CHAPTER -2

REVIEW LITERATURE

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CHAPTER –II
REVIEW OF LITERATURE

2.1 Introduction

Review literature is defined as “a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic”. Literature reviews are secondary sources, and as such, do not report any new or original experimental work. Also, a literature review can be interpreted as a review of an abstract accomplishment.

Most often associated with academic-oriented literature, such as a thesis, a literature review usually precedes a research proposal and results section. Its main goal is to situate the current study within the body of literature and to provide context for the particular reader.” by Wikipedia, the free encyclopaedia. Thus in research review literature is first step after selection of problem, review literature traces out the research results, scope, limitations of previous study. The insight by reviewing literature one can plan research on specific problem. The investigator carried out review of literature on “Social Network Analysis of Author Collaboration” using LISA, LISTA, UGC-INFONET and Google Scholar. The literature thus obtained as divided in to five major parts based on the relevance of study i.e.

a) Collaboration Studies
b) Scientometric studies
c) Social network analysis
d) Co-authorship studies
e) Social network analysis of author collaboration

2.2 Collaboration Studies

This area of sub-division focuses on the review of literature related to Collaboration studies carried in researchers pertaining to scope of author or collaboration between authors, institutions, countries etc. the review gave strong background for the area selected by researcher. Collaboration studies help in understanding the collaborations of authors, scientists, researchers for varied reasons. The list here gives researcher carrying collaboration related studies at varied time span and varied area of collaboration listed in descending order.
Wang et.al. (2014) carried a study on international scientific collaboration in dye-sensitized solar cells of web of science databases. In this study they used correlation analysis of sub-criterions and verified the rationality of different countries forming three major collaboration maps of inter-country, intra-continent and inter-continent collaborations. In their study they employed the international collaboration active index to measure the active degree of relevant countries or regions in collaborative research.

Murithi, Horner and Pemberton (2013) conducted study on research collaboration and publication productivity for academic scientists in Kenyan universities. They found the factors affecting level of collaboration, including disciplinary area, academic qualification and the national and institutional context within which research is done which have an effect on productivity of academic scientist s productivity, and methods best suited to investigate collaboration and productivity in developing areas.

Choi (2012) conducted a study on Collaboration of OECD members to understand the collaboration links between countries through authorship study. The result suggests that geographical, linguistic, and economic affinities did not have a meaningful impact on the formation of co-authorship network between ‘advanced’ nations, different from previous research results which claimed their importance on international cooperation. Globalization facilitated by the development of information and transportation technologies was found to influence the co-authorship link between countries, but not to accelerate centralization of the network in the past 15 years. Though the core-periphery pattern still persists, new rising stars, which are Korea and Turkey, have emerged in the co-authorship network among ‘advanced’ nations. These two countries, having a rapid increase in the share of degree centrality from 1995 to 2010, had strategic financial support from the government which stimulated the collaboration between universities and industries and emphasized the development of science and engineering fields.

Tang, Shapira (2011) conducted a study to analyses the growth of china in the field of nanotechnology by conducting co-authorship study of China-US nanotechnology. Patterns of China–US nanotechnology paper co-authorship are examined over the period 1990–2009, with an analysis of how these patterns have
changed over time. The paper combines bibliometric analysis and science mapping. There was limited collaboration in a few fields in the early stages of nanotechnology R&D development at the start of the 1990s. By the late 2000s, China–US nanotechnology R&D collaboration had become fully fledged, covering the key domains of nanomaterials, nanoelectronics, nanochemistry, nanobiology and nanomedicine, but also extending into multiple other areas of science. R&D collaboration with the US appears to be a way that aids China not only to build upon its traditional disciplinary strengths but also to extend its research activities in emerging fields of nanotechnology research.

Giuliani, Petris, Nico (2010) investigated that Over the past decade there have been many investigations aimed at defining the role of scientists and research groups in their co-authorship networks. Starting from the assumptions of network analysis, in this work we propose an analytical definition of a collaboration potential between authors of scientific papers based on both co-authorships and content sharing. The collaboration potential can also be considered a useful tool to investigate the relationships between a single scientist and research groups, thus allowing for the identification of characteristic “types” of scientists (integrated, independent, etc.). We computed the collaboration potential for a set of authors belonging to research groups of an institute specialized in the field of Medical Genetics. The methods presented in the paper are rather general as they can be applied to compute a collaboration potential for a network of cooperating actors in every situation in which one can qualify the content of some activities and which of them are in common among the actors of the network.

Boyack (2009) proposed a method for identifying targets for future collaboration between institutions. The utility of the method was shown in two different applications: identifying specific potential collaborations at the author level between two institutions, and generating an index that can be used for strategic planning purposes. Identification of these potential collaborations was based on finding authors that belong to the same small paper-level community (or cluster of papers), using a map of science and technology containing nearly 1 million papers organized into 117,435 communities. The map generated in the study was unique by combining the ISI proceedings Database, Science and Social science Indexes.
Andrade, López and Martín (2009) carried a study of research collaboration identification using ISI articles. The study focused on Inter-institutional collaboration of research articles along with international partners. The analysis showed that collaboration involves more international partners due the reason of journals having high impact number leading to greater opportunities to be cited by researcher around the world.

Zimmerman, Glänzel, Bar-Ilanc (2009) conducted a study to identify the collaboration rate or growth between European Union with American countries, European Union with Israel government. The analysis showed that there is steady growth of research collaboration between European Union with Israel government and Decline in rate of collaboration European Union with USA and also Israel government with USA. The study suggested some basic notions to increase the research collaboration to be taken by Israel government with USA.

Boyack (2009) found that Institute for Science Technology and Society, Henan Normal University, Henan (China) On the basis of the measured frequency distribution of China’s inter-regional co-authored papers covered by the Chinese Science Citation Database, this paper shows the pattern of China’s inter-regional research collaboration (IRRC), and analyzes how the collaborative pattern was formed. A new method is used to calculate the expected value matrix based on an observed value matrix of IRRC, which is asymmetric and has no diagonal elements. The results fall into three groups. 1) Regional scientific productivity affects both the collaborative preference and ranking of authors’ name; 2) geographical proximity is an important factor determining the pattern of IRRC; 3) when using Salton’s measure, regional mean collaborative strength increases as the regional productivity increases, and as the distance between two regions decreases.

Leydesdorff and Wagner (2008) studied international collaboration in science, identifying the patterns of scientific collaboration suggesting the network effects of collaboration due to no political institution mediating relationships at that level except for the initiatives of the European commission. In their study they found that Science at the international level shares features with other complex adaptive systems whose order arises from the interactions of hundreds of agents pursuing self-interested strategies. During the period 2000–2005, the network of global
collaborations appears to have reinforced the formation of a core group of fourteen most cooperative countries. This core group can be expected to use knowledge from the global network with great efficiency, since these countries have strong national systems. Countries at the periphery may be disadvantaged by the increased strength of the core.

Pauline et. al. (2008) found that collaboration is associated with higher article citation rates; a body of research has suggested that this is, in part, related to the access to a larger social network and the increased visibility of research this entails, rather than simply a reflection of greater quality. Examine the role of networks in article citation rates by investigating article publication by the nine New Zealand Government-owned Crown Research Institutes (CRIs), drawing on the Science Citation Index. Analyse an aggregate data set of all CRI publications with duplicates removed, and, in addition, investigate each CRI. We find that a greater number of authors, countries and institutions involved in co-publication increases expected citation rates, although there are some differences between the CRIs. However, the type of co-publication affects the expected citation rates. Discover a periphery effect. Where greater levels of co-publication with domestic institutions decreases expected citation rates. Conclude that scientists working on the periphery looking to increase the visibility of their research should strive to link their research to the international research community, particularly through co-publication with international authors.

