SCIENTOMETRIC PORTRAIT OF R. CHIDAMBARAM: A PUBLICATION PRODUCTIVITY ANALYSIS

Publications R. Chidambaram, the well known Nuclear Physicist have been analysed by year, domain, collaboration pattern, channels of communications used, keywords etc. in this paper. The results indicate that the he is eminently qualilied to be taken as a 'role model' for the younger generation to emulate.

V.L. KALYANE AND B.S. KADEMANI

ABSTRACT

R. Chidambaram, the well known Nuclear Physicist is widely recognised as a very successful scientist. His publications were analysed by year, domain, collaboration pattern, channels of communications used, keywords etc. The results indicate that the temporal variation of his productivity and of the types of papers published by him is of such a nature that he is eminently qualified to be taken as a 'role model' for the younger generation to emulate. He has to his credit 17 papers in 'Nuclear Magnetic Resonance', 64 papers in 'Neutron Diffraction and Hydrogen Bonding; 46 papers in 'High Pressure and Shock Wave Physics', 10 papers in 'Quasicrystals' and 27 papers of 'General' interest.

The highest collaboration coefficient (1.0) was observed during 1964-67, 1969, 1971, 1973-75, 1977 and 1982. The publication productivity coefficient was 0.66.

He has published his papers through 49 journals. The core journals wherein he has published his papers were 'Acta Crystallographica-B', 'Pramana' and 'Current Science'. Publication density was 2.34 and publication concentration was 20.40.

V.L. KALYANE and B.S. KADEMANI are serving at Library and Information Services Division, Bhabha Atomic Research Centre, Trombay, Bombay - 400 085

During the publication period of 30 years S.K. Sikka had collaborated in 52 papers whereas during 28 years A. Sequeira had collaborated in 25 papers with him. Other prominent collaborators having 13 papers each in collaboration with him were S.C.Gupta, B.K. Godwal and S.M. Sharma during 20 years, 13 years and 15 years respectively.

1. INTRODUCTION

Most scientific and technological activities in India is funded, directly or indirectly, by public money and virtually all scientists and technologists of today are salaried people employed in organisations and this leads to the requirement of continuous assessment of performance, both of the individual scientist or technologist and of the institution or organisation. There is a need to assess the performance on a continuous basis, to ensure that neither the scientist or technologist nor the administrative structure within an institution or organisation, get stratified and, therefore, fossilised (1).

The Comptroller and Auditor General report complained about inefficient use of funds, not lack of resources, was responsible for the failure of scientific departments to meet their targets. To this statement various scientists responded. M.G.K. Menon insisted that "auditors do not always have a clear understanding of scientific research". Yash pal emphasised the accountant's norms" cannot be the same for assessing productivity or efficiency" in scientific research. (2).

Scientists are worried because, India was investing 1.1 percent of the Gross National Product (GNP) in research and development (R&D) which was reduced in 1991 to less than 0.9 percent. (3,4).

India's national expenditure on R&D as percentage of the GNP continued to fall during 1992-93, according to data published by the Indian Department of Science and Technology (DST).

The country's total expenditure on R & D was US $ 1,754 million in 1992-93. In absolute terms, this represents an increase on the previous year. But as a fraction of GNP, the total budget has been declining steadily since 1988-89, when it peaked at 0.96 per cent of GNP.

In 1991-92, this fell to 0.84 per cent of GNP, and it dropped still further to 0.83 per cent during 1992-93. This is far below the target of two per cent contained in a new science and technology policy.

According to the DST report, most of this money still comes from central and state governments. The private sector share of national R & D expenditure was on 15 per cent of the total, and industry spent only 0.57 per cent of its sales turn over on R & D (5).

It was observed that scientists in the developing countries produce an estimated five per cent of the world's scientific literature. Although this represents a small portion of the whole, it is remarkable - a given social, economic, and sometimes political advancements - that the output is as it is (6).

Venkataraman expressed the mystery why, though endowed with so many resources, we are doing so badly while Japan, which has no iron, no coal, no oil and no minerals, is thriving so well. (7).

Despite its late start, China has published many more collaborative papers with most Asian countries and the advanced countries of the west, except the UK, than India - confirming the effectiveness of the open door policy of post-Mao China (8).

S.N. Bose also wondered while delivering the K.S. Krishnan memorial lecture: "It is a perpetual challenge to the Indian genius as to how, even though the country is endowed with such natural resources, even though the country has had such a brilliant history, it continues to be third rate."

C.V. Raman had said : "What we lack is perhaps courage, what we lack is perhaps a driving force which takes one anywhere. We have, I think, developed an inferiority complex. I think what is needed in India today is a destruction of that defeatist spirit."

While writing a book review, Krishna commented that "most of the developing countries lack local 'role models' to motivate other scientists." (9).

No doubt India has made some important and high quality contributions in selected areas of science. But the total scientific scenario in the country is not altogether encouraging. There are very few men and institutions of excellence. The morals and performance of the average working scientist are not very high (10). Concerns are expressed over the slow pace of research and the overall poor quality of science in India (11).

Thus there are several aspects of national R & D activities which are being debated recently. Let us follow positive approach of 'role model scientist'. There are individual scientists who have been doing good work. If we can project image of such scientists, it may be possible to attract talents of younger generation by inspiring them through success stories. It may encourage younger scientists to continue in the honourable profession with vigour and determination to overcome hurdles and contribute their might to Indian Science and Technology.

It is said that we are increasingly moving, and moving faster and faster from an age of things to an age of thoughts, and age of mind over matter. In this new age, it is the mind of man free to invent, free to experiment, free to dream, that is our most precious resource. The value of silicon chip does not lie in the sand from which it comes, but it lies in the microscopic architecture engraved upon it by ingenious human mind. The most promising superconductors are made from ceramics - their value does not come from their material, but from the brilliant inspiration of a few scientists. It is human imagination that is going to build the 21st century out of sand and clay (12).

Existing biographies of scientists are descriptive in nature. There are a very few countable attempts made recently to highlight 'role model scientist' using quantitative methods of Bibliometrics, Informetrics, and Scientometrics (13 - 29).

Scientometrics provides an understanding of the structure of scientific activity, the disciplines being researched, the organisations involved, the strengths and deficiency in the scientific groups and their communication channels. Research productivity of a scientist is determined primarily by the ability to (i) recognise a good research problem, (ii) obtain the resources needed to work on this problem, (iii) plan and execute the research project, (iv) write up the results, and iv) perseverance in getting the results published.

2. BIOGRAPHICAL NOTE

Rajagopala Chidambaram was born on 12th November 1936 at Madras in Tamil Nadu. He obtained his B.Sc. (Hons.) degree in Physics in 1956 securing the first rank and M.Sc. in Physics by research in 1958 from Madras University. His M.Sc. thesis dealt with the design of an analogue computer for Fourier summation in crystallography. He started his scientific career at Indian Institute of Science, Bangalore and obtained his Ph.D. in 1962. The thesis was awarded the Martin Foster Medal for the best thesis submitted to the Institute during the two year period 1961-62. He has collaborated with G.M. Brown and published 7 papers during 1965-73.

R. Chidambaram has made outstanding contribution in various fields namely 'Nuclear Magnetic Resonance', 'Neutron diffraction and Hydrogen Bonding', 'High Pressure and Shock Wave Physics', and 'Quasicrystals'.

He placed emphasis on indigenous development of sophisticated instruments for research. The high precision neutron scattering studies carried out by his research group have been possible because they pioneered the design and construction of sophisticated neutron diffractometer in the country. The research groups he has built over a period of time are considered among the best in the world. He has received several honours for his contribution.

- Chairman of the Session on 'Hydrogen Bonding in Hydrates' at the International Union of Crystallography congress in Stony Brook, USA in 1961.
- Visiting Expert of the IAEA on Neutron Diffraction to the Philippine Atomic Energy Commission (1967-68).
- Consultant and member on the Technical Committee on peaceful Nuclear Explosion of IAEA (1970-77).
- Padma Shri' Award in 1975 for his key role, in the 'Peaceful Nuclear Experiment' at Pokhran on May 18, 1974.
- Honorary Professor at the Jawaharlal Nehru Centre for Advanced Scientific Research at Bangalore since 1990.
- Distinguished Alumni' award by the Council of the Indian Institute of Science and the Indian Institute of Science Alumni Association in 1991.
- D.Sc. by Indian Institute of Science, Bangalore in 1991.
- President, Physics Section of the Indian Science Congress for 1991-92.
- Second Jawaharlal Nehru Birth Centenary International Visiting Fellowship by the Indian Science Academy in 1992 to visit Germany and Japan.
- Chairman, Board of Governors of the International Atomic Energy Agency (1994-95).

He is also an elected fellow of the Indian Academy of Science, Bangalore, and Indian National Science Academy, Delhi. There are several other awards/honours bestowed on him in recognition of his outstanding contributions to the field of nuclear science and technology (30, 31).

He worked in several national and international committees. He shouldered leadership and administrative responsibility in several capacities as Head, Neutron Physics Section, 1962; Head, Neutron Physics Division, 1981; Director, Physics Group 1984; Director, BARC, 1990; and Chairman, AEC, since 31st January 1993 onwards.

