Chapter 2

Review of literature

Review of literature or Literature Search involves review of literature on the problem under study. It helps in understanding problem clearly and knowing what has already been done on the area under study including allied area. It helps in refining the ideas, specification of research procedure, clarity and understanding of things to be done. For reviewing of literature primary sources such as periodicals, reports, theses etc and secondary sources abstracts and indexes are used.

Harrods Librarian Glossary (2005) “An exhaustive search from published information on a subject conducted systematically using all available bibliography finding tools, aimed at locating as much existing material on the topic as possible, an important initial step in any serious research project”.

2.1 Research

Research is a careful study of a subject especially in order to discover new facts or information about it. An efficient and effective approach to expand knowledge is to conduct a special, planned and structured investigation, which is known as the process of research. Research is considered as an important function of university together with teaching and community service. Research is a human activity based on intellectual investigation discovering and revising human knowledge on different aspects of the world. This research provides scientific information and theories for the explanation of the nature and the properties of humans. Research is a scientific undertaking, which by means of logical and systemized methods aims to discover new facts or verify old facts and to their sequences, interrelationship, casual explanation and the natural laws that govern them. Research is an intellectual act that starts with the asking of a question and progress through the critical and analytical study of evidence, and arrives at new conclusion or new knowledge.

Webster’s International Dictionary (1986) defines research “As studious enquiry or examination, especially critical and exhaustive investigation, or experimentation having for its aim the discovery new facts and their correct interpretation, the revision of accepted conclusions theories or laws in the light of newly discovered facts, or practical application of new or revised conclusions, theories or laws.”

With regard to the value or importance of research Meek and Lee (2005) mentioned that the relevance of the research problems is of utmost concern. Problems that exist at the time of the research and that are expected to occur in the future. Universities are expected to provide research that is nationally significant. Importance
of research would include the extent to which the research meets an identified need. So even though a piece of research may not meet an identified need at present, it might be critical in the longer term.

2.2 Productivity

Zamarripa (1993) stated that productivity is used in different connotations in different fields such as in manufacturing productivity involves quantity of products manufactured. The total number of products manufactured in a period can be known as the productivity level. In a service industry productivity can be measured by the number of existing and new customer’s turnovers. In sales productivity measures the sales performance of an employee or the entire company.

Print and Hattie (1997) Research productivity can be defined as the totality of research performed by academics in universities and related contexts within a given time period. Research performance indicators can then be devised to measure the performance and to provide a basis for making judgments about research quality.

Organization for Economic and Cooperation Development (2001) According to OECD the main objectives of productivity measurement includes:

Technology: A frequently stated objective of measuring productivity growth is to trace technical change which may be in documented form of new blueprints, scientific results, new organizational techniques or development of new products.

Efficiency: Productivity measurement concerns the industry level, efficiency gains can either be due to improved efficiency in individual establishments that make up the industry or to a shift of production towards more efficient establishments.

Real cost savings: A pragmatic way to describe the essence of measured productivity change. In this sense, productivity measurement in practice could be seen as a quest to identify real cost savings in production.

Benchmarking production processes: In the field of business economics, comparisons of productivity measures for specific production processes can help to identify inefficiencies. Typically, the relevant productivity measures are expressed in physical units (e.g. cars per day, passenger-miles per person) and highly specific.

Living standards: Measurement of productivity is a key element towards assessing standards of living. A simple example is per capita income, probably the most common measure of living standards: income per
person in an economy varies directly with one measure of labour productivity and value added per hour worked.

Hornby (2010) wrote that the rate at which a worker, a company or a country produces goods and the amount produced, compared with how much time, work and money is needed to produce them. A productivity measurement is the only yardstick that can actually gauge the competence of management and allow comparison between the managements of different units within the enterprise, and of different enterprises.

Oxford Advance Learners Dictionary (2010) The rate at which a worker, a company, or a country produces goods and the amount produced compared with how much time, work and money is needed to produce them.

Broadly, productivity measures can be classified as single factor productivity measures (relating a measure of output to a single measure of input) or multifactor productivity measures (relating a measure of output to a bundle of inputs). The choice between them depends on the purpose of productivity measurement and in many instances on the availability of data.