Yamashita, Okubo (2006) conducted a collaboration study of Japan-France to identify bilateral relationship. The study identified that there is stronger domestic networks created in France than in Japan. In addition to French universities and public institutions becoming intensely mixed, French sectors tend to construct a tight domestic network within international activity, whereas Japanese sectors tend to collaborate with international partners independently from their colleagues. All in all, collaboration policy does not seem to be clearly defined between the two countries, where 67% of collaborative activity is undertaken in a multi-lateral framework. The majority of co-authorship created between France and Japan is rather the result of research conducted under international programs than of relations spontaneously established among scientists, and this multi-nationality has manifestly developed during the decades examined.
**Radas (2005)** conducted a study to understand the collaboration among industry and science in innovation system. The research explored the motives of collaboration with motives for collaboration and company approach to innovation and technology influence collaboration with scientists. The research also examined the differences among small, medium sized and large companies. Since collaboration between science and industry is expected to have a positive impact on a company’s innovation capabilities, they explored how selected innovation indicators are affected by collaboration.

**Kim (2005)** investigated Korean scientific output, focusing on international collaboration patterns, through an analysis of journal publications. For the study, 44,534 publications, published by researchers affiliated with Korean institutions and indexed by SCI during the six years 1995-2000 were considered. The study period was divided into two periods to compare the international collaboration for three years 1995-1997 and 1998-2000. The results showed a clear decrease in Korea’s international collaboration level between the study periods even though the number of researchers as well as the total R&D expenditure decreased considerably after Korea’s economic change. The decrease of international collaboration in Korean science was inversely associated with different determinants such as scientific size as well as national scientific infrastructure. This decreasing trend of international collaboration in Korean science was largely caused by discipline to discipline variations in coverage of the SCI database. Among the top-ten collaborating countries, only the Chinese and the Canadian share of collaborative publications with Korea increased between the two periods under consideration.

**Dastidar (2004)** attempted to unfold the intellectual base in ocean science and technology. The articles appeared in Science Citation Index (SCI) under Oceanography in the year 2000 were analyzed to decipher the scientist to scientist, organization to organization and country to country network structures. The causal linkages between the knowledge productivity function and the socio-economic imperatives of knowledge production units were studied.

**Dillenbourg et. al. (1996)** carried a study to find out the research collaboration on empirical studies and found that, for many years, theories of collaborative learning tended to focus on how individuals function in a group. More
recently, the focus has shifted so that the group itself has become the unit of analysis. In terms of empirical research, the initial goal was to establish whether and under what circumstances collaborative learning was more effective than learning alone. Researchers controlled several independent variables (size of the group, composition of the group, nature of the task, communication media, and so on). However, these variables interacted with one another in a way that made it almost impossible to establish causal links between the conditions and the effects of collaboration. Hence, empirical studies have more recently started to focus less on establishing parameters for effective collaboration and more on trying to understand the role which such variables play in mediating interaction. In this chapter, we argue that this shift to a more process-oriented account requires new tools for analysing and modelling interactions.

Persson, Glänzel, Danell (2004) found that Several research studies and reports on national and European science and technology indicators have recently presented figures reflecting intensifying scientific collaboration and increasing citation impact in practically all science areas and at all levels of aggregation. The main objective of this paper is twofold, namely first to analyse if the number or weight of actors in scientific communication has increased, if patterns of documented scientific communication and collaboration have changed in the last two decades and if these tendencies have inflationary features. The second question is concerned with the role of scientific collaboration in this context. In particular, the question will be answered to what extent co-authorship and publication activity, on one hand, and co-authorship and citation impact, on the other hand, do interact. The answers found to these questions have strong implication for the application of bibliometric indicators in research evaluation, moreover, the construction of indicators applied to trend analyses and studies based on medium-term or long-term observations have to be reconsidered to guarantee the validity of conclusions drawn from bibliometric results.

Goldfinch, Dale, Derouen Jr (2003) studied collaboration among New Zealand government-owned crown research institutes using Science Citation Index. They found that the greater number of authors, countries and institutions involved in co-publication increases expected citation rates, although there are some differences between the CRIs. However, the type of co-publication affects the expected citation rates. The study discovered periphery effect were greater levels of co-publication
with domestic institutions decreases expected citation rates. They concluded that scientists working on the periphery looking to increase the visibility of their research should strive to link their research to the international research community, particularly through co-publication with international authors.

**Hara et. al. (2002)** investigated challenges that emerge in establishing scientific collaboration; data were collected about members’ previous and current collaborative experiences, perceptions regarding collaboration, and work practices during the centre’s first year of operation. The data for the study included interviews with members of the centre, observations of videoconferences and meetings, and a centre wide sociometric survey. Data analysis has led to the development of a framework that identifies forms of collaboration that emerged among scientists (e.g., complementary and integrative collaboration) and associated factors, which influenced collaboration including personal compatibility, work connections, incentives, and infrastructure. These results may inform the specification of social and organizational practices, which are needed to establish collaboration in distributed, multi-disciplinary research centres.

**Liang, Zhu (2002)** conducted study on China’s inter-regional research collaborations resulting geographical proximity as one of the most important factors affecting China’s IRRC. The probability of 31 regions’ adjoining regions being closest collaborators is as high as 80%. The same situation occurred when calculating the probability of 31 regions’ furthest-away regions being aloofest collaborators. The quantitative relationship between regional scientific productivity and collaborative strength could be mathematically described by a power function, and that between geographical proximity and collaborative strength could by a negative power function.

**Basu and Aggarwal (2001)** A case study of major Indian institutions was undertaken, where Cluster Analysis is used to distinguish between intrinsically high performance institutions and those that gain disproportionately in terms of perceived quality of their output as a result of international collaboration. International collaboration not only serves to increase the overall output of research papers of an institution, the contribution of such papers to the average Impact Factor of the institutional output could also be disproportionately high. To quantify this effect, an
index of gain in impact through foreign collaboration (GIFCOL) is defined such that it ensures comparability between institutions with differing proportions of collaborative output.

Newman (2001) studied social networks of scientists in which the actors are authors of scientific papers, and a tie between two actors represents co-authorship of one or more papers. They calculated a large number of statistics for our networks, including typical numbers of papers per author, authors per paper, and numbers of collaborators per author in the various fields. They also noted that in all the networks studied there exists a giant component of scientists any two of whom can be connected by a short path of intermediate collaborators. A number of differences are apparent between the fields studied. Researchers in experimental disciplines are found to have larger numbers of collaborators on average than those in theoretical disciplines, with high-energy physicists having easily the largest average number of collaborators.

Kretschmer, Gupta (1998) identified in co-authorship networks in subject fields or research three-dimensional representation of all homophily indices. The pattern identified in co-authorship networks in subject fields or research specialities such as theoretical population genetics from 1900-1980 refer to the second stable phase of the irreversible process of a structural development. Structural development is, in a way, subdivided into to stable phases with an unstable transitional phase in between, with the system in the second stable phase being more structured than in the first one. The trend towards collaboration and cooperation has become so dominant that it is necessary to study such processes within scientific research in an effort to gain fundamental knowledge on the intensification of research required because of the retarding growth rate of science in the future.

Katz, Martin (1997) studied resulted that co-authorship is only a rather approximate partial indicator of collaboration. In addition, there is a conceptual problem with the one-author, two-institution paper. No inter-individual collaboration is involved, but is this still an inter-institutional collaboration, the empirical investigation of the multi-institutional author shows that the phenomenon is not uncommon. At a national level, at least 5-15% of collaborative papers seem to involve this form of 'collaboration'. In the light of this 'shared researcher' phenomenon, the
only solution would appear to be to distinguish inter-institutional collaboration from inter-individual collaboration and to recognise that the former need not always involve the latter.

2.3 Scientometric studies

The sub-division scientometric studies highlights the review of literature carried to find out scientometric studies related to collaboration of authors. Scientometric studies gave a insight for the analysis of collaboration among authors for identifying the growth of literature and for identifying the collaboration between authors over a period to understand the factors leading to collaboration. The reviewed articles have been listed here.

**Harinarayana et.al. (2016)** conducted study on facebook posts and lotka’s law; the study examined the participation of librarians in Facebook by testing whether it follows the pattern given by Lotka's law. The result shows that it does not. The paper analysed the reasons and also provides the methods of collecting data for bibliometric study.

**Sangam, Madalli & Arali (2015)** carried a scientometric study of Genetics publications in Web of Science. In this research an attempt has been made to study the Growth pattern, doubling time of world and Indian Genetics literature. During both the block periods (1993-2002 and (2003-2012) Evolutionary Genetics has lesser number of publications. Study finally inferred that the Logarithmic and Linear growth models fit well for World’s genetics literature whereas for India Exponential and Logistic models fit well.