During all these years he has published a number of papers on a variety of topics. He has guided the scientific career of many scientists as 'Mentor' and has written a number of papers in collaboration with them. An analysis of his productivity of the domains in which he has worked and of the scientists with whom he has worked is highlighted quantitatively in this paper. The outstandingly cited and most significant papers of R. Chidambaram has already been carried out. The study regarding citation analysis of all publications (32) has also been carried out.

3. METHODOLOGY

The choice of the unit of analysis has a strong influence on the measures and results of any bibliometric study. Up-to date Bibliography of publications of R. Chidambaram (1958-1993) was compiled and considered to highlight following quantitative aspects of his research communications: (i) authorship pattern (ii) domainwise contribution (iii) author productivity, (iv) use of channels of communication, and (v) documentation of keywords from titles of articles.

Normal count procedure (33) gives full credit to all contributors because each appearance of the author's name in the by-line is counted, regardless of whether he happens to be the first or the last author. If a scientist puts his name to a report he should have been directly involved in at least some part of it, contributing to either planning, doing, or analysing the study, or writing the paper. It is widely recognised that scientists all over the world look at their own papers exclusively in that way.

The collaboration co-efficient (34) in a domain was defined as the ratio of the number of collaborative research papers to the total number of research papers published in the domain during a certain period of time.

Productivity Co-efficient (26) was defined as the ratio of 50 percentile age to the total productivity age.

Publication Density (35) was defined as the ratio of the total number of papers published to the total number of journals in which the papers were published, and Publication Concentration was defined as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study.

4. RESULTS AND DISCUSSION

During the years 1958 - 1993, R. Chidambaram has published 164 papers out of which single authorship papers were 50 (30.49%). Two authorship papers were 30 (18.29%). Three authorship papers were 49,(29.88%). Four authorship papers were 25 (15.24%). Five authorship papers were 6 (3.55%). Six authorship paper was only one (0.61). and Eight authorship papers were three (1.83%).

Domainwise contributions indicate that he has published 17 papers (10.37%) in 'Nuclear Magnetic Resonance', 64 papers (39.02%) in 'Neutron Diffraction and Hydrogen Bonding', 46 papers (28.05%) in 'High Pressure and Shock Wave Physics', 10 papers (6.10%) in 'Quasicrystals', and 27 papers (16.46%) of 'General' Category.

Publication output of R. Chidambaram is depicted in Fig. 1 as main author papers, single author papers, multiauthorship papers, total publications, collaboration co-efficient, his age, and career advancement with time.

The highest collaboration co-efficient (1.00) was observed during 1964-67, 1969, 1971, 1973-1975, 1977, and 1982. He has published his first paper in 1958 when he was of 22 years age.

His Productivity Co-efficient was 0.66 which clearly indicated that his high productivity period started after 50 percentile age of his scientific career under consideration.

His most productive years were 1990 having 10 papers and 1991 having 15 papers.

It is said that mathematicians publish more in early life and biologists work more in the middle of their careers (26). The productivity co-efficients for various INSA Fellows in physical sciences were as follows.

K. Banerjee (0.3), B.B. Bhoumik (0.8), J.C. Bose (0.6),

B. Chatterjee (0.7), G. Chatterjee (0.4), S.N.Kapur (0.7),

K. R. Krishnaswamy (0.3), D. Narayanamurty (0.6), D.A. Ramdas (0.5), M.K.V. Bappu (0.6), and R.B.B. Venkatachar (0.8).

The general finding (36-39) was that scientists publish most frequently in their fourth decade of life and there after publication rate drops. Zuckerman (40) compared age distribution of American Nobel Laureates in Science with the age distribution of American Scientists in general. The majority of the Nobel Laureates were relatively young when they had made their prize winning discovery, but the majority of American scientists also were relatively young. Since the age distribution for laureates matches that for scientists in general, he concluded that when allowance is made for the number of scientists at different ages, younger scientists are not more likely to be creative. However, due to their greater numerical representation, younger scientists are responsible for substantially more important contributions than older scientists. The issue of productivity and age is important to scientific endeavour. If Productivity declines with age, then scientific capacity may be affected by an older age structure in science.

Two peak periods of high productivity during five year periods 1981-85 (having 28 papers), and 1986-90 (having 35 papers) were observed in case of R. Chidambaram at the age of 45-49 and 50-54 respectively.

Lehman (41) found the majority of discoveries in science have come from individuals under the age of 40. The peak age for achievements differed between disciplines, ranging from 26-30 for Chemistry to 36-40 for genetics, geology, physiology, and psychology. Scientists remain productive in the sense of publishing frequently, beyond 40, but what they then generate was less likely to have impact. His general conclusion was that genius does not function equally well throughout the years of adulthood. Superior creativity rises rapidly to a maximum which occurs usually in the thirties and then falls of slowly. Einstein was reported (42) to have said of scientists that "a person who has not made his great contribution to science by the age of thirty will never do so".

Prof. H.C. Brown, who is a Nobel Laureate has done some very original work after his 70th year and long after winning the Nobel prize and he still publishes 30 papers a year. Prof. Sir Neville Mott, one of the greatest minds in solid state science, retired at 67 as Cavendish Professor at Cambridge. He then decided to pick a new problem and got a Nobel prize for that (43).

The "success breeds success" phenomenon had its limits, (44) a saturation takes place and instead of accelerating of a production rate, prolific authors are satisfied with their position and produce less than could be expected from Lotka's law. Whereas Allison and Stewart (45) stated that among highly skewed distribution of productivity among scientists could be partly explained by a process of accumulative advantage. The publication productivity was found to be increasingly unequal as the career age increased.

Studies of stratification in science have increasingly accepted the idea that science is a highly stratified and elitist system with skewed distributions. Attempts to explain the higher productivity of higher status scientists by pointing to their greater ease of publication as far as acceptance of their work by journals and publishers is concerned were not supported by the data in some recent studies. If status in general does not confer greater ease of publication in the paper (46) position within a research organization does confer greater ease of author or coauthorship and this was the major explanation variable accounting for productivity difference within research laboratories as far as quantity of articles was concerned. Upward moves in laboratory's formal or informal position hierarchy were associated with a change of a scientist's research involvement from goal executing to goal setting functions as well as with an increasing access to scientific manpower and project money. Goal setting tasks provided for a significant reduction of time expenditure in research necessary to assure that the scientist was identified with the research results; consequently, they allowed for an involvement in more research tasks than originally. Equivalently, resources in scientific manpower and project money act as a multiplying element as far as quantity of output was concerned.

This agrees with various scholars who have noted a growing trend toward multiple authorship of scientific papers (47-53). Later studies (54) found, instead of one peak the productivity of researchers was shown to have two modes. One before the age of 40 and second around the age of 50. Researchers, it was suggested, may reach one type of plateau for innovative work and then, at a later stage, a second plateau for integrative work. Veteran R & D professionals will consists of those who devote most of their time to administration and those who are still active in technical work. The two mature types are basically similar in academic background and in their readiness to develop products, but they differ in their commitments to the scientific community and in the desire for greater extrinsic rewards (55).

Domainwise publications of R. Chidambaram is depicted in Fig.2. He has very high productivity in 'Neutron Diffraction and Hydrogen Bonding', medium productivity in 'High pressure and Shock Wave Physics' and low productivity in 'Nuclear Magnetic Resonance'.

'Quasicrystals', and 'General' papers when we consider only the number of papers published by him.

Authorship pattern in various domains is shown in Tables 1-5 and Figures 3-4.

He had only three collaborators in 'Nuclear Magnetic Resonance' publications. He had 34 collaborators in 'Neutron Diffraction and Hydrogen Bonding'. He had 15 collaborators in 'High Pressure and Shock Wave Physics'. He had seven collaborators in 'Quasicrystals'. He had six collaborators in his 'General' publications.

Domainwise author productivity and distribution of authors and papers is given in Table 6. There were 26 Scientists who have collaborated with R. Chidambaram in only one paper each. Nine scientists have collaborated in two papers each. Two scientists have collaborated in three papers each, and two scientists have collaborated in four papers each. Five to nine papers producing authors in collaboration with R. Chidambaram are considered as active collaborators and they are 14 in number. The high productivity group consists of active researchers having collaboration in number of papers as S.K. Sikka (52), A. Sequeira (25) and R. Chidambaram (164).

The 55 collaborators with R. Chidambaram, their period of association, and authorship is provided in Table 7 and visualised in Fig. 5. Indeed R. Chidambaram was highly influential as 'Mentor' (56).

Blackett was of the view that 'A First rate laboratory is one where even mediocre scientists produce outstanding work'.

Head of the department seem to be most productive researcher. First it may be assured that the most productive scientists become heads, second, heads are 'owners' of almost all scientific results scored in the department headed by him. (46, 57).

Fox (58) summarised the following main factors influencing publication productivity of scientists: psychological characteristics, work habits, age, environmental location, and prestige of department or institution. She concluded that institutional prestige emerged as one of the strongest correlates of publication productivity.

High status departments have the foresight to select those who will become productive and that the positions are allocated on the basis of potential (though not present) contribution (59).

