertations, availability of cited journals in Kuvempu University, frequency distribution of periodicals, and the core journals.

Gupta and Suresh kumar (1998) examine the applicability of Lotka's law and a few other statistical distributions for their goodness of fit to the author productivity data from core journals in theoretical population genetics. The negative binomial and geometric distribution and found to be generally applicable in majority of the date sets and also in terms of best fit.

Meera (1998) reports the results of a bibliometric study on plant ecology literature. Data have been collected from the plant ecology, a subsidiary of 'Environmental Biology' section of biological Abstract. From the analysis it is seen that 13,179 authors had contributed 4,840 items. Out of 13,179 only 179 had contributed more than one paper and rest 13000 (98%) had contributed only one paper. But according to Lotka's law single contribution should be about 60%. The number of authors
contributing 2 persons should be 3,200 (according to law) but it shows only 81 authors contributing 2 papers. So this law is not verified.

Kumbar and Akhtary (1998)\textsuperscript{69} reports the results of a study based on 7451 references/citations appended to the 322 articles published in the 'American Journal of Ophthalmology' Vol117 to 120 during the year 1994-95. The result indicates that major type of document is periodical 682 (91.63%); authorship pattern shows, highest contribution made by three authors 72; and Ophthalmology journal score the highest number of citations 998 9(14.62%).

Bordous and Zulneta (1997)\textsuperscript{70} compares the scientific performance of two groups in biomedical field i.e. pharmacology and pharmacy, and the cardio vascular systems using bibliometric indicators. The teams were characterized according to their size, production, productivity, research level and expected input factor of their output, collaboration pattern and inter disciplinarily character. The study was undertaken to identify structural or dynamic features of teams associated with good scientific performance.

Nederhof and Van Wijik (1997)\textsuperscript{71} introduces a method to identify and map the internationally most visible research topics occurring in the social and behavioral sciences, as well as the topics which changed most over a decade. The paper describes methods and data relevant to a portfolio analysis of national research efforts. Key words used by authors in scientific or scholarly publications provide a window on scientific
development and changes in scientific research. Shows that the maps enriched with scientometric indicators of strength and weakness of national research efforts can be important tool for science policy. The findings indicate that the research front on many topics in both social and behavioral sciences was international in the late 1980s.

Boyce and Hendren (1996)\textsuperscript{72} reports result of study to investigate a method of evaluating and ranking library schools, in the USA, to assess the number of articles published by the faculty members of 57 library schools over a period of ten years. The study revealed that the publication counts in library literature are not claimed to constitute a valid single measure of library school effectiveness but argues that the measure is easily calculated and easily responsible.

Vogel (1997)\textsuperscript{73} examines the 598 papers on physics published between 1987 and 1994 with at least one author presenting Chilean affiliation. It identified the number of papers, cumulative impact factor, average impact factor, international co-authorship, most cited journals, and main Chilean institution. Shows that physics is growing in Chile with international collaboration. The average impact factor is relatively high and constant during the period. The articles are spread throughout 165 different journals, but most of the productivity is found in a few journals of high impact factor.

In their article Macias-Chapula Castro (1997)\textsuperscript{74} in their article discusses the result of an analysis performed on 1323 records retrieved...
from international database, related to the Mexican production on environmental health. MeSH and BIREME’s Health Sciences Descriptors (DeCS) was used as guiding tools to select the subject content of records. The result indicated that most of the production was focused on water and air pollution and environmental monitoring. Though the development of hierarchical models, patterns of subjects covered and uncovered could be easily identified. Proposes further lines of action and research.

The article prepared by Budd and Seavey (1996) is a replication of a paper by Robert Hayes (1983), based on productivity of US library and information science faculty. It examines both individual productivity and productivity by school presents ranking and per capita publications and calculates citations. Offers comparisons within the 12 year period and with the Hayes paper whenever possible.

Trend in publication productivity of library and information science faculty is the subject of study of Dalrymple and Varley’s (1995). The number of publication were counted and categorized by contest at 3 points in time, 1978, 1983 and 1988. The names of faculty were selected from the directory of the ALISE and search against 3 libraries and information science abstracting services (Library literature, Information science abstracts and LISA. The analysis includes distribution by publications by rank and sex, determination by publications of per capita publication rates etc. Results show gains in productivity across time, persistently higher
rates by man and increasing integration of library science and information science in the literature.