**Gorraiz, Reimann, Gumpenberger (2012)** carried a bibilometric study of collaboration of Austria and six countries to differentiate between bilateral and multilateral contingents in the assessment of international scientific collaboration. The study focused on Degree of bilaterality and citation degree of bilaterality which resulted in lower than 1/3 and 1/5 of multi contingent Only a very weak correlation between ‘times cited’ and the number of affiliations or authors was observed at publication level. Neither the number of authors or affiliations determines impact increase. Rather internationalisation and cooperation seem to be the crucial factors.
Kretschmer et. al. (2012) carried a scientometric study of gender studies in “Psychology of Women Quarterly”. Collaboration behaviour in gender studies is different from that in the natural sciences. The results confirm our expectation that the strength of gender bias is related to the subject matter of journals, and that it is less expressed in the journals of gender studies.

Mooghali et.al. (2011) conducted a scientometrics study of scientometric journal. Findings revealed that out of 691 articles in the field of Scientometrics, a total number of 183 articles (26.48%) were written during 1980 to 2009 by the top ten authors. Some of these articles were produced in authors’ collaboration and some of them were by single authors. Geographical analysis indicated that the field had evolved considerably in different regions of the world. Hungarian Academy of Science with 40 records (5.71%) was the most productive institution in the field of Scientometrics. Furthermore, chronological analysis disclosed that the scientific production in the field of Scientometrics showed a slow increase from 1980 to 2009. The overwhelming majority of documents were in English, and the international journal of *Scientometrics* was the most prolific journal in the field. It has also been declared that 67.87% of the literature was published in the area of Library and Information Science.

Zheng et.al (2011) carried a scientometric study to identify the China’s collaboration and its impact factor of patent articles in Science and Technology. China’s international scientific collaboration (ISC) is broadly distributed over many countries, the USA being the most important ISC partners. China’s international technological collaboration (ITC) is mainly carried out with USA and Taiwan, and Taiwan has been the most significant ITC partner of when taking countries’ patent output into account. Besides, ISC shows a continuous raise of Chinese papers’ citation. Even the countries with a small amount of papers and ISC with China, exert a positive influence on the impact of citation of Chinese papers as well. However, ITC does not always play an active role in the improvement of citation impact of Chinese patents.

Kumbar, and Kumar, N. Girish (2011) conducted Study attempting to identify the authorship trend and collaborative research in Genetics and Plant Breeding, based on the data collected from the Indian Journal of Genetics and Plant
Breeding published during 1998-2002. The study reveals that two authors papers are maximum 215 (44.24%). The degree of collaboration in research is 0.87 in genetics and plant breeding as a whole and ranged between 0.86 to 0.89 during 1998-2002. The contribution from research institutions and laboratories i.e., 216 (44.08%) is vividly ahead of other segments such as universities and colleges. 475 articles contributed by the Indian authors and a significant percent i.e., 107 (22.49%) is reported from Delhi State.

Chandrashekar, Mulla, and Harinarayana (2010) conducted Bibliometric analysis of digital libraries available in the Emerald databases from April 1991 to March 2009. The study has undertaken total 454 articles published on digital libraries which are available in Emerald database the results revealed that Maximum number of articles contributed by single author 307 (67.62%), USA takes first place with 145 articles (31.94%) followed by UK is takes second place with 27.09 percent. Electronic Library stands first rank among the published literature on digital library.

He (2009) carried a bibliometric study to identify the collaboration pattern of China and G7 countries based on Science Citation Index. The study resulted that there was exponential growth aroused by the growth of science in China. USA is the most important collaboration country and the international collaboration between China and the G7 countries display differences at each research field.

Sooryamoorthy (2009) Conducted citations pattern of the publications of South African scientists. The focus of the study was to identify the collaborative dimensions publications in ISI data. The study reveals that the number of citations received by a publication varies not only according to the collaboration but also to the types of collaboration of the authors who are involved in its production. Furthermore, it emerges that the impact of citations on publications differs from discipline to discipline, and affiliating sector to sector, regardless of collaboration.

Hou, Kretschmer, Liu (2008) The structure of scientific collaboration networks in scientometrics is investigated at the level of individuals by using bibliographic data of all papers published in the international journal Scientometrics retrieved from the Science Citation Index (SCI) of the years 1978–2004. Combined analysis of social network analysis (SNA), co-occurrence analysis, cluster analysis and frequency analysis of words is explored to reveal: The microstructure of the
collaboration network on scientists’ aspects of scientometrics; the major collaborative fields of the whole network and of different collaborative sub-networks; The collaborative centre of the collaboration network in scientometrics.

**Kumbar, Gupta and Dhawan, (2008)** Describes the growth, contribution and impact of research carried out by the scientists of University of Mysore in science and technology. Indicate the patterns of communications of university scientists and studies the extent of concentration and scattering of their research output in different journals. Analyses the strong and weak areas of university research, their growth rate and impact in terms of average citations received. Also studies the output and impact of research under different existing subject departments of the university. Analyses the international collaborative share of research output at the overall level as well as across various subjects, indicating also the major countries involved in international collaboration. Describes the share and characteristics of select highly cited papers and the top productive authors

**Davarpanah, Aslekia (2007)** conducted quantitative study of productivity, characteristics and various aspects of global publication in the field of library and information science (LIS). A total of 894 contributions published in 56 LIS journals indexed in SSCI during the years of 2000–2004 were analyzed. A total of 1361 authors had contributed publications during the five years. The overwhelming majority (89.93%) of them wrote one paper. The average number of authors per paper is 1.52. All the studied papers were published in English. The sum of research output of the authors form USA and UK reaches 70% of the total productivity. Most papers received few citations. Each article received on an average 1.6 citations and the LIS researchers cite mostly latest articles. About 48% of citing authors had tendency of self-citation. The productive authors, their contribution and authorship position are listed to indicate their productivity and degree of involvement in their research publications.

**Vinkler (2007)** conducted a scientometric study of citations of science publications. The results show indicate that calculating scientometric indexes for individuals, self-citations should be excluded and the effect of the different bibliometric features of the field should be taken into account. The correctness of the
indexes used for evaluating journal papers of individuals should be investigated also on the individual level.

**Rey-Rocha, Garzón-García, Martín-Sempere (2006)** the study gives an empirical evidence is given on how membership in a consolidated, well-established research team provides researchers with some competitive advantage as compared to their colleagues in non-consolidated teams. Researchers belonging to consolidated teams perform quantitatively better than their colleagues in terms of the number of articles published in journals covered in the *Journal Citation Reports*, but not in terms of the impact of these publications. Consolidation favours publication, but not patenting, and it also has a positive effect on the academic prestige of scientists and on their capacity to train new researchers. It does not significantly foster participation in funded R&D projects, nor does it influence the establishment of international collaborations. Impact is influenced to a remarkable degree by seniority and professional background, and is significantly greater for young scientists who have spent time abroad at prestigious research laboratories.

**Kumbar, Harinarayana and Tejaswini (2005)** studied the authorship trend and collaborative research in the field of Agricultural Sciences. The required data collected from “The Indian Journal of Agricultural Science” published during 2000-2001. Result shows that three authored papers were maximum 164 (34.02%) and the degree of collaboration in agricultural sciences is 0.87. Authors in the field have been ranked based on their academic productivity. The study indicate that contribution from research institutions and laboratories 190(39.42%) is vividly ahead of other segments such as universities. Of 456(94.50%) articles, a significant percent i.e., 70(14.52%) is reported from U.P. state.

**Gupta, Dhawan (2003)** conducted a bibliometric study result showing growth in collaboration between India and China as evident from the rise in the number of co-authored papers from 21 in 1994 to 74 in 1999. It is also found that S&T collaboration between India and China has been taking place mainly through multilateral channels and the output through bilateral channels is very small (11.7%). The collaborations through multilateral channels involved participation of several other developed and developing countries. Field-wise Physics and Clinical Medicine have been the priority areas in the collaborative research, accounting for 62% and 14% publications
respectively. Within Physics, the largest share (78%) goes to nuclear & particle physics. The priorities across subject fields have been different under bilateral and multilateral research. The publications output was maximum in Physics under multilateral as well as in bilateral research.