2.3 Academic Research Productivity (ARP)

In academics, productivity is outcome in terms of students, trained researchers, scientific and technological advances, publications, consultancy for public and private organizations and community service of various kinds in a time frame. Research productivity can be defined as the totality of research performed by academics in universities and related contexts within a given time period. The different components of research productivity are given in the Fig. 2.1. Research performance indicators can then be devised to measure that performance and to provide a basis for making judgments about research quality.
(Tafreshi, Heidari Imani and Ghashlag (2013)  This study is an applied-mixed one which aims to evaluate research productivity of Faculty of district 2 of Islamic Azad University. Present study was conducted in two qualitative and quantitative parts. In qualitative part of study, researcher used Delphi method to converge opinions of experts and in quantitative part, correlation and advanced multi-variable analyses (exploratory factor analysis, confirmatory factor analysis and structural equation model) were used for data analysis. In ranking organizational factors, motivation obtained the first rank and employees and colleagues' attitudes had the least importance. Another important tangible outcome is the satisfaction of the people who work in universities, on whom the quality and quantity of research, service and scholarship finally depends. They suggested peer review process to evaluate the academic productivity. Also results of exploratory factor analysis and confirmatory factor analysis showed that individual factors can be divided in to three groups: (1) job satisfaction, (2) learning and teaching process and (3) specialized job ability. Also organizational factors divided into six groups: (1) organizational support, (2) organizational culture, (3) organizational purpose (4) motivational factors, (5) students characteristics and (6) industrial relationship.
2.4 Previous Studies on Research Productivity

Various studies have done from time to time to study the factors that impact research productivity such as Finkelstein suggested seven critical variables: Faculty researchers having a research orientation, the highest terminal degree within a field, early publication habits, previous publication activity, communication with disciplinary colleagues, subscriptions to a large number of journals, and sufficient time allocated to research.

Ramsden (1994) This article describes results from a study of academic productivity in Australian higher education. It estimates the output (in terms of quantity of publications) of individuals and academic Departments across the different subject areas and types of institution. Several potential correlates of productivity, including level of research activity, subject area, institution, gender, age, early interest in research, and satisfaction with the promotion system, reexamined. A model linking Departmental context to personal research performance through Departmental and personal research activity is developed and tested. An index of research productivity is defined as the five year sum of (3*number of single or multi author books)+(number of papers in referred journals)+(number of edited books)+number of chapters in referred books).

Dundar (1998) in his study mentioned about the various studies done by scholars to find the various component of academic research productivity which he classified in three broad attributes and they are Individual Attributes that consists of gender, age, experience, personality, training, freedom at workplace, Departmental and Institutional Attributes that consists of Faculty and organization size, quality researchers, equipment, supplies, institutional and travel funds, library collections, etc

Bland etal. (2002) model suggested that Faculty research productivity is highest when a Faculty member has specific individual qualities, works in an institution that is highly conducive to research, and is led by someone who possesses essential leadership qualities and uses an assertive-participatory management approach. Exploring the relationship between inputs and outputs of research is a straightforward way of measuring research productivity. A combination of cost-benefit analysis and evaluation of research results has therefore been used by several scholars. A social-scientific approach is used to address the question of the impact of knowledge management on research productivity instead of directly measuring knowledge productivity of research groups by a comparison of inputs and outputs.

Toutkoushian (2003) Here it is shown how readily available data on publication from the ISI may be used to estimate the number of scholarly articles written by and institution’s Faculty member. A standard measure of
research output is calculated by dividing total publication by the number of fulltime Faculty Members at the institution. The articles with one or more authors of the institution are identified.

Bland et al (2005) One of the best works in measuring research productivity was done by Bland et al. Here the authors summarized the previous research productivity model of earlier scholars very succinctly and presented his model. Creswell’ model suggested successful researchers with senior professorial rank, spend at least one-third of their time on research activities, publish early in their careers, receive positive feedback from peers, have close contact with colleagues, Faculty researchers are more productive when they are employed in a major University that rewards research and assigns ample time for Faculty to conduct research. They mentioned that Dundar and Lewis proposed a model in which Faculty research productivity is primarily associated with two attributes: firstly individual attributes that relate to personal traits and environmental experiences and secondly institutional and departmental attributes that entail variables related to leadership, culture, structure, and policies. They mentioned that Teodorescu’s model asserted that individual achievement variables and institutional characteristic variables would predict Faculty research productivity across national boundaries. They mentioned that Brocato proposed that Faculty research productivity in the context of medical school family practice departments is related primarily to factors such as socialization, individual Faculty’s psychological demographic characteristics, institutional and departmental research environments.