Kalyane and Sen (1995) reports the results of a bibliometric study of 498 research articles on oilseeds, from the periodical, journal of Oil seeds Research, published between 1984 and 1992. The study aimed to determine; space allotment for full length articles and short communications; authorship pattern; author productivity; prominent contributors; important locations of oilseed research; pattern of tabular and graphical presentation; citation pattern; obsolescence; Bradford distribution of citations; important keywords in the titles and time lag between submission and publication of articles.

Rogers and Anderson (1993) reports a new method for defining a multi disciplinary research area for bibliometric analysis based on the subject cardiovascular biology. It is reported that UK and US dominate in total numbers of papers and the relative emphasis on cardiovascular research in these countries is low and declining. Japan and Germany in contrast appear to give greater emphasis to cardiovascular research. In their national portfolios of biomedical science and between 1988-91 Japan established a marked increase in activity.

Sharma and Garg (1993) discusses a bibliometric analysis of 536 papers published in periodicals and presented at conferences in the field of solar power research in India with a view to identifying research and development efforts being undertaken in India. The study is intended to
identify bibliographical forms of literature and their characteristics; areas of research; types of institution carrying out the research; collaboration in research; and the scientific productivity of authors.

Nagpal and Pant (1993) presents a study of the specialization profiles of 11 countries comparing research publication output and citation impact in 9 sub fields of chemistry. Identifies sub fields of relative strength and weakness for the 11 countries from the values of indicators such as activity index and attracting index. Maps the similarity structure of specialization profiles of the 11 countries using hierarchical cluster analysis and multidimensional scaling. This mapping leads to the representation of chemistry as it is structured by the dynamics of national science policies of these countries.

Rinia and others (1993) in their study measure the national output in physics, and its delimitation problems. Science citation index is used to collect data for the study. Integer counted World shares are highly influenced by the degree of internationalisation. First author counting gives a satisfactory approximation of fractional counting. Citation indicators based on first author counting may be distorted in fields with a large fraction of international co-authored publications.

Bordons and Barrigon (1992) explain the result of a bibliometric analysis of publications of Spanish pharmacologists published between 1984 and 1989. 44.3% of their total scientific production in periodicals classified by the SCI in sub fields other than pharmacology and pharmacy.
Analysis shows that the distribution by institutions, geographical regions, journals, sub fields and research levels. It introduces the normalized journal position as an indicator of the expected impact in each sub fields. And also compares results with those of the production of the Spanish Pharmacologists in the Pharmacology and Pharmacy sub field. It revealed that both areas are increasing trends in productivity, irregular geographical distribution with three regions as major producers and a university as the main productive institution. The extra pharmacology area is characterized by irregular growth of publications, high dispersion of publications in journals and subfields, high collaboration rate and a low percentage of authors characterize the extra pharmacology area with at least 1 paper per year. The study analyses the cross disciplinary research of Spanish pharmacologists by journals of publication covering neurosciences, biochemistry and molecular biology and physiology.

Gupta (1992)\textsuperscript{83} carried out a study based on a cumulative index of geophysics for the two most important journals Geophysics and Geophysical prospecting in the field of exploration Geophysics for the period 1936-1985. Author productivity trends were tested for the application of Lotka’s law by applying K-S statistical test. It is revealed the Lotka’s law did not apply as inverse square law but could apply satisfactorily with exponent value of 2.1 on author productivity distribution patterns of both the fields.
Singh and Arunachalam (1991) provide the result of an analysis of bibliographic data on 430-journal article on liquid crystals (LC) covered in physics Abstracts 1976 and the 4729 citations. It identifies the geographic origin, the prominent institutions, language and journal-wise distribution of the highly cited papers unlike most other high tech areas of physics, in LC research the difference in performance between the USA and the other lending countries is not very pronounced. Publication date from 1976, 78 and 85 reveal that liquid crystals literature is on the rise and that the percentage share of the Soviet Union is rising fast and that of the USA is on the decline.

Garland (1991) examines the nature of the literature produced by a random sample of faculty in American Library Association accredited schools of library and information science over the period 1980-84. 5 questions regarding publication pattern were addressed. Publication data were collected from several databases-LISA, ERIC, OCLC and Library literature. Scholarly publications accounted for 39.3% of the sampled faculty publication. A significant relationship was found to exist between writing scholarly and non-scholarly publication. None of the 15 variables found to predict scholarly productivity in at least one previous study predicted non-scholarly productivity in this sample.