Liang et.al. (2001) conducted scientometric study of the age structure of scientific collaboration in Chinese computer science. Analysis revealed some special age structures in scientific collaboration in Chinese computer science. Most collaborations are composed of scientists younger than thirty-six (Younger) or older than fifty (Elder). For two-dimensional collaboration formed by first and second authors, Younger-Elder and Younger-Younger are the predominant age structures. For three-dimensional collaboration formed by first, second and third authors, Younger-Younger-Elder and Younger-Younger-Younger are the most important age structures. Collaboration between two authors older than 38 amounts to only 6.4 percent of all two-person collaborations. Collaboration between two middle-aged scientists seldom was seen.

Arkhipov (1999) conducted a scientometric study of 300,000 reports in Nature during the 1869-1998 period have been reviewed. The distribution of articles by subfields was determined. Additional sources of information were several journals on analytical "chemistry and papers at the Pittsburg conference series during 1950-1999. One of the key trends in the development of basic sciences, namely, the increase of articles dealing with instrumental analytical chemistry, in Nature is revealed.

Zitt, Bassecoulard (1998) conducted a scientometric study of SCI articles, as the average profile of science drifts with the level of visibility, stratification by impact level is discussed. In this study, experimental internationalization indexes were calculated on the SCI for journals belonging to Earth & Space and Applied Biology. Convergence of measurements (types of indexes, type of normalization, and publication vs. citation scope) is addressed. Internationalization indexes may have a variety of applications, including characterization of the scientific publishing market and sampling of the SCI for science indicators.

Kumbar, (1998) conducted Bibliometric analysis for 7451 references/citations appended to the 322 articles published in the 'American journal of
Ophthalmology Vol. 117 to 120 during the year 1994-95 has been carried out to determine the average number of citations per article, types of literature cited, authorship pattern, obsolescence of literature and ranked list of cited periodicals. Results indicate that major the type of document is periodical 682 (91.63%); authorship pattern shows, highest contribution is made by three authors 72; in this field research goes back to 28 years, it accounts 6192 (90.71 %) and Ophthalmology Journal score the highest number of citations 998 (14.62%).

Persson et.al. (1997) conducted a bibliometric study results show that scientific collaboration plays a key role for all universities, and that they collaborate with external institutions in just about the same extent. The inter-Nordic university network comprises about ten percent of all institutional collaborations. However, the amount of collaboration varies across fields, physics and medicine having a high degree of collaboration. The inter-Nordic network is of equal importance as the national network in physics and geosciences. Especially, when one looks at international collaboration outside the Nordic arena, the number of overlapping partners is quite low. This suggests that research specialization is the major force governing international contacts.

Avkiran (1997) examined the significant difference between individual research and collaborative research in finance, which reported an empirical comparison of quality of collaborative research with the quality of individual research. Quality of a paper is measured by the citation rate over the four years following the year of publication. Papers published in fourteen Finance journals between 1987-1991 are sampled. There is no significant difference between the quality of collaborative and individual research. Decision-makers should hesitate in interpreting collaborative research as a definitive sign of ability to produce better research.

Karisiddappa, Maheshwarappa and Shirol (1990) The proportion of single authored papers has fallen to 39.43% in 1988 when compared to 1920's and 1950's indicating the trend towards multiple authorship. The authorship pattern varies from one subfield to another. The proportion of multi authored papers was highest in one subfield and it ranged between 60·69% in six, 50-59% in six and 48%,37%,27% in the remaining three subfields. The degree of collaboration in research in
psychology as a whole is 0.60 and it ranged between 0.29 to 0.87 indicating the variation in the extent of collaboration in different subfields of psychology. There is significant difference between the pairs of subfields as regards the proportion of single and multi authored papers in psychology.

**Rip, Courtial (1984)** scientometrics is illustrated by using as data a ten-year period of articles from a biotechnology core journal. After coding with key-words, the relations between articles are brought out by co-word analysis. Maps of the field are given, showing connections between areas and their change over time, and with respect to the institutions in which research is performed.

**Subramanyam (1983)** Bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research. In this paper, several types of collaboration have been identified, and earlier research on collaboration has been reviewed. Further research is needed to refine the methods of defining and assessing collaboration and its impact on the organization of research and communication in science. Further he proposed a formula for calculating degree of collaboration among authors and researchers.

### 2.4 Co-authorship studies

The sub-division co-authorship reviews the research articles related to area. The co-authorship studies focuses mainly on authors collaborating together for better research results and other beneficiaries. The reviews revealed that there has been lots of research carried to understand the co-authorship patterns in different subjects over different time span. The studies were carried using bibliometrics, scientometrics, webometrics etc. for analysing the co-authorship patterns by different researchers.

**Mani (2014)** conducted bibliometric study of Malaysian Journal of Library and Information Science. A total of 279 research articles and 575 authors were examined by growth of contributions by year and volume, authorship patterns by year and volume, authorship patterns, author productivity, single and multi authored papers by year, authorship patterns by global, most prolific contributors and degree of collaboration. Maximum number of contributions 28 (10.036%) were published in the year 2011. Average number of authors per paper is 2.06. The highest number of author productivity 72 (12.522%). Majority 180 (64.516%) of the total contributions
represent collaborative research. The average degree of collaboration has been arrived at 64 during the study period.

Cheng et. al. (2013) research findings reveal that in Malaysia, researchers tend to work in teams but collaboration is more dominant in science-based research than social sciences. Academics published extensively with their colleagues from the same university or from other academic institutions, but there is little collaboration with researchers from public research institutes or industry. In terms of international collaboration, Iran, India, UK, Japan and the USA are the top five collaborating countries. Disciplines with significant international collaboration are physics and astronomy; chemistry; agricultural and biological sciences; engineering; health profession and computer sciences. The study highlights the skewed distribution of co-authorship patterns where there is limited evidence of cross sectors collaboration in journal publication. The findings call for policy makers as well as universities to look into the constraints as well as drivers that would enhance the linkage of different actors in the national research system.

Thilakar and Ponnudurai (2013) carried study on global scientists in agricultural field, the authorship pattern shows majority of joint authorship contributions with 98.35 percents and high collaboration coefficient (0.93) which reveals that team research is predominant. Two, three and four author collaboration is common trend among global scientists. There are 26,306 authors contributing out of which 4728 authors have single contribution. Also very few authors have 10 or more contributions. This is a poor sign in measuring productivity of any country. The value of dominance factor of most of the prolific authors is found low (less than 0.05) which should be a poor sign for collaboration. CC is an interesting measure of collaborative strength in a discipline that has the merit of lying between 0 and 1 (unlike previous measures of collaboration) and tends to 0 as single authored papers dominate.

Giuliani, Pio De Petris, Nico (2010) carried a study to identify the collaboration potential between scientists and research groups that is based on the scientific interests researchers have in common but of which they are not aware of. The method could also be the basis for the design of an original search engine allowing users to find, given a particular researcher, who are the researchers studying subjects close to his own, among the ones not co-authoring papers with him.
Eventually, generalizing the concept of collaboration to a broader scope, the methods presented in this paper could easily be generalized to every case in which one can classify the content of some activities and determine which of them are in common among the actors cooperating to perform such activities.

Suárez-Balseiro, García-Zorita, Sanz-Casado, (2009) carried a scientometric study to analyse the visibility of scientific relationships at local or intentional nature. The results of the study show that the establishment and furtherance of local and international co-authorship favour the visibility of the papers published and consequently can be regarded to be.

Olmeda-Go´mez (2009) Spanish inter-university collaboration patterns appear to be influenced by both geographic proximity and administrative and political affiliation. Inter-regional co-authorship encompasses regional sub-networks whose spatial scope conforms rather closely to Spanish geopolitical divisions. Papers involving international collaboration are written primarily with European Union and North and Latin American researchers. Greater visibility is attained with international co-authorship than with any other type of collaboration studied. Impact was measured in terms of journals rather than each individual paper.