They found that individual Faculty’s characteristics such as motivation, professional networks, research training, were highly correlated to research productivity. To explain individual and group (Department) research productivity within the context of a large medical school. This study used data from a University of Minnesota Medical School—Twin Cities vitality survey conducted in 2000 that had a response rate of 76% ($n = 465$ Faculty). A statistical software package was used to conduct $t$ tests, logistic regressions, and multiple regressions on these data. The validity of Faculty, Department, and leadership characteristics identified in the Bland et al. model were confirmed as necessary for high levels of research productivity. Faculty productivity was influenced more by individual and institutional characteristics and proposed the following model for research productivity as mentioned in Fig 2.2 below.
Fig. 2.2 Bland’s Research Productivity Model

Wang, Peters and Guan (2006) The goal of the paper is to identify factors that contribute to high knowledge productivity based on the findings of a study of German research group. A total of 15 in-depth face-to-face interviews with heads of German academic research groups in the field of physics were conducted. The questions referred to the current practices of knowledge creation and knowledge management and to the subjective assessments of these practices. The study identified human resource management as the weakness
of the German knowledge management practice. There seems to be an inherent contradiction between the goals of attracting promising students to a career in science and securing mobility.

Bland et al. (2005) In the model, Faculty research productivity is highest when a Faculty member has specific individual qualities, works in an institution that is highly conducive to research, and is led by someone who possesses essential leadership qualities and uses an assertive–participatory management approach. Exploring the relationship between inputs and outputs of research is a straightforward way of measuring research productivity. A combination of cost-benefit analysis and evaluation of research results has therefore been used by several scholars. A social-scientific approach is used to address the question of the impact of knowledge management on research productivity instead of directly measuring knowledge productivity of research groups by a comparison of inputs and outputs.

Moed (2006) The study presented in this paper provides a series of bibliometric indicators of the research performance of universities, derived from the Web of Science, published by Thomson Scientific. Papers were selected with the name of a University (and its major Departments) mentioned explicitly in the address. Name variations were taken into account. Additional papers were selected from affiliated, teaching hospitals on the basis of an author analysis. This round added to a particular University’s article output selected in the first round papers from affiliated hospitals, published by authors who did not explicitly mention this University’s name in their institutional affiliation, but who showed strong collaboration links with that University, as its name appeared in the address lists of at least half of their papers. The first and most important one is the set of universities that published more than 5,000 articles in WOS journals during 1997–2004, or on average more than 625 papers per year during this time period. The first indicator, denoted as article output, disciplinary specialisation Index, Normalised citation impact (also denoted as citation impact per paper), % Internationally co-authored articles and the % Articles with private sector.

Qiu, Ma and Cheng (2008) In this paper a new method – Paper Quality Index (PQI) to evaluate the output of a researcher is developed. The main purpose of our method is to solve two problems that consist in the method of h-index: one is that the h-index can’t compare the outputs of researchers in different fields; the other is that it is unsuitable for evaluating the outputs of young researchers. On the basis of the thoughts, we advance a method named “paper quality index” (PQI). Its mathematical expression is given below:

\[
PQI_{ij} = \frac{IF \times TC}{IF_m \times TC_m}
\]

In this mathematical expression, “i” stands for a paper. “j” stands for the publication year of the paper i. “m” stands for the field to which the paper i belongs. IF stands for the impact factor of the journal in which paper i published. IF stands for the journal’s average IF in recent three years. IFm stands for the impact factor of
the field $m$. $IFm$ stands for the average $IFm$ in recent three years. $TC$ stands for the total number of citations of the paper after its publication. $TCm$ stands for the total citations of the articles published in the year $j$ in the field $m$. $TCm$ stands for the average citations of per paper published in the year $j$ in the field $m$. The calculation is the total number of citations to the articles published in the year $j$ in the field $m$ / number of papers published in the year $j$ in the field $m$. The citations in 2007 was taken out because the JCR has not supplied the corresponding data.

Tatavarti, Sridevi and Kothari (2010) For the determination of research output and quality a new metric called as Research Turnover (RT) is defined to indicate the research value of the University. RT which may be assessed based on an empirical relation is proposed in this paper by considering the following parameters and criteria.

- Number and quality of publications in peer-reviewed and refereed journals
- Number of patents filed/published in national and international patent offices
- Number of sponsored research projects procured for the University
- Number of consultancy projects completed and revenue generated for the University
- Number of books published
- Number of Ph Ds supervised

$$RT = RT_{pt} + RT_{pt} + RT_{sr} + RT_{cp} + RT_{bk} + RT_{ph}.$$ 

RTpt is the research turnover with respect to patents, RTcp is the research turnover with respect to consultancy Projects, RTph is the research turnover with respect to Ph Ds supervised, RTpb is the RT with respect to refereed paper publications. The computed RT value will give a comprehensive metric for determining the quality of research. The higher the RT value, better the research quality.