Nederhof and others (1989) examine the scientific performance of cum laude and non-cum laude degree holders in chemistry, from 5 years before their graduation to 4 years afterwards by using bibliometric
indicators. It is found that papers of cum laudes were cited more frequently than those of non-cum laudes from 3 year before graduation until 1 year after graduation. 2-3 years after the graduation, the short-term impact per paper was no longer significantly different for both groups. A similar pattern was found with regard to productivity. The results support the concurrent validity of bibliometric indicators with per view indicators of quality of the research project.

Subramanyam (1984)\textsuperscript{87} focuses on the relationship between research productivity of computer scientists and the breadth of research interest. A random sample of 419 authors was drawn from 4-year cumulative author index of computer and control abstracts. A moderately strong positive correlation was found between the number of papers published by each author and number of sub fields of computer science in which these papers were published. Research productivity and breadth of research interest of computer scientists appear to be directly related.

2.7 Factors of Productivity

Yesan and Ally Sornam (2001)\textsuperscript{88} highlights the factors affecting the scholarly publications by the teaching faculty of the REC, Trichy. The study has revealed the difference in productivity between male and female faculty and reports that the female faculty member's productivity is very low. Lack of finance and lack of time are cited as major barriers to publication. These could be removed to a maximum extend by providing financial assistance, etc., to motivate their publication skill. Another factor
to motivate the publication is the role of library and its services. The article concludes with the suggestion that the study if extended to other disciplines would yield fruitful answers to many questions in the field of productivity.

Babu and Singh (1999) report an investigation to discover the determinants of the productivity of scientists. 80 variables were selected for the use of the Q-sort technique. Data was collected mainly through questionnaires and personal interviews. On the basis of Q-sorted data, 26 variables were selected for further analysis and they were subjected to principal components factor analysis. The result indicated 11 factors affecting research productivity of scientists: persistence, resource adequacy, access to literature, initiative intelligence, evaluating, learning capability, stimulative leadership, concern for advancement, external orientation and professional commitment.

Leta and others (1998) in their article discusses the relation between human resources and scientific productivity in Brazil. The study revealed that the number of Brazilian scientific publications increased from 0.29 percent to 0.56 percent of the World Wide during the 1981-1993 periods. There was a decrease in funds allocated to most scientific activities, except for those allocated to the training of new scientists. The number of research fellowships and scientific publications are increased by the same ratio during the period. The data presented indicate that even in a period of economic crisis, a selective investment of funds in human
resources may lead to an increase in the scientific productivity of a country in all scientific fields.

Hemelin and Gustafsson (1996)\textsuperscript{91} report the result of a study using a questionnaire survey to explain the main factors influencing research production in the arts and humanities. It focuses on factors important for the individual researcher as reflected in the number of PhDs and papers produced states the characteristics of the questionnaire, and discusses how the ratings given in these were analyzed. Given an account of the main results of the survey and analysis, and presents a number of conclusions based on the study. Also suggests few more areas for further study.

Prepie (1996)\textsuperscript{92} provides the findings of a questionnaire study of 385 eminent Croatian scientists that examined the quality, pattern and factors of their scientific production in 4 different fields. The findings confirm that contextual influences are greater within this elite group that within the whole research population, notary that the respondent’s scientific productivity none clearly shows the pattern typical for their fields. Also discusses the significance of linguistic and scientific qualifications, and involvement in international scientific activity.

The subject of study conducted by Edem (1994)\textsuperscript{93} reports the results of a study to determine the influence of academic qualifications on the publication output. The study based on a sample of 202 librarians in 24 Nigerian Universities, from 1985 to 1993. The result indicates that
librarian's academic qualifications have positive influences on the quantity of publications produced. Other factors include; inadequate funding; high inflation rate; poor working and living conditions; lack of motivation and current information materials and lack of time and interest for research. It recommends that librarians obtain higher degree to enhance high publication productivity.

2.8 Research Collaboration

Scientific Research is becoming an increasingly collaborative endeavor. The nature and attitude of collaboration vary from different disciplines. Several public policies actively encouraged scientific collaboration at different levels especially individual, Department and institutional levels. So many studies were conducted to examine the impact of collaboration and collaboration patterns to scientific productivity.

2.8.1. International Scientific Collaboration

Glanzel (1999) and others in their article "a bibliometric analysis of international scientific cooperation of the European Union (1985-1995)" analysed the scientific cooperation of the EU countries with other developed regions. The study shows that international scientific collaboration is particularly advantageous for less advanced countries. Moreover highly industrialized countries are also getting benefit out of international scientific collaboration.
Gomez and others (1995) studied the institutional scientific collaboration of Latin American countries amongst themselves, with the USA and with the European Union during the period 1991-1995. In the paper presented at the 5th International Conference on Science and Technology indicators, Hinxton (Cambridge) UK, 4-6 June 1998, show some special characteristics of multi regional cooperation networks.