Kretschmer, Kretschmer (2007) conducted a co-authorship study in Web visibility indicators the calculation of Web Visibility Rates of collaboration needs a starting point, in the form of a list of names of authors. This form of data collection must be tested in future. Nevertheless, to see how practical it is if one would start from the list of authors one could expect to detect also other forms of collaboration than in the form of co-authorship. Thus, this proposed method of collection may produce genuinely new information. If search engines are to be used, one could use the file type advanced search options to look for relations in specific file types. This approach could reduce the number of incorrect matches in the information on the Web.

Li-chun et.al. (2006) studied COLLNET co-authorship network, COLLNET is close to a scale-free network, and displays the clustering aspect of a ‘‘small-world’’ as well. Structure affects function. The COLLNET network suffers the vulnerability in that it depends too much on few nodes that are crucial to the whole network for knowledge production or spreading. Such as, nodes 22, 14, 25 are of the highest
degree in network. At the same time they are the champions in most other measures too. At the same time, there is a degree of robustness and institutionalization apparent in this relatively young network – which may lead, in time, to defining a new field of study. The leading figures do not form a “closed” elite, and the network as a whole is fairly robust against the loss of central figures.

Lundberg (2006) assessed how well university-industry collaborations can be identified and described using co-authorship data. This is done through a comparison of co-authorship data with industrial funding to a medical university. Results show that one third of the companies that have provided funding to the university had not co-authored any publications with the university. Further, the funding indicator identified only 16% of the companies that had co-authored publications. Thus, both co-authorship and funding indicators provide incomplete results. They also observe a case of conflicting trends between funding and co-authorship indicators. They conclude that uncritical use of the two indicators may lead to misinterpretation of the development of collaborations and thus provide incorrect data for decision-making.

Acedo et al. (2006) carried out an exploratory analysis of co-authorships in the field of management from the two aforementioned approaches. The results obtained show a growing tendency of the co-authored papers in the field of management, similar to what can be observed in other disciplines. Our study analyses some of the underpinning factors, which have been highlighted in the literature, explaining this tendency. Thus, the progressive quantitative character of research and the influence of the collaboration on the articles’ impact are enhanced. The network analysis permits the exploration of the peculiarities of the management in comparison with other fields of knowledge, as well as the existing linkages between the most central and prominent authors within this discipline.

Liu et al. (2005) conducted scientometric study of Digital Libraries by studying co-authorship graphs indicating a rich tapestry of collaborations across institutional boundaries, but demonstrate a significantly higher degree of clustering and dispersion than one would find in other domains. In comparison with other co-authorship networks for related disciplines, we find the DL research community co-authorship graph has a smaller largest component, a larger clustering coefficient and a
larger characteristic path length. DL authors thus collaborate closely within specific clusters but restrict their collaborations to specific groups of interest.

Glänzel (2001) found statistical evidence of symmetry and asymmetry in co-publication links, of the relation between international co-authorship and both national research profiles and citation impact. Co-publication maps reveal structural changes in international co-authorship links in the last decade. Besides stable links and coherent clusters, new nodes and links have also been found. Not all links between individual countries are symmetric. Specific (unidirectional) co-authorship affinity could also be detected in several countries. As expected, international co-authorship, on an average, results in publications with higher citation rates than purely domestic papers. However, the influence of international collaboration on the national citation impact varies considerably between the countries (and within one individual country between fields). In some cases there is, however, no citation advantage for one or even for both partners.

Kretschmer (1997) studied co-authorship networks in invisible colleges of physics show the same behavioural patterns as the non-scientific populations: Birds of a feather flock together. It should be studied whether similar patterns exist also in other science disciplines, or what kind of deviations might be possibly provable. Such deviations are possible because the approach of natural scientists to publications and citations appears to be different from that of the social scientists. The behavioural patterns in institutions should also be verified in their three-dimensional form. It is probable that rules to the contrary exist and are valid: Opposites attract.

Cunningham, Dillon (1997) conducted a scientometric study revealing the proportion of single-authored papers is much higher in the humanities and social sciences: in philosophy, for example, collaboration is so unusual that some researchers find it difficult to imagine how a joint project could be produced. Even in these disciplines, however, sub-fields may vary in their degree of collaboration, often reflecting equipment or team needs outside the norm for that discipline (for example, biophysical and archaeological anthropology show higher degrees of collaboration than sociocultural and linguistic anthropology, seems to fit more into the multiply authored norm of the physical or experimental sciences than the humanities/social sciences.
Bird (1997) studied collaboration among researchers in marine mammalogy; the results found that Multi-authored papers where two or more authors are affiliated at different institutions were used in this analysis. The fact that there was a positive increasing trend of these papers over the years shows an increase in collaboration among researchers at different institutions. This may possibly show that individual colleges, universities, and other organizations and institutions increasingly do not have the expertise and/or equipment/laboratories to support increasingly complex marine mammal research.

De Lange, Glanzel (1997) bibliometric studies on the issue pertain to the share of international co-authored papers in national publication output and their impact on national and international research, or to the analysis and mapping of the structure of collaboration links. The study attempted to develop a model to measure and analyse the extent of multilateral international co-authorship links. A new indicator, the Multilateral Collaboration Index (p) is introduced and analysed as a function of the share of internationally co-authored papers (J). Based on series expansion approach is applied that can be considered an extension of a fractionation model by Nederhof and Moed and allows classifying the extent of multi-lateral links both among science fields and among individual countries.

Vimala and Reddy (1996) Studied the trend in authorship pattern and collaborative research in zoology with a sample of 19,323 journal citations figured in the theses on zoology accepted for the award of the doctoral degree by Sri Venkateswara University, Tirupati, India. The study indicates that although multiple authorship is dominant, solo research also exists. The proportion of single authored papers has shown a declining trend during the period 1901-1995. It is observed that the proportion of single authorship is likely to be insignificant after the year 2030. The degree of collaboration in research is 0.75 in zoology as a whole.

2.5 Social network analysis

The sub-division social network analysis presents the articles related to social network analysis of journals, authorship studies; collaboration studies etc. though social network analysis is vastly applied in the field of sociology, information science for analysing the network of different individuals with other individuals, organisations
with other organisations over a period. Here social network analysis deals with collaboration studies conducted by different researchers.

**Giannakis (2012)** study reveals that the current structure of the network of journals is characterised by an evident shift of focus of operations management journals towards more SCM phenomena, the cohesion of the discipline has improved but is still fragmented due to a lack of reciprocal co-citations among the journals, and the emergence of three distinctive clusters in the network. The study reflects the growth of supply chain management; by studying an eclectic number of academic journals over the past 20 years, but can be extended beyond this period and it can include more academic and practitioner journals to examine its extended problem domain.

**Opsahl (2011)** proposed local clustering coefficient is undefined for nodes with a two-mode degree less than two and a projected one-mode degree less than two. Although the one-mode coefficient is undefined for nodes with a one-mode degree less than two, the additional requirement of a two-mode degree less than two is likely to affect more nodes. For example, in scientific Collaboration networks, a scientist must have co-authored at least two papers with distinct others to attain a score. The local clustering coefficient has been calculated for all nodes in a network by repeating the analysis twice; the same is not true for the global clustering coefficient.

**Zhaoa, Rousseaub, Yea (2011)** the study pointed the h-degree similar to the h-index; also the h-degree may be an indicator lacking discriminatory power. The measures introduced in this paper may lead to further informetric network studies. In citation networks, the h-degree refers to the most cited nodes. In keyword networks, it points to core concepts. In co-author networks, it singles out the most collaborative authors. Using the notion of h-centralization different networks can be compared. Furthermore, the h-degree may be applied in any discipline, and in any weighted network. We conclude by saying that the h-degree, h-centrality, h-centralization and other parameters based on the h-degree provide a set of useful measures for the study of weighted networks. Similar to node strength the h-degree is a basic measure, leading to new characterizations in networks, which may stimulate further studies.

**Opsahla, Agneessens, Skvoretze (2010)** conducted Social Network Analysis to study ties often have a strength naturally associated with them that differentiate
them from each other. Tie strength has been operationalized as weights. A few network measures have been proposed for weighted networks, including three common measures of node centrality: degree, closeness, and betweenness. However, these generalizations have solely focused on tie weights, and not on the number of ties, which was the central component of the original measures.