Abramo (2011) mentioned about an assessment system which is designed to evaluate research and development carried out by public research organizations, including both universities and research organizations. Here universities were asked to submit research outputs to the panels, outputs acceptable were limited to articles, books, and book chapters; proceedings of national and international congresses; patents and designs; performances, exhibitions and art works. Thus the model was designed as an ex-post evaluation exercise focused on the best outputs produced by Italian research Institutions.

Duffy et al (2011) In his study he mentioned about the various studies about the research productivity assessment like author-weighted publication formula, individual productivity measurements from the publicly available data. The research productivity of academic psychologists: assessment, trends, and best practice recommendations.
Dominigo (2011) To evaluate the performance of whole University systems by Shanghai Jiao Tong Academic Ranking of World Universities the author dealt with system aggregates by means of averaging scores taken over a number of Institutions from each higher education system according to the Gross Domestic Product of its country. He treats the set of indicators (measures) at the country level as a scale, and investigates its reliability and dimensionality using appropriate statistical tools. After a Principal Component Analysis is performed, a clear picture emerges: at the aggregate level ARWU seems to be a very reliable one-dimensional scale, with a first component that explains more than 72% of the variance of the sample under analysis. The percentages of variance of the indicators explained by the first component do shed light on the fact that ARWU is in fact measuring the research quality (both at the individual and collective levels) of a University system. The indicators used are:

Individual indicators

1. Alumni Total number of graduates from an institution winning Nobel Prizes in the sciences or Fields Medals in Mathematics.
2. Award Total number of the staff working at an institution at the time of winning Nobel prizes in the sciences, or Fields Medals in Mathematics.
3. HiCi Total number of highly cited researchers in broad subject categories found at the web site of the Institute of Scientific Information.

Collective indicators

1. N&S Total number of articles published in Science and Nature in the past five years.
2. PUB Total number of articles indexed by Science Citation Index-Expanded and Social Science Citation Index in the previous year.
3. PCP Total scores of the previous five indicators divided by the number of full-time equivalent academic staff.

The ARWU ranking data thus rely on the history of universities in the past and current centuries (indicators Alumni and Award), in the last ten to twenty years, reflected in the number of Highly Cited Authors, and in the previous five years, as measured by the indicator N&S. It also measures the current performance in quantity of publications by means of the indicator PUB.

Wang, et. al (2011) This study reports research on analyzing the impact of government funding on research output. 500,807 SCI papers published in 2009 in 10 countries are collected and analyzed. The results show that, in China, 70.34% of SCI papers are supported by some research funding, among which 89.57% are supported by National Natural Science Foundation of China (NSFC). Average grants per funding-supported paper in China is 2.95, when in the USA the number is 2.93 and in Japan it is 2.40. The results of funding agency analysis show that, China, Germany and Spain are single funding agency dominated countries, while
USA, Japan, Canada and Australia are double funding agencies dominated countries and the source of funding in UK, France and Italy is diversified.

Abrizah and Wee (2011) There study is based on 1662 computer science researchers and focused on the research productivity of universities of Malaysia. Bibliometric methods are employed to conduct the research during the period 2000-2010 and the field includes journals, conference proceedings, lecture notes. In the 11 year period 903 records were noted. Time series analysis of Institutional productivity based on the publications counts of 5 sub domains of computer science was analysed.

Kumar and Dora (2012) This study measured the research output of IIMA in the 12 years (1999-2010). To review the impact of research in terms of published papers, Web of Science from Thompson Reuters and Scopus from Elsevier were used. The study revealed that IIMA has 172 publications in Web of Science and 284 in Scopus. The results were tabulated in MS Excel and the duplicates (138) were removed from 456. The final list included 318 unique entries for IIMA from both Web of Science and Scopus.

Ranasingh (2012) This study is based on the Sri Lanka publication data, retrieved from Sciverse Scopus database for 10 years from 01/01/2000 to 31/12/2009. Conference Proceedings books, trade publications and book series are excluded. Articles identified are classified according to subject area life and health sciences.

Matthews (2013) Publication productivity during 2009–2011 was studied for physicists who teach in South African universities, using data from Departmental websites and Thomson Reuters’ Web of Science. The objective was to find typical ranges of two measures of individual productivity: number of papers and sum of author share, where author share per n-author paper is 1/n author units. The lowest 10% did not publish, and the top 10% produced above four papers and above 1 AU. Productivity varied with rank, ranging from medians of 0.67 papers and 0.2 AU for lecturers to 1.67 papers and 0.4 AU for full professors.