Melin (1999) examined the scientific size and amount of international research collaboration. It presents a study in which the collaboration patterns of 49 Universities were analyzed and made a comparison between the northern Universities were analyzed and made a comparison between the northern universities and American universities. The study revealed that the American universities have more national and less international collaboration than the European ones. And also report that the European Universities there is no impact of national size although the countries differ much in scientific size.

Van Raam (1998) reported the result of a study to know the influence of international collaboration on the impact of research results. An extensive bibliometric study of astronomical research in the Netherlands proved that higher rates of self citation in international collaboration do not play any significant role as impact amplifier.

presenting Chilean affiliation. Analysed the number of papers on physics published between 1987 and 1994 with at least one author presenting Chilean affiliation. Analysed the number of papers, cumulative Impact factor, average impact factor, international co-authorship, most visited journal, and main Chilian institutions. The study shows the physics is growing in Chille with international collaboration playing an important role. Most of the research is done by institutions in Santiago but other emerging institutions are also identified.

De Lange and Glanzel (1997) have attempted to develop a model to measure and analyse the multilateral international co-authorship links. A new indicator, the multilateral collaboration index, is introduced and analysed as a function of the share of internationally co-authored papers.

Haiqui and Hong (1997) presented a study whose purpose is to analyse the characteristics of scientific research collaborations in China by bibliometric indicators, collaborative index, degree of collaboration and level of collaboration, based on the articles published in 1218 titles of Chinese scientific and technical periodicals in 1993. The results suggest that the current trend of collaboration among multi authors and multi institutions for producing scientific articles may have reflected the multi dimensional science of China.

Harande (1997) conducted a comparative study of author collaboration in seed science literature among Nigeria, India, Australia, UK and US. The results shows that both the annual and accumulated rates
for each country were generally high, although UK and US figures were higher than the 3 other countries. It also indicates that seed science literature is dominated by multi-authored papers and there is a trend towards collaboration in countries studied.

Uzum (1996)\textsuperscript{102} analysed the publications of physicists from Egypt, Iraq, Iran, Jordan, Saudi Arabia, Syria and Turkey in international journals during the period 1990-1994. The results show that 75\% percent of the total output came from Egypt and Turkey. The highest concentration of papers in a few journals was found in Egypt. Condensed matter physics was found to be the most active subject. A change in publication patterns towards increased collaboration and decreasing isolation.

Braum and Glazel (1996)\textsuperscript{103} conducted a survey to examine the changes in the co-authorships patterns of scientists and researchers in Bulgaria, then Czechoslovakia, Hungary, Poland and Romania for the periods 1981-1984 and 1985-1993, using data from the science citation index. The study throws light on changes in international scientific collaboration is caused by political and economic changes in these countries. It discussed different patterns of change in these countries, particularly between Poland and Hungary and others.

Russel (1995)\textsuperscript{104} in his article "the increasing role of international cooperation in science and technology research in Mexico" presented an analysis of the studies published by Mexican institutions in co-authorship with foreign colleagues between 1980 and 1990. It described different
characteristics of the collaboration, such as research areas, countries and institutions involved.

Alami (1992)\textsuperscript{105} and others opined through their article 'International scientific collaboration in Arab countries are concentrated on engineering and technology and applied biology. Finding shows that cultural and historical traditions play an important role in collaboration.

2.8.2. Authorship pattern

Bird (1997)\textsuperscript{106} bring out the results of an authorship study on physics and economics show that with the passage of time there has been an increase in the number of authors per paper, which indicates a trend towards more collaboration.

Sen (1997)\textsuperscript{107} discussed the results of a bibliometric study conducted to investigate the phenomenon of mega authorship which means the constitution of 10 or more authors. The study was carried on a sample of 1924 articles published in the proceedings of the National Academy of science of the USA during February July 1996. The result showed that about 5 percent of the papers fall in to the category of mega authorship. He attempted to identity the causes of mega authorship and discussed its impact on author indexes, indexing services, citations and problem, of identifying the principal author.

The study conducted by Arora and Pawas (1995)\textsuperscript{108} deals with the collaboration research activities in the field of immunology. Analysing the
authorship pattern they report that, there is a corresponding increase in multi authorship and collaboration between researchers is an indication of growing professionalism in different fields of science.