**Racherla, Hu (2010)** the analysed result shows that developing a network of collaborations/ collaborators is highly beneficial to researchers as evidenced by the fact that researchers with multiple collaborations usually tend be the most productive researchers in the field. At the same time, this result can be stochastic in the sense that people prefer to collaborate with highly productive researchers and this further increases the network size surrounding a productive researcher. The results also show that the boundaries of varied research streams are relatively permeable thereby assisting in inter-disciplinary collaboration. As of now, the collaborations seem to be dominant among closely related groups (e.g., segmentation and marketing & strategy) but the results are a growing trend in the positive direction.

**Sooryamoorthy (2009)** found that Using bibliographic records from the Science Citation Index, the paper examine the publication of South African scientists. The analysis shows that collaboration research in South Africa has been growing steadily and the scientists are highly oriented towards collaborative rather than individualistic research. International collaboration is preferred to domestic collaboration while publication seems to be a decisive factor in collaboration. The paper also looks at the collaboration dimensions of partnering countries, sectors and disciplines, and examines how collaboration can be predicted by certain publication variables. Characteristic features are evident in both the degree and nature of collaboration which can be predicted by the number of countries involved, number of partners and the fractional count of papers.

**Schnettler (2009)** offered a structured overview of 50 years of small-world research. Initially formulated by Pool and Kochen in the mid-1950s, the small-world concept can be divided into six research foci, based on three dimensions (structural, process-related, psychological), and two process-related themes (diffusion, search). Building on this analytical distinction, the article provides a historical summary of the different phases of research on the small-world problem, and summarizes the
empirical and theoretical progress on different facets of the small-world phenomenon. The paper concludes with a brief assessment of accomplishments and open questions, suggesting some possible future research areas.

Toivonen (2009) conducted a study on NAMs generating networks containing a large number of cliques and consisting of dense clusters loosely connected with low overlap links. Their clustered structure appears more pronounced than in the data. We find that many of the studied network evolution models (NEMs) produce broader degree distributions and decreasing clustering spectra that agree more closely with empirical data. Most of them also generate assortative networks, although typically not to the same extent as in the data, and many large cliques and $k$-clusters. In the dynamical NEMs, node deletion is seen to produce more assortative networks than link deletion. With respect to their holding by overlap, the dynamical KOSKK model displayed the clearest clustered structure of all the NEMs.

Gao, Guan (2009) conducted a SNA Study by mining the Chinese patent data granted by USPTO during 1995–2002. They found a number of interesting properties of these networks as follows. From the global view, the large giant components with more than 90% of total size of the network exist in the networks for all fields and for the three strongly science based fields. It indicates that in these networks, vast majority of journals are connected via knowledge relations. The three centralization measures for networks, they also found that the network for the Biotechnology is the most centralized in all networks while the network for Telecommunication is the least.

Anne, Wal & Boschma, (2009) social network analysis is a promising tool for empirically investigating the structure and evolution of inter-organizational interaction and knowledge flows within and across regions. However, the potential of the application of network methodology to regional issues is far from exhausted. To shed light on the untapped potential of social network analysis techniques in economic geography: they set out some theoretical challenges concerning the static and dynamic analysis of networks in geography. Basically, they claim that network analysis has a huge potential to enrich the literature on clusters, regional innovation systems and knowledge spill over’s.
Carolan (2008) Social network analysis was conducted to identify this core community, the network’s largest ($n = 47$), demonstrates a significant amount of permeability across a fairly broad idea space that promotes readership across specialty areas. There is little topical consensus within the community. Its internal density (30.3%) is relatively high, meaning that slightly over 30% of available relations are present. This high density is surprising given its lack of internal topical consensus.

Grasenick, Wagner and Zumbusch (2008) Analysed was based on automated data retrieval of electronic documents available, e.g. at governmental institutions, research databases, and the internet. Results are exemplified by studying knowledge intensive networks in Styria. The applied set of IT based tools and visualisation of regional co-operations based on SNA provides a comprehensive view of the interdependencies and the embeddedness of different institutions as well as actors of the region. Based on this visualisation conclusions are drawn concerning network management by analysing specific attributes of interest, concerning partners, cooperative behaviour, balance of power, openness and embeddedness of the network. Network benefits success may not be achieved automatically.

Mitev, Nathalie (2008) reported an empirical study of the virtual relationships between books sold by Amazon.com, an American online company, leader in the distribution of a wide range of products and services. The research has focused on the web links among books dynamically generated by a special algorithm according to customers’ purchasing experiences. Those links have been analyzed by using the logic, the models, and the tools of Social Network Analysis. The research has provided interesting results, not only in terms of useful recommendations for future works, but also with regard to practical insights for the publishing industry actors.

Pereiraa, Soaresa, (2007) evaluated collaboration in an organization, offering information on the informal organizational structure that coexists with the formal one and that assumes an important role in the sharing of information and knowledge. It also allows also to determine who effectively collaborates with whom inside of an organization by identifying the “weak points” and the “strong points” of the collaboration inside of the institution and to classify in terms of importance the requirements of a collaborative information management system, leading to
substantial improvements in the processes of managing and sharing information in a collaborative way.

**Allen, James and Gamlen (2007)** conducted study on multi-business firms with a distributed R&D function, such as investigated in this instance, the informal network suggests that problem-solving activity between separated R&D centres and the inherent knowledge sharing which this requires may be highly limited. Instead, this study found that technical personnel appear to collaborate most closely with those in close organizational and geographical proximity to them, rather than with colleagues located in other businesses or regions. In the case of the ICI study, formally prescribing the memberships of various collaborative and knowledge-sharing structures was found to result in fragmented groups and little collaboration on problem-solving issues. It is considered likely that such structures might be more effective and productive if their membership were instead advised by social network analysis studies. Such an approach would potentially reveal more fruitful collaborative relationships and areas where Group wide collaborations may be nurtured and extended.

**Borgatti, Everett (2006)** described the notion of centrality in purely graph-theoretic terms: what all measures of centrality do is assess a node’s involvement in the walk structure of a network. This is the graph-theoretic answer to the question ‘What do centrality measures measure?’ We have suggested that centrality measures differ along four key dimensions: choice of summary measure, type of walk considered, property of walk assessed, and type of involvement. The choice of summary dimension has the least variance, consisting mostly of simple sums and averages, along with a few exemplars of weighted sums (e.g., eigenvectors) and centroids. The type of walk dimension distinguishes measures based on edges, geodesics, paths, trails and walks. The property of walk dimension distinguishes between volume and length measures. The type of involvement dimension distinguishes between radial and medial measures.

**Borgatti (2005)** studied social network analysis using Simulations to examine the relationship between type of flow and the differential importance of nodes with respect to key measurements such as speed of reception of traffic and frequency of receiving traffic. It is shown that the off-the-shelf formulas for centrality measures are
fully applicable only for the specific flow processes they are designed for and that when they are applied to other flow processes they get the “wrong” answer. It is noted that the most commonly used centrality measures are not appropriate for most of the flows we are routinely interested in.

Hatala (2006) introduced social network analysis as a unique methodology for studying social relationships of importance to HRD. SNA will add significantly to the field by measuring the relations that exist between individuals and the impact those relations will have on human capital output. In addition, SNA will help further develop the field of HRD by enabling researchers to analyze the interaction between individuals and their environment. Social network analysis can add empirical rigor to such diverse areas as organizational change, instructional design and training delivery. The practical utility of SNA can assist HRD practitioners in measuring intervention effectiveness and its impact over time.

Cantner, Graf (2006) the social network analysis a success-breeds-success mechanism on the level of the technology will then lead to an increasing specialization of the system in these technologies. The same dynamics regarding the network positions of entering and exiting innovators are observed when analysing the cooperation and scientist mobility networks. Other studies of this type will have to find evidence in favour of the hypothesis that network positions are a crucial factor in explaining the innovative performance of the actors. It has been suggested that the partnering in R&D cooperation is a problem for firms and has even led to political intervention.

Borgatti, Molina (2005) study reveals probability sample of North Americans about their attitudes toward the environment just does not seem very threatening. As a result we have called for expanding the standard consent form which they view as a simple contract between researcher and participant. So that it essentially becomes an agreement between all three parties, namely researcher, participant and management. In addition, they have suggested various design features that can make network data collection a better experience for respondents and, in so doing, help ensure the future of network research.