It is obvious that authors publishing only one or few papers during a life time can hardly contribute to the progress of science. Naturally, not all publications of long term authors contain a noticeable scientific contributions, but they "Set the fashion" on the development of science. (60)

"The most important step in getting a job done is the recognition of the problem. Once I recognize a problem I usually can think of someone who can work it out better than I could". A page of Szilardisms included this thought on credit and fame: In life you must often choose between getting a job done or getting credit for it. In sciences, the important thing is not the ideas you have but the decision which ones you choose to pursue. If you have an idea and are not going to do anything with it, why spoil someone else's fun by publishing it? (61).

A researcher is good if he or she surpasses the expectations of what he or she might achieve. But this is only possible if the focus is on work and the problem involves, and not on competition or success. The effectiveness of research or of running an institution depends primarily on the researcher himself, on his models, and within the institute itself, on the respect he shows his staff members, which, in turn, enables him to demand that they work to capacity. (62). Scientists of all disciplines should learn from the humanities.

The duty of scientists and technologists is not only to conduct their own work at the highest possible level of quality but also to make the societies in which they live more aware of the powers and climate of science. Since by definition, scientists and technologists are the first to know of scientific advances they can be described as the cartographers of the future. The must work to ensure that the public, and especially the public's leaders, understand the maps that they draw. The options which are possible and sustainable, so that wise democratic decision can be taken (63).

Nagpaul and Gupta (64) have concluded after study of 1460 research units in six countries that professional competence is a necessary but not a sufficient condition for effective leadership; managerial competence is also required for effective leadership, but professional competence is much more important than managerial competence. This implies, inter-alia, that the quality of leadership cannot be improved merely through management development programmes. It would also be essential and desirable to improve the level of expertise of the leaders through a package of incentives like sabbatical leave to enable them to work at centres of excellence within or outside the country and by inviting leading scientists from such centres to work in the research institutions.

Notani (65) listed the problems of doing great science in India: i) Mastering of a particular field with identification of attendant deep problems awaiting elucidation, ii) think-alikeness and teamsmanship, iii) poor access to new and first hand information, and iv) lack of informed and objective criticism. Material support is required of course, but the foregoing requirements may be needed in equal measure. Good competent science, of course, is being done in several labs.

Max Perutz, one of Britain's most distinguished scientists in his book " Is science Necessary: Essays on Science and Scientists" states: " In Science, as in other fields of endeavour, one finds saints and charlatans, warriors and monks, geniuses and cranks, tyrants and slaves, benefactors and misers, but there is one quality that the best of them have in common, one that they share with great writers, musicians, and artists : creativity". On the other hand there must be caution so as not to uphold orthodox scientists who are as adamant as religious fundamentalists on resisting new ideas destructive to some of their own pet theories and systems of thought. However, it takes belief in ones own ability and ideas, and courage to be a potential rising star and it takes a special kind of person like R. Chidambaram to push out the frontiers of knowledge beyond the current state of the art.

"The creative scientist has much in common with the artists and poet. Logical thinking and an analytical ability are necessary attributes to a scientists, but they are far from sufficient for creative work. Those insights in science that have led to a breakthrough were not logically derived from pre-existing knowledge: The creative processes on which the progress of science is based operate on the level of the subconscious" (66).

Journalwise distribution of publications of R. Chidambaram are given in Table-8. In all he has used 49 journals. Maximum 14 papers were published in 'Acta Crystallographica - B' during 1968 - 1980. He has published eight papers in 'Current Science'. The Publication Density was 2.34 and Publication Concentration was 20.40. He has published one Paper each in high impact factor journals 'Physical Review Letters' (7.375), 'Progress in Materials Science' (6.667), 'Physics Reports' (6.20), and 'FEBS Letters' (3.505). He has published five papers in 'Physical Review B' having impact factor 3.250. He has published four papers in 'Journal of Chemical Physics' having Impact factor 3.433.

Countrywise publishers of the journals in which R. Chidambaram has published his papers revealed their belongingness as : India (45), Denmark and UK 21 each, US (15), Netherlands (10), France (2), and Korea one only.

Distribution of articles as per Bradford law of scatter are given in Table 9. The Bradford distribution (four zones) for publications are given in Table 10 which has resulted in Bradford multiplier (b) of 2.11.

Graphical representation of the number of papers and cumulative number of papers, journalwise are plotted in Fig.6.

Our present study also supports the views of Bonitz (67, 68) who found that the transition from a macroscopic into a microscopic field of scientific communication invalidates the Bradford's law in case of single scientist. Bradford's law applied suites the macrotheme like research output of an institute (69) or country (70) output based studies seem appropriate for studies of the sociology of knowledge because they begin with corpous of written knowledge.

Librarians have been invisible members of the science community for too long. Through the studies in the interdisciplinary domain of scientometrics they can show their visibility. The librarianship profession should share the concern of educators, public servants, and scientists regarding the science literacy crisis. (71). To date, there has been relatively little written in the literature of librarianship about science literacy. The librarianship profession has to play its potentially significant role in the promotion of science literacy.

Logopollution is caused by the production of information that cannot reach its potential users. It is dangerous because it makes useful or vital information unavailable. Factors that influence logopollution include message length, assimilation time, message efficiency and availability, message response, merit, and dispersal. Message packaging should assume new forms in order to reach the right recipient, and him or her only. (72).

A very important purpose for an author writing a paper is for himself. Write in order to learn. Scientists still prefer to obtain their information by talking to other scientists. What they want from journal articles is not really information but stimulation towards the creative thinking which will help them meet the challenges in their area of research (73).

The classic media for science publishing - journals put out by societies and other discipline-oriented organisations - were designed only for the specialists working in the same field as that in which the findings were made (74).

Keywords from the titles of the articles were counted and their frequencies more than two included in Table 11. Highest frequency keywords were: Neutron diffraction (34), High pressures (11), Hydrogen bonding (9), Crystal structure refinement (6), Lithium potassium sulphate (6), Omega phases (6), Phase transitions (6), Positron annihilation (6), Quasicrystals (6), Crystals (6), Proton magnetic resonance (5), and Zirconium (5).

The keywords from the titles of the articles used only once are presented in Table 12.

The results indicate that he had wide ranging interests and superspecialization in the microthemes.

5. CONCLUSION

Achievements of R. Chidambaram in continuous publication productivity indicated his meritorious services to Nuclear Science and Technology. He can be considered as a 'role model' for younger researchers to follow. Knowledge is valuable for its own sake and research has cultural value. Desire of being creative is built in our genes. Who knows this effort may switch on genes for creativity in some of those who happen to read this article. Narrating success stories always has an encouraging effect. It is also important to recognise that excellence in science is not just a matter of a few individual successes, what is required is a wide base of high quality which would enable peaks to come up more frequently and on a more definite basis. New ways to motivate scientists seems as important to contest outcome as new sources of funds. Science policy makers, interested to know about functioning of active research teams as centres of excellence outputs, may find further interest in scientometrics. As per Indian scientific policy Resolution 1958, which our scientists regard as their charter, "to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity" all must work together with holistic approach and synergistic progress.

There is no dearth of ideal role model scientists in India what we lack is the systematic and continuous studies on such scientists. Hence, the comment "Most of the developing countries lack local 'role models' to motivate other scientists" (9) does not hold good at least for India.

6. REFERENCES

1 BHARGAVA (PM) and CHAKRABARTI (C). Accountability in the profession of science and technology. In Accountability of public institutions: emerging issues in the Indian context. Edited by Rao (GSR). Rajaji International Institute of Public Affairs and Administration; Hyderabad, 1991, 141-161.

2 ANON. CAG report: Little to show for crores of rupees spent. Down to Earth. 2 (2), 1993, 14.

3 RAO (CNR). Saving Indian Science. Curr. Sci. 63 (9-10), 1992, 505-508.

4 PADMANABHAN (G). Indian Biology research at cross roads. Curr. Sci. 63 (9-10), 1992, 509-511.

5 JAYARAMAN (KS). India's spending on R&D falls far behind promises. Nature. 370, 18th Aug., 1994, 496.

6 GARFIELD (E). How to boost third world science: an international effort can maintain the information flow. Curr. Content. 19(6), 1988, 4.

7 VENKATARAMAN (G). Assaults on Indian Creativity and Technology. Curr. Sci. 59 (3), 1990, 128-129.

8 ARUNACHALAM (S), SRINIVASAN (R) and RAMAN (V). International collaboration in science: participation by the Asian giants. Scientometrics. 30 (1), 1994, 7-22.

9 KRISHNA (VV) Book review - 'Scientists in the Third World' by JACQUES (GO. Lexington; 1991. In J.Sci. Ind.Res. 50, 1991, 463 - 466.

10 RAO (CNR). Outgoing president's address to the Indian National Science Academy. Science Today. Feb., 1987, 8-9.

11 BHATIA (CR). Science and Technology in poor country. Curr. Sci. 64, 1993, 549.

12 SRIVASTAVA (PN). Science in India. Curr. Sci. 66,(12), 1994, 907-914.

13 KALYANE (VL) and KALYANE (SV). Scientometric portrait of M.S. Swaminathan, Lib. Sci. with a Slant to Documentation and Information

Studies. 31 (1), 1994, 31 - 46.

14 KADEMANI (BS), KALYANE (VL) and BALAKRISHNAN (MR). Scientometric portrait of P.K. Iyengar. Lib.Sci. with a Slant to Documentation and Information Studies. 31(4), 1994, 155-176.