Choudhry (2013) Here the research publications in the field of Veterinary Animal Sciences by Indian researchers was downloaded from VETCD-COMS and 2000-2006 tabulated through MS EXCEL. Articles are broadly classified in two disciplines and various subjects are included in the disciplines. Data is computed to record and analyze the number of publication discipline-wise and subject wise for each of 7 years (2000-06). Two core journals are selected to study the pattern of articles. Subject wise article productivity and geographical distribution by the author and institutes are noted.

Chen, Hu and Yang (2013) This paper aims to compare R&D productivity change across countries by providing the empirical evidence: First, although existing studies have measured R&D productivity change at the firm and industry level. Secondly utilizing the concepts of directional distance function, this study develops the Luenberger R&D productivity change index (LRC) to addresses the estimating methodology
and describes the dataset. They follow the concept of Luenberger productivity index to construct the R&D productivity change and decompose it into efficiency change and technical change. Utilizing a panel dataset of 29 countries over the 1998–2005 period to implement the empirical estimation, the results show that the R&D productivity growth is mainly attributed to the innovation effect.

Vinluan (2012) used objective assessment using bibliometric indicators or research productivity in Education and Psychology in Philippines using the journal article as unit of analysis at the individual, institutional and national levels using the SSCI data and ISI Web of Knowledge citation database service of Thomson Reuters for a period of 1966 to 2009.

Lehman (2008) Here authors employ Bayesian statistics to analyze several different indicators of scientific performance. They categorize each author by some tentative indicator based on their total citation record. Once assigned, it can empirically construct the prior distribution, \( p(\_\_\_\) \), that an author is in author bin \( \_\_\_ \) and the probability \( P(N\_\_\_\) \) that an author in bin \( \_\_\_ \) has a total of \( N \) publications. They also construct the conditional probability \( P (i\_\_\_\) \) that a paper written by an author in bin \( \_\_\_ \) will lay in citation bin \( i \). Studies performed on the first 25, first 50 and all papers of authors in a given bin reveal no signs of additional temporal correlations in the lifetime citation distributions of individual authors. They bin papers into \( L \) bins according to the number of citations. The binning of papers is approximately logarithmic.

### 2.5 Indicators for Academic Research Productivity

Various performance indicators which are used for measuring academic research productivity have been mentioned in the literature.

Martin (1996) discussed what the various indicators of basic research measure scientific activity; production and progress; publications; citations; quality; importance; impact of publications and peer evaluation. It provides a measurement for weighing the quantitative performance of a system.

Martin (1996) The indicators should measure scientific activity (scientists and other supporting staff, funding and scientific equipment); production (scientific results from the various input resources); progress (scientific knowledge form various scientific activities); publications (contributions in the form of journal articles institution wise, country wise, subject wise) and Citations (scientific progress by various publications through increased quality, importance and impact of publications).

Print and Hattie (1997) studied the education discipline and mentioned that within the context of higher education Institutions, performance indicators can be used for comparison purposes. Comparison may be over time, within a Department, between Departments within a University, or across universities. There are 14 different indicators used under 3 broad categories and they are research grants, research students and publications.
Toutkoushian et.al (2003) Here it is shown how readily available data, a publication from the ISI may be used to estimate the number of scholarly articles written by an Institutions Faculty. A standard measure of research output is calculated by dividing total publication by the number of fulltime Faculty Members at the institution. The journal article with one or more authors of the institution is identified.

Guan and Wang (2004) They proposed a model to evaluate the efficiency of research groups in the area of information science in PR China. By taking the research groups as Decision Making Units (DMUs), the budget of the projects and size of the groups as inputs and the quantity and quality of publications produced by the groups as outputs of the model, the relative efficiencies of 21 research projects are evaluated. The output indicators, including both quantity and quality of research projects are:

1. Number of papers published in international journals;
2. Number of papers indexed by SCI;
3. Cumulative citation counts minus self-citations of each publication ,
4. Measurement of overall level of all the publications,
5. Average citation counts per paper, citations per paper,
6. Ratio of the number of papers having independent citations to the number of papers indexed by SCI,
7. Percentage cited by others versus uncited and number of papers that received more than 5 citations.

Vaan (2005) in his study found that for the decision regarding matters of scientific activities advanced bibliometric indicators have to be used in parallel to a peer-based evaluation procedure. The major technical and methodological problems in the application of publication and citation data in the context of evaluation and citing-cited matching process are to be reduced.

Meek, Lee and Der (2005) in their work stated the various aspects of indicators such as the indicators should be

1. They are expressed numerically;
2. They relate inputs to outputs (ie they measure efficiency of resource use);
3. They are linked to the overall goals of the organization (i.e. they are concerned with effectiveness in meeting desired outcomes);
4. They allow users to determine how the performance of the individual or organization under study has changed over time and/or how it compares with the performance of other individuals or organizations and
5. They may be used as incentives to influence the activities in socially desired ways.