Aviv et.al. (2003) Asynchronous Learning Networks (ALNs) make the process of collaboration more transparent, because a transcript of conference
messages can be used to assess individual roles and contributions and the collaborative process itself. The analyzed data from two three-month long ALN academic university courses: a formal, structured, closed forum and an informal, non-structured, open forum. We found that in the structured ALN, the knowledge construction process reached a very high phase of critical thinking and developed cohesive cliques. The students took on bridging and triggering roles, while the tutor had relatively little power. In the non-structured ALN, the knowledge construction process reached a low phase of cognitive activity; few cliques were constructed; most of the students took on the passive role of teacher-followers; and the tutor was at the centre of activity. These differences were statistically significant.

White (2003) conducted social network analysis resulting in Two-dimensional PFNETs made with a spring embedded can quickly present up to ca. 200 authors’ names for simultaneous viewing. They can actually present many more names than that, but a range of ca. 25 to ca. 125 seems attractive for three reasons. First, numbers in that range correspond to the size of typical invisible colleges or specialty groups and adequately suggest a given field in terms of its leading researchers. Second, as mapped names are pushed into the hundreds, the cognitive load on the viewer increases; at some point there are simply too many names and relations to absorb, and the viewer’s interest flags. Third, while authors’ names make simple and effective labels, a surfeit of nodes results in label overlap and, quite often, impenetrable thickets of links. Both impede communication.

McPherson, and Cook (2001) the idea of homophily is an old concept, talked about by Aristotle and Plato. It is also a long held common sense understanding of the social world, hence the title ‘birds of a feather’. The authors of this article define homophily as follows: “Homophily is the principle that a contact between similar people occurs at a higher rate than among dissimilar people. The pervasive fact of homophily means that cultural, behavioural, genetic, or material information that flows through networks will tend to be localized”.

Newman (2001) an algorithm for counting the number of shortest paths between vertices on a graph that pass through each other vertex, which is one order of system size faster than previous algorithms, and used this to calculate the so-called “betweenness” measure of centrality on our graphs. We also show that for most
authors the bulk of the paths between them and other scientists in the network go through just one or two of their collaborators, an effect that Strogatz has dubbed “funnelling.”

Zeggelink (1995) found that individual-oriented approach to model the evolution of networks. In this approach, the dynamics of friendship network structure are considered as a result of individual choices with regard to friendship relationships. Individuals have specific characteristics and behavioral rules. The previous model was based solely on individuals' different needs for social contact. In the model presented here, we introduce another important determinant of friendship formation: preferences for similar friends. The amount of heterogeneity of the distribution of individual characteristics on which this similarity is based thus becomes important. In contrast to most existing dynamic social network models, this aspect of heterogeneity, as well as dependence of dyads, can easily be dealt with. We examine how individual characteristics and preferences (individual attributes at the micro level) with respect to prospective friendship relations interact and aggregate to outcomes at the macro level: the network structure.

Tichy, Tushman, & Fombrun (1979) the social network framework, methods, and a case example were presented to support our claim that significant advances can be made in organization theory and research using this approach. Such optimism for the future of social network analysis is not meant to hide the considerable hurdles ahead. Many significant problems need to be overcome before we can speak of a network paradigm.

2.6 SNA of Authorship Studies

The sub-division Social network analysis of authorship studies is purely dedicated to authorship studies conducted using social network analysis. The enumerated list of articles gives a proof of that many of researchers has already applied social network analysis for understanding the network of authors, it also proves that the area chosen by investigator for the research has not been attempted previously by any researchers, this strengths the reason for chosen statement of the problem or research.
Zervas et.al. (2014) studied in different research areas, so as to provide useful insights on how researchers combine existing distributed scientific knowledge and transform it into new knowledge. Commonly used metrics for measuring research collaborative activity include, among others, the co-authored publications (concerned with who works with whom) and the citations (concerned with who cites who). Within this context, in this paper, we focus on the co-authorship network of researchers who collaborate in Technology-enhanced Learning (TeL). This is achieved through the example of the Educational Technology & Society (ETS) Journal, where Social Network Analysis (SNA) metrics are applied for analyzing the co-authorship network of the journal. The results of our analysis provided us with evidence that the key authors of ETS Journal co-authorship network have a Taiwanese national background and they have established a strongly connected group that collaborates frequently, diversely and widely.

Abbasia, Altmann, Hossaina (2011) developed a theoretical model based on social network theories and analytical methods for exploring collaboration (co-authorship) networks of scholars. Results from our statistical analysis using a Poisson regression model suggest that research performance of scholars (g-index) is positively correlated with four SNA measures except for the normalized betweenness centrality and the normalized closeness centrality measures. The results related to efficiency show that scholars, who maintain a strong co-authorship relationship to only one co-author of a group of linked co-authors, perform better than those researchers with many relationships to the same group of linked co-authors. The negative effect of the normalized eigenvector suggests that scholars should work with many students instead of other well-performing scholars. Consequently, we can state that the professional social network of researchers can be used to predict the future performance of researchers.

Perianes-Rodríguez et.al. (2011) provided insight into business involvement in the R&D system based on: research papers published; national, international and sectoral collaboration patterns; structural patterns; and the identification of the most prominent companies from a systematic comparison of their research results and their position in the resulting collaboration network. The emphasis on the essential role of collaboration in improving scientific results, as borne out by the correlation between the clustering coefficient and the hybrid indicators. The findings also provide proof of
the success of strategies for institutional collaboration. The foregoing shows that the application of hybrid indicators to institutional aggregates yields novel results not explored in preceding studies.

**Nikzad, Jamali, Hariri (2011)** conducted a study on Degree of Collaboration (DC) and Collaboration Coefficient (CC) was calculated for each discipline. Results show that two or three authors were the most common number of authors per paper, and authors of PSY tended to have more multi-authored articles, compared to the other disciplines. LIS had the lowest rank regarding CC. MNG had the densest co-authorship network and PSY had the sparsest. Iranian authors in the field of PSY mostly collaborated with those in the U.S., while LIS and MNG authors tended to collaborate with U.K. authors, and ECO authors tended to collaborate with Canadians.

**Snijdersa, van de Bunt, Steglichc (2010)** introduces the use of actor based models for analyzing the dynamics of directed networks – expressed by the usual format of a directed graph – and of the joint interdependent dynamics of networks and behaviour – where ‘behaviour’ is an actor variable which may refer to behaviour, attitudes, performance, etc., measured as an ordinal discrete variable. The purpose of these models is to be used to test hypotheses concerning network dynamics and represent the strength of various tendencies driving the dynamics by estimated parameters. To be useful in this way for statistical inference, the models must be able to give a good representation of the dependencies between network ties, and between network positions and behaviour of the actors.

**Everetta, Borgatti (2010)** decomposed total centrality into an endogenous part, which is the base measure of centrality used to construct the invariant, and an exogenous part, which is the difference between the total centrality and the endogenous part. The exogenous centrality can be interpreted as the indirect contribution a node makes to the centrality of all the other nodes. We then show that we can construct a node by node contribution matrix that gives the amount of centrality contributed by each node to each other node’s centrality, thereby indicating the latter node’s dependency on the former node. Our examples have focused on centrality measures which are derived from shortest path type considerations, but as we have noted this technique are applicable to other variants such as maximum flow.
Johnson et.al. (2010) explained why, as a late and unplanned reaction to this, but also in contradiction with ANT principles, it ended up complementing ANT with Clegg’s theory of power to bridge that gap. The paper concludes with a discussion of where the difficulties lie in using ANT and how it can be misused in IS research; the author argues that this is due to a lack of exposure to post-structuralism in IS research, compared with other management-related disciplines; and that recent efforts by scholars in the science and technology studies field to combine constructivist approaches such as ANT with critical social analysis should be considered.

Perianes-Rodríguez et.al. (2010) the findings provide insight into business involvement in the R&D system based on: research papers published; national, international and sectoral collaboration patterns; structural patterns; and the identification of the most prominent companies from a systematic comparison of their research results and their position in the resulting collaboration network.