15 KALYANE (VL) and DEVARAI (RS). Informetrics on C.S. Venkata Ram. In New Horizons in Library and Information Science: Dr. Velaga Venkatappaiah Festschrift, Edited by Vashishth (CP), Ramaiah (LS), Jagga Rao (NV), and Prafulla Chandra (TV), Madras, T.R. Publications. 1994, 475 - 478.

16 KADEMANI (BS) and KALYANE (VL). Outstandingly cited and most significant publications of R. Chidambaram (to be published).

17 GUPTA (DK). Plate tectonics: a case study of transmission of ideas. Ann. Lib. Sci. Doc. 25 (1-4), 1978, 86-92.

18 RUFF (I). Citation analysis of a scientific career: a case study. Social Studies of Science. 9, 1979, 81-90.

19 CAWKELL (T) and GARFIELD (E). Assessing Einstein's impact on today's Science by citation analysis. In Einstein: the first hundred years. Edited by Goldsmith (M), MACKAY (A) and WOUDHUYSEN (J). Oxford, Pergamon press, 1980, 31-40.

20 SINHA (SC) and BHATNAGAR (IMS). The information profile of a plant pathologist : a bibliometric study. Ann. Lib. Sci. Doc. 21 (1-4), 1980, 106-113.

21 GUPTA (DK) and GUPTA (S). A citography on Lepichon's article on sea-floor spreading and continental drift: application of Bradford's law. IASLIC Bull. 28 (2), 1983, 49-58.

22 GUPTA (DK). Citation analysis: a case study of a most cited author and his most cited article on see floor spreading. IASLIC Bull. 28 (1), 1983, 1-12.

23 GUPTA (DK). Chandrasekhar: winner of the 1983 Nobel prize for physics: a citation analysis study of his works.
Ann. Lib. Sci. Doc. 30 (3-4), 1983, 177-184.

24 GUAY (Y). Emergence of basic research on the periphery: organic chemistry in India, 1907-1926. Scientometrics. 10 (1-2), 1986, 77-94.

25 KRAGH (H). Dirac Bibliometrics. In Dirac : a scientific biography. Cambridge ; Cambridge University press; 1990, 293-301.

26 SEN (SK) and GAN (SK). Biobibliometrics: concept and application in the study of productivity of scientists. Int. Forum Inf. and Doc. 15(3), 1990, 13-21.

27 TODOROV (R) and WINTERHAGER (M). An overview of Mike Moravcsik's publication activity in physics. Scientometrics. 20 (1), 1991, 163 - 172.

28 GARG (KC) and KARKI (MMS). Bibliometrics of research communications of INSA fellows. J. Sci. Ind. Res. 51, 1992, 929-935.

29 SINHA (SC) and ULLAH (MF). Citation profile of Dr. V.S. Ramachandran: a bibliometric analysis of his highly cited articles and books in the area of cement and concrete Chemistry. Ann. Lib. Sci. Doc. 40 (1), 1993, 21-31.

30. Indian National Science Academy. Profiles in Scientific research. Contribution of the fellows, New Delhi, INSA, 1986, V.1, 149-151.

31 Indian National Science Academy. Fellows of the Indian National Science Academy: Past and Present, New Delhi, INSA, 1984, 101.

32 KADEMANI (BS) and KALYANE (VL). Scientometric portrait of R. Chidambaram: A Citation analysis.

33 PRAVDIC (N) and OLUIC-VUKOVIC (C). Dual approach to multiple authorship in the study of collaboration/scientific output relationship. Scientometrics. 10 (5-6), 1986, 259-280.

34 SUBRAMANYAM (K). Bibliometric studies of research collaboration: a review. Jl. Inf. Sci. 6(1), 1983, 33-38.

35 VINKLER (P). Bibliometric analysis of publication activity of a scientific research institute. In Informetrics 89/90. Edited by EGGHE (L) and ROUSSEAU (R). Elsevier Science Publishers. B.V., 1990, 309-334.

36 COLE (S). Age and Scientific Performance. Am.J.Sociol. 84, 1979, 958-977.

37 OVER (R). Does research productivity decline with age ? Higher Education. 11, 1982, 511.

38 SIMONTON (DK). Quality, Quantity and age: the careers of ten distinguished psychologists. Int. J. Aging. and Human Development. 21, 1985, 241.

39 HORNER (KL) RUSHTON (JP) and VERNON (PA). Relation between aging and research productivity of academic psychologists ? Psychology and Aging. 1, 1986, 319.

40 ZUCKERMAN (H). Scientific elite. New York; Free Press, 1977.

41 LEHMAN (HC). Age and achievement. Princeton University Press; Princeton, 1953.

42 ADAMS (CW). The age at which scientists do their best work. ISIS. 36, 1946, 166.

43 MURTY (I). C.N.R. Rao - Interview. Science Today 2001. July, 1991, 41-42 and 65-68.

44. KUNZ (M). Lotka and Zinf: Paper dragon with fuzzy tails. Scientometrics. 13, (5-6), 1988, 289-297.

45 ALLISON (PD) and STEWART (JA). Productivity difference among scientists: Evidence for accumulative advantage. Am. Soc. Rev. 39, 1974, 596.

46 KNORR (KD) and MITTERMEIR (R). Publication productivity and professional position: Cross-national evidence on the role of organizations. Scientometrics. 2 (2), 1980, 95-120.

47 STRUB (RL) and BLACK (FW). Letter to editor, Multiple authorship. Lancet. 2, 1976, 1090-1091.

48 DARDIK (H). Multiple authorship. Surg. Gynecol. Obstet. 145, 1977, 418.

49 MERTON (RK). The sociology of science: theoretical and empirical investigations. Chicago; University of Chicago press, 1973, 497-575

50 PELZ (DC) and ANDREWS (FM). Scientists in organisations productive climates for research and development. New York, Wiley, 1966.

51 BELGUM (KJ) and SAMI (LK). Research collaboration in agricultural Science. International Library Review. 20, 1988, 57-63.

52 MUNSHI (UM), VASHISHTH (CP) and GAUTAM (JN). Research collaboration in agricultural sciences. ILA Bulletin 28 (3-4), 1993, 57-60.

53 FARR (AD). Multiple authorship of scientific papers. Medical Laboratory Sciences. 41, 1984, 1-2.

54 VINCENT (HF) and MIRAKHOR (A). Relationship between productivity, satisfaction, ability, age and salary in a military R & D organization. IEEE Trans. Eng. Manag. EM - 19 (2), 1972, 45-52.

55 GOLDBERG (AI) and SHENHAV (YA). R & D Career Paths : their relation to work goals and productivity. IEEE Trans. Eng. Manag. EM-31 (3), 1984, 111-117.

56 LONG (JS) and McGINNIS (R). The effect of the mentor on the academic career. Scientometrics. 7 (3-6), 1985, 255-280.

57 PRATT (AD). A measure of Class Concentration in Bibliometrics. Journal of American Society for Information Science. 28 (5), 1977, 285-292.

58 FOX (MF). Publication productivity among scientists : A critical review. Social Studies of Science. 13, 1983, 285-305.

59 LONG (JS) and McGINNIS (R). Organizational context and scientific productivity. Am. Soc. Rev. 46, 1981, 422-442.

60 TROFIMENKO (AP). Scientometric analysis of the development of nuclear physics during the last 50 years. Scientometrics. 11 (3), 1987, 231-250.

61 LANOUETTE (W) and SILARD (B). Genius in the shadows : a biography of Leo Szilard the man behind the Bomb. New York; Charles Scribner's Sons, 1992, 441.

62 MAIER (LH). Science and the humanities - a plea for interdisciplinary communication. Interdisciplinary Science Reviews. 17 (2), 1992, 171-177.

63 DAINTON (L). Knowledge is our destiny. Interdisciplinary Science Reviews. 17(2), 1992, 116-119.

64 NAGPAUL (PS) and GUPTA (SP). Effect of professional competence, managerial role and status of group leaders to R & D performance. Scientometrics. 17 (3-4), 1989, 301-331.

65 NOTANI (NK). Doing good and great science in India. Curr. Sci. 64 (5), 1993, 227.

66 SALK (J) Foreword. In Genius in the shadows: a biography of Leo Szilard the man behind the bomb by LANOUETTE (W) and SILARD (B): New York; Scribner's sons, 1992, xiii - xiv.

67 BROOKES (BC). Derivation and application of the Bardford-Zipf distribution. J. Doc. 24 (3), 1968, 247-265.

68 BONITZ (M). Evidence for the invalidity of the Bradford law for the single scientist. Scientometrics. 2 (3), 1980, 302-214.

69 KALYANE (VL) and KALYANE (SV). Scientometric dimensions of innovation communication productivity system. Ann. Lib. Sci. Doc. 38 (1), 1991, 8-29.

70 KALYANE (VL). Informetrics on neem research in India. Library Science with a slant to documentation and information studies. 30 (4), 1993, 130-214.

71 SAPP (G). Science literacy through popularization : Problems and potential. Sci. Tech. Lib. 12, 1991, 43-57.

72 PERATH (I). Logopollution and ways to prevent it. In Scientific information transfer: the editor's role. Edited by BALABAN (M). Holland; Reidel, 1978, 123-124.