Overcoming the debate and controversy over performance indicators some holistic approach towards the features of performance indicators are
1. The performance indicators should be objective and clear.

2. The indicators can be presented numerically (ordinal or cardinal) so that at least they can help in decision making.

3. The indicators are mission oriented so as to serve the purpose of institution for which the performance is measured.

4. The indicators should be time bound such that it should measure performance in present context.

Carey (2007) Due to the variability of the sub disciplines of mathematics and statistics only bibliometric data cannot be used to understand the culture of the sub disciplines and it is suggested to use other indicators other than publications. Citations to articles in mathematical sciences are less compared to other sciences eg. A paper may be cited as the result contained therein may be used. The study further suggested that due to time lag impact of the article may be measured over decades rather than years. The study further discussed the various pros and cons of bibliometric indicators used in various rankings of world universities and provided five indicators to measure productivity such as article output, disciplinary specialization index, normalized citation impact, % internationally co-authored articles and % articles with private sector.

Hendrix (2008) The objective of this study was to analyze bibliometric data from ISI, National Institutes of Health (NIH)–funding data and Faculty size information for Association of American Medical Colleges (AAMC) member schools during 1997 to 2007 to assess research productivity and impact. This study gathered and synthesized 10 metrics for almost all AAMC medical schools (n=5123): (1) total number of published articles per medical school, (2) total number of citations to published articles per medical school, (3) average number of citations per article, (4) institutional impact indices, (5) institutional percentages of articles with zero citations, (6) annual average number of Faculty per medical school, (7) total amount of NIH funding per medical school, (8) average amount of NIH grant money awarded per Faculty member, (9) average number of articles per Faculty member and (10) average number of citations per Faculty member. Using principal components analysis, the author calculated the relationships.

Nicolini (2008) In their study assessed the activity of each single scientist and each institution during the time interval (1990–2006) in Science Citation Index the number of publications and their impact factors in international SCI journals were properly ranked properly weighted for their position, number of coauthors and discipline using deciles. The database is a well-known multidisciplinary and multinational index to the journal literature of science and technology. SCISEARCH indexes the contents of 90% of the world’s most
significant scientific and technical literature with 3,322 source issues and 620,000 authored source items. In addition the number of patents registered in various countries and the number of inventions produced by each industry, institution, or country has been obtained using the World Patents Index database of the Derwent Publications, Ltd. of London, through the Dialog Information Services. This database contains about seven million patents, corresponding to over 29 national and international offices. The resulting different indicators utilized in this evaluation are based on the total number of publications differently weighted in relation with the number of co-authors and with the fraction as first author.

Rodrigo (2010) in his work studied the factors that contribute to the assessment of the research performance of scientists (evaluative purposes) as well as the different aspects of their behaviour (descriptive purposes). They believed that the combination of bibliometric indicators and personal data of researchers (i.e., age, tenure, professional status, years of experience, etc.) can provide a rich picture of the performance of scientists from a micro-level perspective.

Franceschini and Maisano (2011) mentioned that bibliometric indicators are the most practicable instrument in case of large-scale evaluations (in opposition to peer review methods) that takes into account two important aspects: overall productivity—generally measured in terms of publications—and overall diffusion/impact—generally measured in terms of received citations. They developed tools to perform qualitative/quantitative evaluations on the regularity of one scientist’s output in a simple and organic way. Input data consist of the distribution of Py values, namely the total number of publications for each year of one researcher’s career and the distribution of Cy values, namely the total number of citations accumulated by the (Py) publications of each year, up to the moment of the analysis.

### 2.6 ARP in Higher Education Institutions in India

India home of more than 1.2 billion population of which 0.672 billion population are in age group 15-64 years. This age group is considered as the “working age population” that provides the necessary invaluable human resource which should be engrossed, attached and nurtured with skills so that they can live a purposeful life and contribute to nations development. There has been a tremendous improvement in the number of foreign R&D Centers and universities in India. Most of these R&D centers relate to Information and Communication Technologies (ICTs), automobile and pharmaceutical industries.

Adams, King and Singh (2009) As per Global Innovation Index, India was placed at 54th rank in 2008. India has become the world’s largest exporter of IT services since 2005 and exports of aerospace products have been increasing at a rate of 74% per year. In higher education government is seeking to raise the gross
enrolment ratio from 11% in 2007 to about 15% by 2012 and 21% by 2017. One-quarter of the student body is now enrolled in Science & Technology fields.