Gupta (1993)\textsuperscript{109} observed that like in any other discipline in the science, collaboration in exploration geophysics research has also been increasing. The study was based on comprehensive database, the cumulative index of geophysics for the period 1936-1985.

Maheswarappa and Savadetti (1990)\textsuperscript{110} reported the results of an investigative study of the authorship pattern and collaborative research in the field of plant breeding, based on data collected from plant breeding. Abstracts for the years 1934 to 1989. The result shown an increase in the degree of collaboration in research into plant breeding.

Richar Hart (1990)\textsuperscript{111} and others discussed various authorship characteristics of library information science periodical articles. They made a comparison between the characteristics of authors of the population of articles that were not supported by finding. Findings reveal that the authors of funded research are more likely to collaborate with other authors.

Begum and Rajendra (1990)\textsuperscript{112} analysed the Indian zoological science literature for the years 1975 to 1984 to study the authorship patterns and collaborative research trends. They reported that the single author papers accounted for 33 percent and the proportion of papers with
2 more authors is 67 percent clearly indicating the trend of multiple authorship in the field.

Maheswarappa and Mathias (1987) explained the trends in authorship patterns and the research collaboration as indicated by the multi-authored papers in different disciplines of applied sciences in India based on data collected from the Indian Science Abstracts (1965-1983). The study found that 2 authored papers were the maximum in applied science in general and agricultural and chemical technology in particular. Single authored papers are maximum in engineering. There is an increasing trend towards collaboration in all discipline.

2. 9 Age and productivity

Dizon and Sadorra (1995) in their article published in scientometrics, measured the scientific productivity of BS, MS, and Ph.D degree holders of the staff working at the International centre for Living Aquatic Resources Management, a research organisation based in Philippines. All authored and edited items produced by these staff from 1978 to 1993 were considered, and weights assigned depending on document type, number of pages, and rank of the name in cases of multiple authorship or editorship. The staff's output of conference papers and technical reports outweighed contributions to the primary (journal) literature. Predictors of productivity were position/salary, education and age. However, the study revealed that individual factors are largely determined productivity.
Romanov and Terekhov (1995) explained an approach to the dynamic optimization of the age structure of scientific personal in an organization. The study formulates the appropriate mathematical model describing the age rotation of scientific workers and introduces the criterion for maximizing the integral productivity of scientific personnel over a given time horizon. The article demonstrates the practical application of the suggested approach by means of a real example.

Edem and Atirmo (1995) reported the results of a questionnaire survey of a random sample of 278 librarians working in 22 out of the 35 university libraries in Nigeria to determine the influence of age and work experience on publication output. The study indicates that librarian's age and work experience have a positive influence on their publication output.

Stephen and Levin (1993) examined the relationship between age and productivity of Nobel prize winners in science during the period 1901-1992. He reported that, although it does not require extraordinary youth to do prize winning work, the odds decrease markedly in mid life and fall off precipitously after the age of 50 particularly in chemistry and physics.

Cohn (1991) opined that the output of a scientific or technical research group is directly proportional to its size. According to him there is no reliable evidence for the existence of a size or a range of sizes for a research group that maximises output per unit of size. It present theoretical explanations for the proportionality between size and output are
largely inadequate or untested. Among reported results on group, age and output, the only consistency so far is that age is uncorrelated with output per capita. There is no evidence for the existence of an age or a range of ages for a research group that is optimal.

The subject of study of Van Heeringen (1987)\textsuperscript{119} and others are to examine to what extent the productivity of researchers is influenced by their mobility. Based on empirical data of Dutch scientists it is shown that job mobility is a characteristic of productive scientists rather than a means to enhance productivity.

Diamond (1987)\textsuperscript{120} presented the result of a study which implies that a scientist's productivity will eventually decline with age. This implication is at variance with some previous findings but corresponds with others.

Watson (1987)\textsuperscript{121} conducted a study of the publication output of librarians at 10 large university libraries in order to suggest norms of productivity for the profession. Relation between productivity and age, professional maturity, educational background and position held were integrated. Publication outlets were examined and suggested ways to improve the publications.

2.10 Conclusion

A number of quantitative studies based on scientometric techniques have been reported to evaluate the research productivity of individuals,
Departments, Institutions, countries etc. Studies are also available to verify the fitness of classic laws of bibliometrics, factors of productivity and impact of research conducted in various countries. These studies are very much helpful to assess the development of science as well as in their application to library and information resource management also.

The growth of literature in scientometrics or bibliometrics shows that it has been accepted as a major research area in library and information field because it enables to identify the research performance, growth of science and it helps to formulate science policy.
REFERENCES