73 ANON. Panel: User's reaction to new techniques in Scientific publishing. In Scientific information transfer: the editor's role. Edited by BALABAN (M). Holland: Reidel, 1978, 59-70.

74 ROY (R). Science publishing is urgently in need of major reforms. The Scientist. 7 (17), 1993, 11 & 12.

Table 1

Authorship pattern of R.Chidambaram and his collaboration in Nuclear Magnetic Resonance Publication

Sr. No.	Authors	I a	II a	II b	Total	%	Cumulative %
1	Chidambaram, R.	12	3	2	17	77.27	77.27
2	Krishnan, S	-	1	2	3	13.63	90.90
3	Krishnan, R.S.	-	1	-	1	4.55	95.45
4	Raghvendra Rao,C	-	-	1	1	4.55	100.00
	Total	12	5	5	22		
	Percentage	54.55	45.45				
	Cumulative Percentage	54.55	100.00				

I = Single author papers   a = First author
II=Two author paper   b= Second author

Table 2

Authorship pattern of R. Chidambaram and his collaborators in 'Neutron Diffraction and Hydrogen Bonding' Publications

Sr.No.	Authers	I	II		III			IV				V					VIII								Total	Percentage	Cumulative Percentage
		a	a	b	a	b	c	a	b	c	d	a	b	c	d	e	a	b	c	d	e	f	g	h			
1.	Chidambaram, R	11	10	8	4	1	23	-	-	-	3	1	-	1			1	-	-	-	1	-	-	-	64	37.86	37.86
2.	Sequeira, A.	-	2	2	4	13	-	-	-	1	-	1	-	-	-	-	-	1	-	-	-	-	1	-	25	14.80	52.66
3.	Sikka S.K.	-	3	1	-	5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	7.10	59.76
4.	Brown, G.M.	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	4.14	63.90
5.	Rajagopal, H.	-	-	-	-	3	-	1	-	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	7	4.14	68.04
6.	Bhakay-Tamhane, S	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3.55	71.59
7.	Ramanadhan, M	-	1	-	4																				5	2.95	74.54
8.	Ramachandran, G.N.	-	-	-	2	-	2																		4	2.37	76.91
9.	Momin, S.N.	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	2.37	79.28
10.	Srikanta, S.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1.77	81.05
11.	Balasubramanian, R	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.19	82.24
12.	Navarro, Q.O.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	2	1.19	83.43
13.	Garcia, A.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	2	1.19	84.62
14.	Linggoatmadjo, K	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	2	1.19	85.81
15.	Shi-Chien, Lin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	2	1.19	87.00
16.	Chandrasekharan, R.	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.19	88.19
17.	Kannan, K.K.	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1.19	89.38
18.	Suh, Il-Hwan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.59	89.97
19.	Bugayong, R.R.	-	-	-	1																				1	0.59	90.56
20.	Gupta, S.C.	-	-	-	1																				1	0.59	91.15
21.	Wadhawan, V.K.	-	-	-	1																				1	0.59	91.74
22.	Soni, J.N.																			1					1	0.59	92.33
23.	Lal, K.														1										1	0.59	92.92
24.	Sing, R.P															1									1	0.59	93.51
25.	Vohra, Y.K				1																				1	0.59	94.10

Table 2 *contd.*

Authorship pattern of R. Chidambaram and his collaborators in 'Neutron Diffraction and Hydrogen Bonding' Publications

Sr.No.	Authors	I	II		III			IV				V					VIII								Total	Percentage	Cumulative Percentage
		a	a	b	a	b	c	a	b	c	d	a	b	c	d	e	a	b	c	d	e	f	g	h			
26.	Sanyal, M.K.			1																					1	0.59	94.59
27.	Vinaykumar				1																				1	0.59	95.28
28.	Madhav Rao, L							1																	1	0.59	95.87
29.	Rao, K.R.								1																1	0.59	96.46
30.	Dasannacharya, B.A.									1															1	0.59	97.05
31.	Jaya, V								1																1	0.59	97.64
32.	Jakkal, V.S.					1																			1	0.59	98.23
33.	Dilip Kumar																								1	0.59	98.82
34.	Ramana Rao, A.																					1			1	0.59	99.41
35.	Gopu, V.M.																						1				
																								1	1	0.59	100.00
	Total	11	18	18	28	28	28	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	169		
	Percentage	6.50	21.30		49.70			7.10				5.93					9.47										
	Cummulative Percentage	6.50	27.80		77.50			84.60				90.53					100.00										

I = Single author papers
II = Two author papers
III = Three author papers
IV = Four Author papers
V = Five author papers

a = First author
b = Second author
c = Third author
d = Fourth author
e = Fifth author
f = Sixth author
g = Seventh Author
h = Eighth author

Table 3

Authorship pattern of R. Chidambaram and his collaborators in 'High Pressure & Shock Wave Physics' Publications

Sr. No.	Authors	I	II		III			IV				V					VI						VIII								Total	Percentage	Cumulative Percentage
		a	a	b	a	b	c	a	b	c	d	a	b	c	d	e	a	b	c	d	e	f	a	b	c	d	e	f	g	h			
1.	Chidambaram, R.	3	4	-	1	-	18	-	-	-	15	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	1	46	29.29	29.29
2.	Sikka, S.K.	-	-	-	3	18	-		2	13	-	-	-	-	3	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	39	24.84	54.13
3.	Godwal, B.K.	-	-	-	4	2	-		2	1	-	-	1	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	13	8.28	62.41
4.	Gupta, S.C.	-	-	1	3	-	1	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	12	7.64	70.05
5.	Sharma, S.M.	-	-	1	3	-	-	2	3	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	11	7.00	77.05
6.	Vijaya Kumar, V.	-	-	-	-	-	-	4	1	-	-	2	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	9	5.73	82.78
7.	Gyanchandani, J.S. (Daswani, J.M.)	-	-	-	1	-	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	8	5.10	87.88
8.	Vohra, Y.K.	-	-	-	4	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	4.46	92.34
9.	Sankaran, H.	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	5	3.18	95.32
10.	Ramsuna, R.	-	-	1	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.64	96.16
11.	Ramanadham, M.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.64	96.80
12.	Meenakshi, S.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.64	97.44
13.	Agarwal, R.G.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	0.64	98.08
14.	Roy, S.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.64	98.72
15.	Suresh, N.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	0.64	99.36
16.	Lakodkar, A.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	0.64	100.00
	Total	3	4	4	19	19	19	15	15	15	15	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	157		
	Percentage	1.91	5.10		36.30			38.21				9.56					3.82						5.10										
	Cumulative Percentage	1.91	7.01		43.31			81.52				91.08					94.9						100.00										

I - Single author papers
II - Two author papers
III - Three author papers
IV - Four author papers
V - Five author papers
VI - Six author papers
VIII - Eight author papers

a - First author
b - Second author
C - Thrid author
d - Fourth author
e - Fifth author
f - Sixth author
g - Seventh author
h - Eighth author

Table 4

Authorship pattern of R. Chidambaram and his collaborators in 'Quasicrystals' Publications

S.No.	Authors	I	III			IV				V					Total	Percentage	Cumulative Percentage
		a	a	b	c	a	b	c	d	a	b	c	d	e			
1.	Chidambaram, R.	1	-	-	2	5	-	1	-	1	-	-	-	-	10	27.78	27.78
2.	Sanyal, M. K.	-	1	-	-	1	5	-	-	-	1	-	-	-	8	22.22	50.00
3.	Nambissan, P. M. G.	-	-	-	-	-	1	5	-	-	-	-	1	-	7	19.44	69.44
4.	Sen, P.	-	-	-	-	-	-	-	6	-	-	-	-	1	7	19.44	88.88
5.	Sahni, V. C.	-	-	1	-	-	-	-	-	-	-	-	-	-	1	2.78	91.66
6.	Sharma, S. M.	-	-	1	-	-	-	-	-	-	-	-	-	-	1	2.78	94.44
7.	Sikka, S. K.	-	1	-	-	-	-	-	-	-	-	-	-	-	1	2.78	97.22
8.	Raghunathan, V. S.	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2.78	100.00
	Total	1	2	2	2	6	6	6	6	1	1	1	1	1	36		
	Percentage	2.78	16.67			66.67				13.88							
	Cumulative Percentage	2.78	19.45			86.12				100.00							

I - Single author papers
III - Three author papers
IV - Four author papers
V - Five author papers

a - First author
b - Second author
c - Third author
d - Fourth author
e - Fifth author

Table 5

Authorship pattern of R. Chidambaram and his collaborators in 'General' Publications

Sr. No.	Authors	I	II		IV				Total	Percentage	Cumulative Percentage
		a	a	b	a	b	c	d			
1.	Chidambaram, R	23	3	–	–	1	–	–	27	81.82	81.82
2.	Sethna, H.N	–	–	–	1	–	–	–	1	3.03	84.85
3.	Subbarayappa, B.V	–	–	–	–	–	1	–	1	3.03	87.88
4.	Udgaonkar, B.M	–	–	–	–	–	–	1	1	3.03	90.91
5.	Sharma, S.M	–	–	1	–	–	–	–	1	3.03	93.94
6.	Sahani, V.C.	–	–	1	–	–	–	–	1	3.03	96.97
7.	Kakodkar, A.	–	–	1	–	–	–	–	1	3.03	100.00
	Total	23	3	3	1	1	1	1	33		
	Percentage	69.70	18.18		12.12						
	Cumulative Percentage	69.70	87.88		100.00						