Department of Science & Technology R&D Report (2011-12). India’s per capita R&D expenditure has increased to Rs. 451/- (US$ 9.5) in 2009-10 from Rs. 217/- (US$ 4.8) in 2004-05. Gross Expenditure on R&D (GERD) in Higher Education is 4.1%. Academic sector received 64% of the total extramural R&D support during the year 2009-10. Out of the total 16,093 Doctorates in the country, 8,302 (51.6%) Doctorates were from the S&T discipline during 2010-11. India spent 0.87% of its GDP on R&D in 2009-10 whereas the developed countries spent more than 2% of their Gross Domestic Product (GDP) on R&D.

India’s scientific publication output has shown a rising trend during the last decade. In 2010 as per the SCOPUS database, research output was 65,487 and 40,711 as per the SCI database. During 2010-11 a total of 39,400 patents were filed in India. Out of which 8,312 (21.1%) patents were filed by Indians. Patent applications filed in India are dominated by Computer/Electronics, Mechanical and Chemical fields. Indian publications are on a steep rise India’s publication record will be on par with most G8 nations within 7–8 years. India could even overtake them between 2015 and 2020. The most recent data confirms that India’s strength truly lies in the basic sciences such as chemistry, physics, pharmacology and toxicology. India is self-sufficient in food grain production; we have space program that has enabled satellite launches and a moon mission; we have atomic energy program; we have developed indigenous technology for missiles and aircraft; we do exports in biotechnology, pharmaceuticals, and information-technology services. But India lags behind in research investment and output when compared with other countries. In this direction government has made efforts by creating facilities such as the 5 Indian Institutes of Science Education and Research at Pune, Kolkata, Bhopal, Mohali and Thiruvananthapuram dedicated to the international standards of scientific research and science education.

2.7 Bibliometrics: a Tool to Study RP

The term ‘Bibliometrics’ was first coined by Alan Pritchard in 1969. He defined it as the application of mathematical and statistical methods to books and other media of communication. Earlier it was known as ‘Statistical Bibliography’ by Hulme in 1923, ‘Librametry’ by S.R. Ranganathan in 1948. The later terms are ‘Scientometrics’, ‘Informetrics’ and ‘Webometrics’.

Scientometrics is the application of complex mathematical and statistical methods used to analyse the quantitative characteristics of science as an enterprise. Informetrics is the application of mathematical and statistical methods to investigate scientific and technical information. The information may in the form of
Print, NonPrint or in Electronic Form. Finally Webometrics is application of all mathematical and statistical methods to analyze the WebPages of the Web.

Bibliometrics is the quantitative evaluation of publication and citation data and it is used for the objective research performance evaluation. It is used by University and government labs, policymakers, research directors, administrators, information specialists, librarians and researchers. Using citation bibliometrics, University can assess the performance of its research units, gauge its contribution to the creation of knowledge and technology and make decisions based on objective and quantitative data.

Vaan (2005) mentioned that bibliometric indicators can be used to support peer review process for objective and transparent evaluation purpose. This can be done by reducing the technical and methodological errors associated with bibliometrics. The technical problems are 1) mismatch of cited and citing publications 2) Variations and errors in author names especially when publications are written by many authors, authors from non-English speaking countries 3) Errors in journal volume numbers, errors in initial page numbers, dual volume-numbering systems or combined volumes. 4) Missing names of University as only a section or Department are mentioned . eg in case of medical research the hospital’s name is mentioned and the University name is not indicated. The Methodological problems are 1) ISI database coverage is low in the disciplines of Engineering, Social and Behaviour science and Humanities. 2) Only the core journals of selected disciplines are covered. Many other forms of communications are not covered. 3) The authors and journals from US are given a preference.

Thomson Reuters (2008) In the report Eugene Garfield’s mentioned that bibliometric data is used for a number of purposes, that a University must have for evaluating its research performance. Each purpose calls for particular kinds of information such as citation metrics can help to answer important questions of University’s research performance, competitiveness, forecast growth of a university, university’s centres of excellence, citation ranking and the influence of a university research. The different sections or citation indices are

**Productivity**: Counts of papers or Paper counts which measure productivity are the most basic bibliometric measure and provide the raw data for all citation analysis. Ranking Institutions in terms of paper counts helps to compare the productivity and volume of research output among various Institutions. The number of researchers at an institution should be taken into account when comparing publication counts across Institutions. Characteristics of the papers, such as document type, publication year, and categorization method, should also be considered.
**Total recognition/influence**: Citations measure impact and influence. Citations to papers are summed over some time period to create an aggregate citation count. Aggregate citation counts of Institutions or researchers over the same time period can be useful in comparing and ranking their research impact.