Olmeda-Gómez et.al. (2009) conducted a social network analysis study of Spanish inter-university collaboration patterns appear to be influenced by both geographic proximity and administrative and political affiliation. Inter-regional co-authorship encompasses regional sub-networks whose spatial scope conforms rather closely to Spanish geopolitical divisions. Papers involving international collaboration are written primarily with European Union and North and Latin American researchers. Greater visibility is attained with international co-authorship than with any other type of collaboration studied. Impact was measured in terms of journals rather than each individual paper. The co-authorship data were taken from the Web of Knowledge and were not compared with data from other databases. The data obtained in the paper may provide guidance for public policy makers seeking to enhance and intensify the internationalization of scientific production in Spanish universities. The Spanish university system is in the midst of profound structural change. This is the first paper to describe Spanish university collaboration networks using social network visualization techniques, covering an area not previously addressed.

Latapy, Magnien b, Vecchio (2008) showed that in random networks the average degree of neighbours of a node is independent of the degree of the node: it forms an horizontal line, indicating that it is a constant (roughly equal to 32). Instead, in the same plot, one sees that for high degree nodes the average degree of their
neighbours tends to be smaller than for lower degree nodes, thus indicating that high degree nodes are more linked to low degree nodes than others (and more than if links were random). In terms of the underlying data, it shows that if a movie has many actors, then many of these actors played in few movies only.

Englebrecht, Hanke, Kuang (2008) examined several important aspects of co-authorship by accounting researchers in premier journals for the years 1979–2004. Logistic regression analysis reveals that collaboration is growing significantly. This increasing trend of co-authorship is substantially greater in premier non-accounting journals than premier accounting journals. The extent of co-authorship within taxation research is notably less than financial, managerial, or auditing research. On the other hand, non-specialized articles have significantly higher co-authorship ratios. Meanwhile, trends of co-authorship are not statistically different between U.S. academic researchers and their international academic cohorts.

Fenner, Levene, Loizou (2007) made an extension of Simon’s classical stochastic process that results in a powerlaw distribution with an exponential cut off. When viewing the stochastic process in terms of an urn transfer model, the difference from the classical process is that, after a ball is chosen on the basis of preferential attachment, with probability $1 - q$ the ball becomes inactive. By following a mean field approach, we derived the asymptotic formula, which shows that the distribution of the numbers of balls in the urns approximately follows a power-law distribution with an exponential cut off.

Batagelj, Mrvar (2007) conducted Social network analysis which turns out to be very useful in the research of genealogies. Three different representations of kinship data were discussed: the Ore graph, p-graph, and bipartite p-graph. Several interesting results in large genealogies can be found by just using standard network analysis approaches, for example shortest paths, network multiplications, and fragment searching. For each application, suitable representation should be selected. They demonstrated that p-graphs are more suitable for searching for relining patterns, whereas Ore graphs are more suitable for computing additional kinship relations using network multiplication. Because some genealogies can be very large networks, only fast (i.e., sub quadratic) algorithms can be used. Such algorithms have been developed and included in the program Pajek.
Sharma and Urs (2007) investigated the networks of ‘academic community’ of Digital Library (DL) using various Social Network Analysis (SNA) tools and metrics. Digital Library emerged from convergence of several fields. This study gave insight of how an interdisciplinary discipline evolved and emerged, Based on the premise that the community structure of the academic community reflects the knowledge structure of the field. Concluded on the dynamics of the digital libraries is small world.

Wray (2006) Collaborative research threatens the motivation of scientists. As a result, collaborative research may have adverse effects on what sorts of things scientists can effectively investigate. Second, collaborative research makes it more difficult to hold scientists accountable, that the authors of multi authored articles are aptly described as plural subjects, corporate bodies that are more than the sum of the individuals involved. Though journal editors do not currently conceive of the authors of multi-authored articles this way, this conception provides us with the conceptual resources to make sense of how collaborating scientists behave.

Acedo (2006) carried exploratory analysis of co-authorships in the field of management from the two aforementioned approaches. The results obtained show a growing tendency of the co-authored papers in the field of management, similar to what can be observed in other disciplines. The study analyses some of the underpinning factors, which have been highlighted in the literature, explaining this tendency. Thus, the progressive quantitative character of research and the influence of the collaboration on the articles’ impact are enhanced. The network analysis permits the exploration of the peculiarities of the management in comparison with other fields of knowledge, as well as the existing linkages between the most central and prominent authors within this discipline.

Barabasia et al. (2002) studied co-authorship network of scientists represents a prototype of complex evolving networks. The results indicate that the network is scale-free and that the network evolution is governed by preferential attachment, affecting both internal and external links. The combined numerical and analytical results underline the important role internal links play in determining the observed scaling behaviour and network topology. The results and methodologies developed in the context of the co-authorship network could be useful for a systematic study of
other complex evolving networks as well, such as the World Wide Web, Internet, or other social networks.

Newman (2001) found a number of significant statistical differences between different scientific communities. Some of these are obvious: experimental high-energy physics, for example, which is famous for the staggering size of its collaborations, has a vastly higher average number of collaborators per author than any other field examined. Other differences are less obvious, however. Biomedical research, for example, shows a much lower degree of clustering than any of the other fields examined. In other words, it is less common in biomedicine for two scientists to start collaboration if they have another collaborator in common. Biomedicine is also the only field in which the exponent of the distribution of numbers of collaborators is greater than 2, implying that the average properties of the collaboration network are dominated by the many people with few collaborators, rather than, as in other fields, by the few people with many.

Batagelj, Mrvar (2000) conducted a study on Patrick Ion Mathematical Reviews and Jerry Grossman Oakland University maintain a collection of data on Paul Erdo˝s, his co-authors and their co-authors. These data can be represented by a graph, also called the Erdo˝s collaboration graph. In this paper, some techniques for analysis of large networks different approaches to identify ‘interesting’ individuals and groups, analysis of internal structure of the main core using pre specified block modelling and hierarchical clustering and visualizations of their parts, are presented on the case of Erdo˝s collaboration graph, using the program Pajek.

Ding, Foo, Chowdhury (1999) studied co-authorship patterns over time there is a possibility to test or evaluate various assumptions and science policies, in so far as they relate to scientific collaboration. The Perceptible increase in the collaborative research in the field of IR from 1987 to 1997 was noted. The authorship per paper has been increasing from 1.52 per paper in 1987 to 2.26 per paper in 1997. IR collaborative papers appear in almost all the core IR journals. The inter- and intra-disciplinary scholarly communications on IR collaborative researches cover very broad areas with Psychology, Computer Science and Medical Science as the most distinctive areas. Geographical proximity plays a significant role in IR collaboration. The greater the geographical distance the greater is the impediment to IR collaboration.
2.7 Inferences:

Based on the review literature the investigator came to following research insights i.e

- Scientific collaboration is most interesting field of research and a lot of research has been carried out to understand the collaboration among scientist.

- Majority of study revealed that there is significant difference in social science and science collaboration i.e. in science collaboration percentage is high compare to social science.

- The reason behind the high percentage of collaboration in science has not been studied much i.e. psychological, economical and political reasons which promote/ avoid collaboration among scientist.

- The studies revealed that there is significant difference in collaboration among developed countries and developing countries i.e. under development countries tend to collaborate with developed country scientist. But reasons for this are not much studied.

- Application of social network analysis to study the author collaboration has been carried to in humanities but Life science has not been done.

2.8. Conclusion

The review of literature related to research problem gave clear view of previous studies conducted in the field, along with the implications and limitations of the study. The categorised reviews along with chorological representations highlight the researcher ideology flow over the years. The review literature identified the fact there is no such studies on author collaboration of biotechnology is carried using social network analysis and scientometrics. The major research carried in area of SNA of author studies and collaboration studies are from USA and European countries. There is not much studies are carried in India for studying the author network along scientometrics of particular area of research. The studies from Indian scientists were more focused on Scientometrics, citation studies, bibliometrics etc. but the author network as such is not studied in LIS field. The Spanish scientist Perianes-Rodríguez et.al. as however conducted study of SNA of author collaboration, but whole network of particular area or discipline is not been attempted by previous researchers in the LIS field. To this extent, it is justified that the present study is the first of its kind that has investigated author collaboration of Biotechnology journals.
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