I = Single author Papers
II = Two author papers
IV = Four author papers

a = First author
b = Second author
c = Third author
d = Fourth author

Table 6

Domainwise Author Productivity and Distribution of Authors and Paper

No. of Papers	Domainwise Authorships A	B	C	D	E	Total Authorships	No. of Authors	Prominent Collaborators
1.	2	12	8	1	3	26	26	
2.	–	14	1	1	2	18	9	
3.	3	3	–	–	–	6	2	S. Krishnan and S. Srikanta
4.	–	8	–	–	–	8	2	S.N. Momin and G.N. Ramachandran
5.	–	–	5	–	–	5	1	B. Sankaran
6.	–	11	1	–	–	12	2	S. Bhakay-Tamhane and M. Ramanadham
7.	–	14	–	14	–	28	4	G.M. Brown, P.M.G. Nambissan, H. Rajgopal and P. Sen
8.	–	1	15	–	–	16	2	Y.K. Vohra, J.S. Gyanchandani [illegible]
9.	–	1	9	8	–	18	2	Vijay Kumar and M.K. Sanyal
13.	–	1	36	1	1	39	3	B.K. Godwal, S.C. Gupta and S.M. Sharma
25.	–	25	–	–	–	25	1	A. Sequeira
52.	–	12	39	1	–	52	1	S.K. Sikka
164.	17	64	46	10	27	164	1	R. Chidambaram
Total	22	166	160	36	33	417	56	
Percentage	5.27	39.80	38.37	8.64	7.92			
Cumulative Percentage	5.27	45.07	83.44	92.08	100.00			

Domains : A = Nuclear Magnetic Resonance; B = Neutron Diffraction & Hydrogen Bonding; C = High Pressure & Shock Wave Physics; D = Quasicrystals; E = General

Table 7
Collaborators With R. Chidambaram

S.No.	Name	Period of Association FPY LPY	TY	No. of Authorships
1.	Chidambaram, R	1958-1993	36	164
2.	Krishnan, S.	1959-1960	2	3
3.	Krishnan, R.S.	1962-1962	1	1
4.	Raghavendra Rao, C	1963-1963	1	1
5.	Sequeira, A	1964-1991	28	25
6.	Sikka, S.K.	1964-1993	30	52
7.	Brown, G.M.	1965-1973	9	7
8.	Momin, S.N.	1968-1978	11	4
9.	Rajagopal, H.	1968-1978	24	7
10.	Srikanta, S.	1968-1970	3	3
11.	Navarro, O.O	1969-1970	2	2
12.	Garcia, A	1969-1970	2	2
13.	Linggoatmodjo,K	1969-1970	2	2
14.	Shi-Chien, L	1969-1970	2	2
15.	Suh, IL Hwan	1969-1969	1	1
16.	Balasubramanian, R	1970-1970	1	2
17.	Ramachandran, G.N.	1970-1971	2	4
18.	Chandrasakharan, R.	1971-1971	1	2
19.	Bugayong, R.R.	1972-1972	1	1
20.	Ramanadham, M	1973-1993	21	6
21.	Gupta, S.C.	1974-1993	20	13
22.	Ramanna, R.	1975-1975	1	1
23.	Wadhwan, V.K.	1977-1977	1	1
24.	Vohra, Y.K.	1977-1984	8	8
25.	Soni, J.N.	1978-1978	1	1
26.	Dilip Kumar	1978-1978	1	1
27.	Ramana Rao, A	1978-1978	1	1
28.	Gopu, V.M.	1978-1978	1	1
29.	Godwal, B.K.	1979-1991	13	13
30.	Sharma, S.M.	1979-1993	15	13
31.	Sethana, H.N.	1979-1979	1	1
32.	Subbarayappa, B.V.	1979-1979	1	1
33.	Udgaonkar, B.M.	1979-1979	1	1

34.	Bhakay-Tamhane, S.N.	1980-1991	12	6
35.	Lal, K.	1982-1982	1	1
36.	Singh, B.P.	1982-1982	1	1
37.	Kannan, K.K.	1983-1989	7	2
38.	Vijayakumar, V.	1984-1991	8	9
39.	Sankaran, H	1986-1991	6	5
40.	Sanyal, M.K.	1987-1993	7	9
41.	Gyanchandani, J.S. (Daswani, J.M.)	1987-1993	7	8
42.	Sahni, V.C.	1988-1989	2	2
43.	Vinay Kumar	1989-1989	1	1
44.	Nambissan, P.M.G.	1989-1993	5	7
45.	Sen, P.	1989-1993	5	7
46.	Jaya, V.	1991-1991	1	1
47.	Madhav Rao, L.	1991-1991	1	1
48.	Rao, K.R.	1991-1991	1	1
49.	Dasannacharya, B.A	1991-1991	1	1
50.	Meenakshi, S.	1991-1991	1	1
51.	Agarwal, R.G.	1991-1991	1	1
52.	Roy, S.	1991-1991	1	1
53.	Suresh, N.	1991-1991	1	1
54.	Kakodkar, A	1991-1991	1	1
55.	Jakkal, V.S.	1993-1993	1	1
56.	Raghunathan, V.S.	1993-1993	1	1
		Total		417

FPY = First Paper Year, LPY = Last Paper Year, TY = Total Number of Years

Table 8

Journalwise Scattering of Publications of R. Chidambaram

S.No.	JOURNAL	No. of papers	Percentage	Cumulative percentage	Period of Journal usage: FPY	LPY	Total	SCI . JCR 1992: Impact factor	Immediacy Index	Coverage in No. of A & I journals	Country of Publication
1.	Acta Crystallographica -B	14	12.18	12.18	1968	-1980	13	1.802	0.312	16	Denmark
2.	Pramana	8	6.35	19.13	1973	-1990	18	0.390	0.064	10	India
3.	Current Science	6	5.21	24.34	1984	-1993	10	0.253	0.075	46	India
4.	Acta Crystallographica	5	4.34	28.68	1961	-1967	7	1.328	0.343	-	Denmark
5.	Journal of Physics-Condensed matter	5	4.34	33.02	1989	-1990	2	1.627	0.296	17	UK
6.	Physical Review-B	5	4.34	37.36	1979	-1993	15	3.259	0.577	19	US
7.	Journal of Chemical Physics	4	3.48	40.84	1962	-1968	7	3.435	0.778	28	US
8.	Physica -B	4	3.48	44.32	1991	-1991	1	0.939	0.258	1	Netherlands
9.	Proceedings of the Indian Academy of Sciences -A	4	3.48	47.80	1971	-1983	13	-	-	-	India
10.	Bulletin of Materials Science	3	2.61	50.41	1981	-1984	4	0.244	0.000	9	India
11.	Indian Journal of Pure and applied Physics	3	2.61	53.02	1958	-1989	22	0.132	0.008	19	India
12.	Journal of Physics-F	3	2.61	55.63	1979	-1986	8	2.275*	0.412*	17	UK
13.	Journal of Scientific & Industrial Research	3	2.61	58.24	1959	-1960	2	0.062	0.003	37	India
14.	Solid State Communications	3	2.61	60.85	1982	-1988	7	1.369	0.162	12	UK
15.	AMPI Medical Physics Bulletin	2	1.74	62.59	1985	-1991	7	-	-	-	India
16.	Biochimica et Bio-physica Acta	2	1.74	64.33	1970	-1970	1	2.160	0.316	25	Netherlands
17.	Electronic Engineering	2	1.74	66.07	1959	-1960	2	0.007	0.012	15	UK
18.	Electronic & Radio Engineer	2	1.74	67.81	1958	-1959	2	-	-	-	UK
19.	Financial Express	2	1.74	69.55	1990	-1990	1	-	-	-	India
20.	High Pressure Research	2	1.74	71.29	1990	-1992	3	-	-	-	UK
21.	Nuovo Cimento	2	1.74	73.03	1959	-1960	2	0.505	0.071	-	France
22.	Physics News	2	1.74	74.77	1987	-1987	1	-	-	-	India
23.	Society & Science	2	1.74	76.51	1979	-1980	2	-	-	-	India
24.	Vigyanik	2	1.74	78.25	1986	-1988	3	-	-	-	India
25.	Acta Crytallographica-A	1	0.87	79.12	1978	-1978	1	2.409	0.255	17	Denmark
26.	Acta Crystallographica-C	1	0.87	79.99	1984	-1984	1	0.479	0.200	7	Denmark
27.	AERB News	1	0.87	80.86	1989	-1989	1	-	-	-	India
28.	Bhavan's Journal	1	0.87	81.73	1992	-1992	1	-	-	-	India
29.	Bulletin of the American Physical Society	1	0.87	82.60	1991	-1991	1	-	-	-	US
30.	Chemical Physics Letters	1	0.87	83.47	1968	-1968	1	2.686	0.560	15	Netherlands