**Indirect recognition/influence**: Second-generation citation counts are the sum of the citation counts of all the papers citing a target paper. This is a measure of the long-term impact of a paper which is similar in effect to the Google PageRank Efficiency.

**Average citations per paper**: Citations per paper (sometimes called “impact”) is computed by dividing the sum of citations to some set of papers for a defined time period by the number of papers (paper count). The citations per paper score is an attempt to weight impact in respect to output, since a greater number of publications tends to produce a greater number of citations. Citations per paper is a useful statistic when comparing large with small producers; however, some minimum number of publications, a threshold, ensures that one or a few highly cited papers do not skew the results.

**H-index**: The Hirsch index, or H-index, is a distribution-based indicator that corresponds to the number of papers at or above a given citation level equal to the value of the citation threshold. This statistic reflects the number of papers (N) in a given dataset having N or more citations. For example an H Index of 77, indicates that 77 papers in the given set were cited at least 77 times each.

The H-index of a subset of papers is always less than the H index of the entire set and hence cannot be normalized in a ratio manner. This measure attempts to reflect both productivity (number of papers) and impact (number of citations) in one number.

**Percent cited/uncited papers**: Relative Percent cited/uncited papers can be considered relative to the field of research, a country, institution, etc. This method provides further context to percent cited/uncited. For example, the rates of citededness vary across disciplines. The measure enables you to judge the influence of the papers in light of the norm in their field, or the norm in their country or institution Field baselines and relative impact

**Field baselines**: These are average citations per paper for papers in a field (usually a journal set) defined for a specific time period. Since different fields exhibit different average rates of citation, the mean for the field should be used to gauge the relative impact of one or a group of papers. By dividing the actual number of citations by the average, a ratio is obtained.

**Research fronts**: A research front is a group of highly cited papers referred to as core papers in a specialized topic defined by a cluster analysis. A measure of association between highly cited papers is used
to form the clusters. That measure is the number of times pairs of papers have been co-cited that is the number of later papers that have cited both of them. Clusters are formed by selecting all papers that can be linked together by a specified cocitation threshold.

**Collaboration indicators:** Metrics for collaboration include rates of co-authorship for pairs of authors, Institutions, countries, etc. They can include standard series such as the percentage of papers with 1, 2, 3, etc. authors over time, as well as the computation of impact and relative impact indicators for specific country or institutional collaboration pairs. These metrics can help identify where collaboration has and has not taken place.

**Disciplinarily index:** This metric indicates the concentration or dispersion of a group of papers over a set of field categories. This can be expressed as the sum of squared fractions of papers over some set of categories (disciplinarily index). A value of 1 indicates total concentration in a single field category. This metric helps to view multi- or interdisciplinary research output. It represents a response to the problem of field definition (a set of journals defining a field or category), which sometimes poses difficulties due to the constantly changing nature of science.

**Time Series:** Time series are powerful depictions of citation data. Whereas single period statistics provide a snapshot of research performance, time-series provide insight into the change in output and impact over time.

Abramo (2011) The recent development of bibliometric techniques has led various governments to introduce bibliometrics, in support or substitution for more traditional peer review. In the United Kingdom the Research Excellence Framework taking place in 2014, is an informed peer-review exercise, here the assessment outcomes will be a product of expert review informed by citation information and other quantitative indicators. It will substitute the previous Research Assessment Exercise series which was pure peer-review. The REF will be undertaken by the four UK higher education funding bodies. In Italy, the Quality of Research Assessment (VQR), expected in 2012, substitutes the previous pure peer-review Triennial Evaluation Exercise (VTR 2006). It can be considered a hybrid, as the panels of experts can choose one or both of two methodologies for evaluating any particular output: (i) citation analysis; and/or (ii) peer-review by external experts.
Citations act as a referral point for scholars to show earlier studies from where they have started their investigations. Tracking citations and understanding their trends in context is a key to evaluate the influence and impact of research.

2.8 Chapter Summary

This literature review has presented a number of views on the meaning of Research, Productivity, Research Productivity, Academic Research Productivity (ARP), Bibliometrics and the various Indicators by individuals and Institutions to measure Research Productivity. Productivity is the relationship between the outputs generated by a system and the inputs provided to create those outputs. Research productivity can be measured by both quantity and quality the most frequently used method is to count research productivity based on a weighting system. The literature review indicates that there have been numerous studies investigating academic research productivity, and there are a range of different theories. Each evaluation technique has its own sets of indicators. The present study is based on the Indicators that are the most desired one for evaluations of research performance.