Table 8 *contd.*

Journalwise Scattering of Publications of R. Chidambaram

S.No.	JOURNAL	No.of papers	Percentage	Cumulative percentage	Period of Journal usage FPY	LPY	Total	SCI . JCR 1992 Impact Factor	Immediacy Index	Coverage in No.of A & I journals	Country of Publication
31.	Crystal structure Communications	1	0.87	84.34	1972	-1972	1	-	-	6	Netherlands
32.	Economic Times	1	0.87	85.21	1989	-1989	1	-	-	-	India
33.	FEBS Letters	1	0.87	86.08	1993	-1993	1	3.505	0.490	40	Netherlands
34.	Hindu Survey of Indian Economy	1	0.87	86.95	1976	-1976	1	-	-	-	India
35.	Hindu Survey of Indian Industries	1	0.87	87.82	1993	-1993	1	-	-	-	India
36.	International Journal of Quantum Chemistry	1	0.87	88.69	1981	-1981	1	1.322	0.293	10	US
37.	Journal of Korean Physics Society	1	0.87	89.56	1969	-1969	1	-	-	-	Korea
38.	Journal of Physics and Chemistry of Solids	1	0.87	90.43	1977	-1977	1	1.255	0.215	15	UK
39.	Nuclear Instruments & Methods	1	0.87	91.30	1964	-1964	1	1.077	0.371	19	UK
40.	Paramanu	1	0.87	92.17	1977	-1977	1	-	-	-	India
41.	Phase Transitions	1	0.87	93.04	1991	-1991	1	0.564	0.180	8	US
42.	Physical Review Letters	1	0.87	93.91	1981	-1981	1	7.375	1.449	17	US
43.	Physics Reports	1	0.87	94.78	1983	-1983	1	6.200	0.761	8	Netherlands
44.	Proceedings of the Indian Academy of Sciences	1	0.87	95.65	1959	-1959	1	-	-	-	India
45.	Proceedings of Physics Society (London)	1	0.87	96.52	1960	-1960	1	-	-	-	UK
46.	Progress in Materials Science	1	0.87	97.39	1983	-1983	1	6.557	0.000	11	UK
47.	Review of Scientific Instruments	1	0.87	98.26	1984	-1984	1	1.298	0.507	28	US
48.	Science Today	1	0.87	99.13	1988	-1988	1	-	-	-	India
49.	Scripta Metallurgica	1	0.87	100.00	1985	-1985	1	1.331	0.199	13	US
	Total	115									

FPY = First Publication Year
LPY = Last Publication Year
* = Impact Factor and Immediacy Index as per SCI . JCR 1988
A & I = Abstracting and Indexing
SCI . JCR = Science Citation Index Journal Citation Reports

Table 9
Distribution of Articles on Bradford's Law of Scatter among Journals used for Publication of Papers of R. Chidambaram

C	CH	ΣCH	CH.C	ΣCH.C
1	25	25	25	25
2	10	35	20	45
3	5	40	15	60
4	3	43	12	72
5	3	46	15	87
6	1	47	6	93
8	1	48	8	101
14	1	49	14	115

C= No. of Communications, CH = Channel of communication

Table 10
Distribution of Articles of R. Chidambaram

Zone	No. of Journals	No. of Papers	Bradford Multiplier
First	3	28	–
Second	6	28	2.00
Third	12	29	2.00
Fourth	28	31	2.33

Average Bradford Multiplier $\bar{b}$ = 2.11

Table 11

Keywords Frequencies in the titles of Papers by R. Chidambaram

Keyword	Frequency	Keyword	Frequency	Keyword	Frequency
Neutron Diffraction	34	Extinction Correction	3	Nuclear Power	2
High Pressures	11	Low Temperature	3	Organic Solids	2
Hydrogen Bonding	9	Trombay	3	Peptides	2
Crystal Structure Refinement	6	Absorption Corrections	2	Phase Transformations	2
Lithium Potassium Sulphate	6	Aluminium-Copper-Iron Alloys	2	Platinum	2
Omega Phases	6	Alpha Phases	2	Potassium Copper Chloride Dihydrate	2
Phase Transitions	6	Amino Acids	2	Potassium Oxalate Monohydrate	2
Positron Annihilation	6	Angular Correlation Measurements	2	Praseodymium	2
Quasicrystals	5	Biological Structures	2	Research & Development - India	2
Crystals	5	Cadmium-Mercury Alloys	2	Shock Waves	2
Proton Magnetic Resonance	5	Deffect State	2	Tetrachloroquinone	2
Zirconium	5	Developing Countries	2	Torsional Oscillators Model	2
Hydrogen Bond Interactions	4	Diode Phase-Sensitive Detectors	2	Vacancy-type Deffects	2
Hydrogen Bond Potential Functions	4	Double Fourier Series Synthesiser	2	Water Molecules	2
Peaceful Nuclear Explosions	4	Empirical Potential Functions	2	X-ray Diffraction	2
Structural Stability	4	Hexagonal-Close-Packed Transitions	2	X-ray Studies	2
Titanium	4	High Pressure Physics	2		
Automatic Diffractors	3	Icosahedral Quasicrystals	2		
Biological Molecules	3	L-Glutamic Acid. HCl	2		
Condensed Matter	3	Lanthanum	2		
Crystal Structure	3	Materials Management	2		
Crystallization	3	Neutron Scattering	2		
Equation of State	3	Nuclear Magnetic Resonance	2		

Table 12 *contd.*

Keywords used only once in the titles of Papers by R. Chidambaram

Metals	Q-Multiplication
Methyl Group	Quality of Science-India
Micro Computers	Quasicrystalline Structures
Mini Diamond Anvil Cell	Radiation Damping
Minimum Energy Conformation	Raman, C.V.
Molecular Packaging	Reaction Kinetics
Molecular Structure	Resorcinol
Momentum Density Distribution	Rotating Anode X-ray Source
Mosaic Structures in Crystals	Safety
N-H---O Hydrogen Bonds	Science and Philosophy
N-H---O-C Hydrogen Bonds	Science and Technology
Nehru and Science	Science, Technology and Society
Neutron Diffractometer	Shale Medium
Neutron Beam Automation	Shock Hugoniot Equation
Neutron Elastic Scattering	Shock Pressures
Neutron Studies	Shock Velocity
Non-Crystalline Phases	Shocks Deformation
Nuclear Fusion	Shocks Discontinuities
Nuclear Magnetic Resonance Signals	Signal-to Noise Ratio
Nuclear Plants	Simple Phase Shifter
Nuclear Research - India	Single Crystal X-ray
Nuclear Systems	Single Stage Gas Gun
Nuclear Technology	Space Group Identification
Numerical Simulation	Space Group Symmetry
OCENER	Spectroscopic measurements
Omega-Zirconium	Spinning Crystals
One Dimensional Code	Structural Phases
One Dimensional Summation	Structural Relaxation
Onitin	Structure Determination
Para dichlorobenzene	Structure of Ice-I
Particle Velocity	Synchrotron Radiation Sources
Peaceful Underground Nuclear Explosions in Rocks	Texture Studies
Phenolic Illudoid Sequeterpene	Tin-Vanadium Alloys
Pokharan	Titanium-Based Alloys
Porosity Effect	Two-Strain Mechanism
Potassium Zinc Cyanide	Tutton's salt
Potassium Zinc Sulphate Hexa Hydrate	United Nations Conference on Science & Technology for Development (UNCSTD)
Praseodymium-Thorium Alloys	Valence Transition
Pressure and Stacking Solition Model	Women in Science
Pressure-Induced Amorphization	X-ray Structural Study
Pressure-Induced Elastic Anomaly	X-ray Topography
Pressure-Induced Transofmation	Yetterbium
Portein Structures	Zinc
Push-Pull Phase Detector	

Table 12

Keywords used only once in the titles of Papers by R. Chidambaram

Alpha-Helical Structure
Alpha-Omega Transformation
Alpha to Beta Transition
Aluminium
Aluminium-Copper-Lithium Alloys
Aluminium-Manganese Alloys
Aluminium-Manganese-Silicon Alloys
Aluminium Phosphate
Ammonium Ions
Ammonium Oxalate Monohydrate
Amorphous Metal Gasket
Ampere-turn Stabilisers
Automatic Neutron Diffractometer
(Three Dimensional)
Balanced Push-Pull Phase Detector
Band Theory Analysis
Barium Chlorate Monohydrate
Bent Hydrogen Bonds
Bent O-H---Hydrogen Bonds
Beryllium
Beryllium Gasketing
Beryllium Sulphate Tetrahydrate
Beta-Omega Transformation
Bhabha Atomic Research Centre
Biological Complexes
Body-Centered-Tetragonal phases
Cadmium-Mercury Alloys
Carboxyl Group
Cold Fusion
Computer Control Experiments
Computers in Cancer Therapy
Cratering Efficiency
Copper (II) Acetate Monohydrates
Copper Ammonium Sulphate Hexahydrate
Crystal Packing
Crystal Symmetry
Crystalline Approximants
Crystallographic Research-India
Cyanide Ion
Dhcp Phases
Department of Atomic Energy
Dinuclear Copper (II) Acetate Monohydrate
Electron Momentum Density
Electron Gruneisen Parameter
Energy Calculations
Energy - India
Erythrocyte
Carbonic Anhydrase
Ethylene
Extinction Effects
Extinction Parameters
Fast Recording
FCC Phases
Fern (Onychium auratum)
Group IV B Elements
Group IV Transition Metals and Alloys
Hafnium
High-Current Electromagnets
High Pressure Research
High Pressure Structural Investigation
High Pressure X-ray Diffraction
High-Velocity Deformation
Human Resources
Hydrates
Hydrogen Atom
Hydrogen Atom Positions
Impurity Effects
Indian Buffalo (Bubalus bubalis)
I - SAND - A
Intermediate Pressure Region
(5-100 megabar)
Isostructural Anomalies
L-Alanine
L-Asparagine Monohydrate
L-Cysteic Acid. H_2O
L - Cystine. 2HCL
L - Lysine Monohydrochloride dihydrate
Laboratory Automation
Lanthanide-Thorium Alloys
Lead
Least-Squares Refinement
Linear Muffin-Tin Orbital
Band-Structure
Lippincott-Schroeder Potential
Function
LMTO Method
Lone-Pair Coordination
LS - Threonine
Materials Research
Macromolecular Crystallography
Research
Magnetic Recorder
Magnetic Storage System
Manganese - Leonite
Medicine and Physics
Mercury

Fig. 3

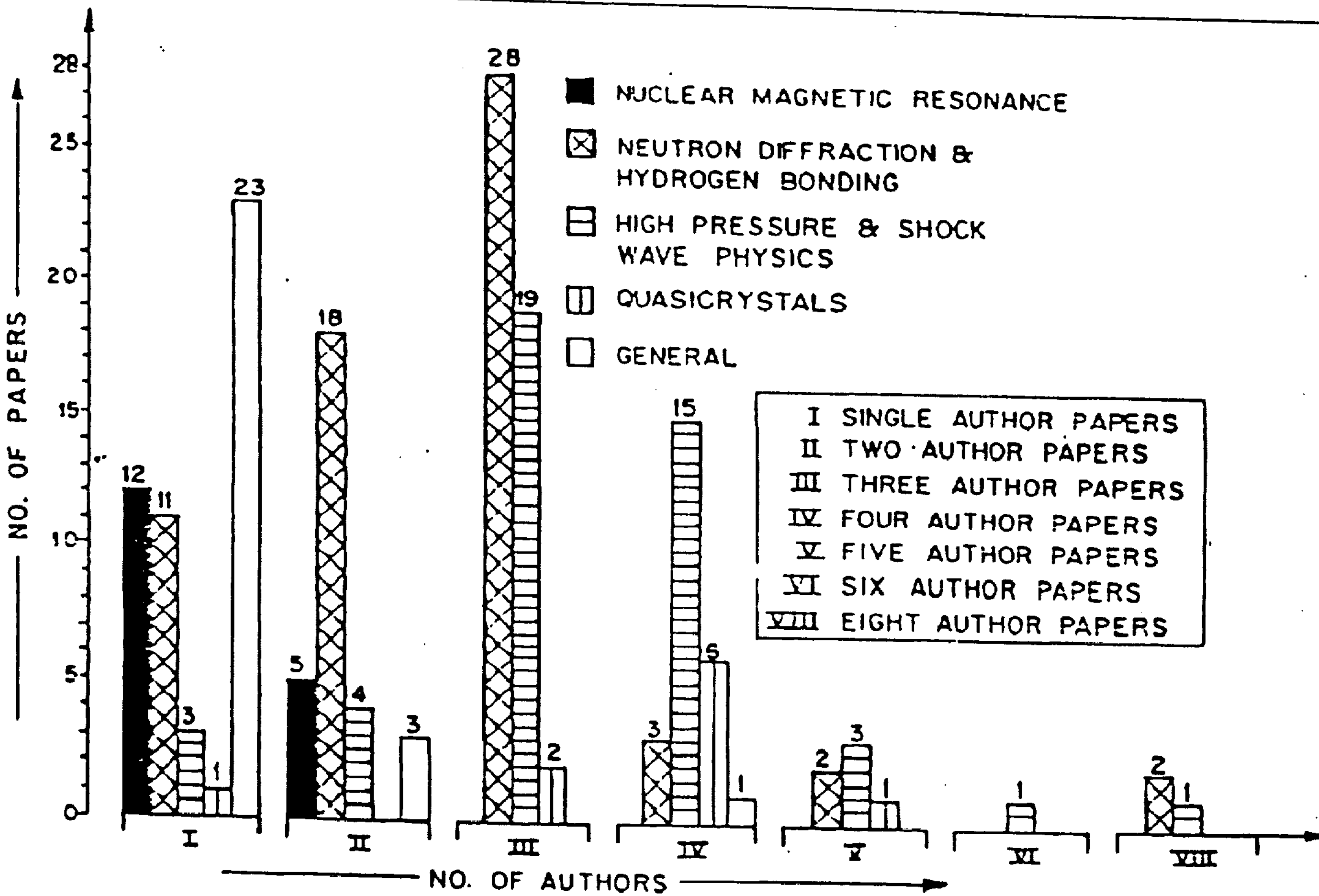

FIG. 3: AUTHORSHIP PATTERN IN VARIOUS DOMAINS

Fig. 1

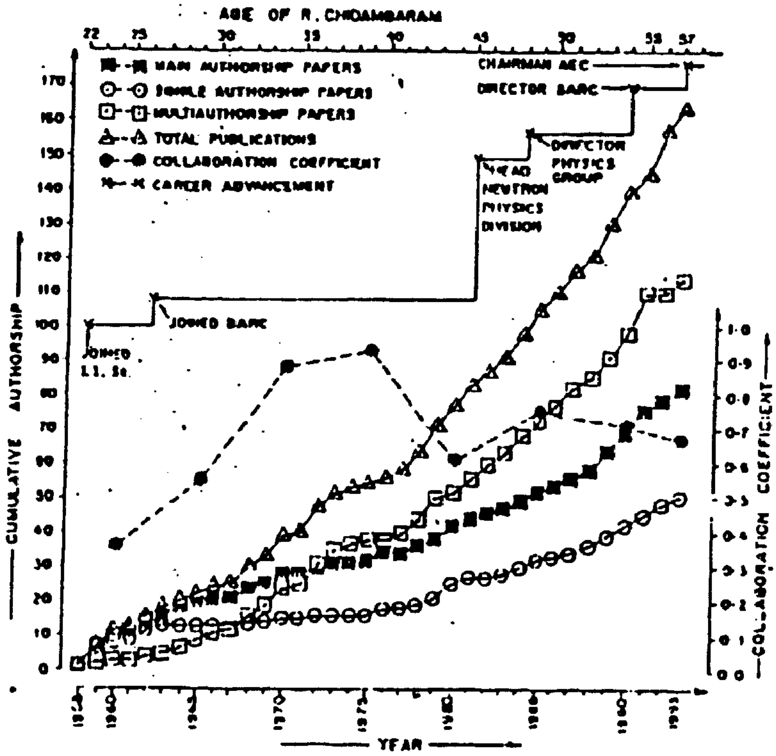

FIG. I : PUBLICATION OUTPUT OF R CHIDAMBARAM

Fig. 2

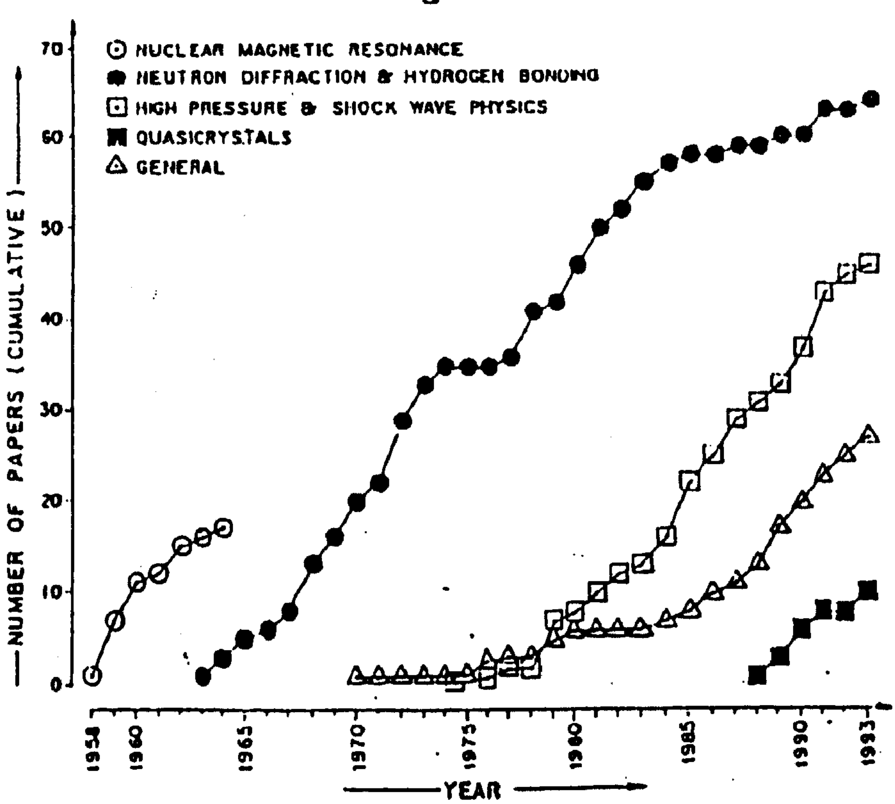

FIG.2: DOMAINWISE PUBLICATIONS OF R. CHIDAMBARAM

Fig. 5

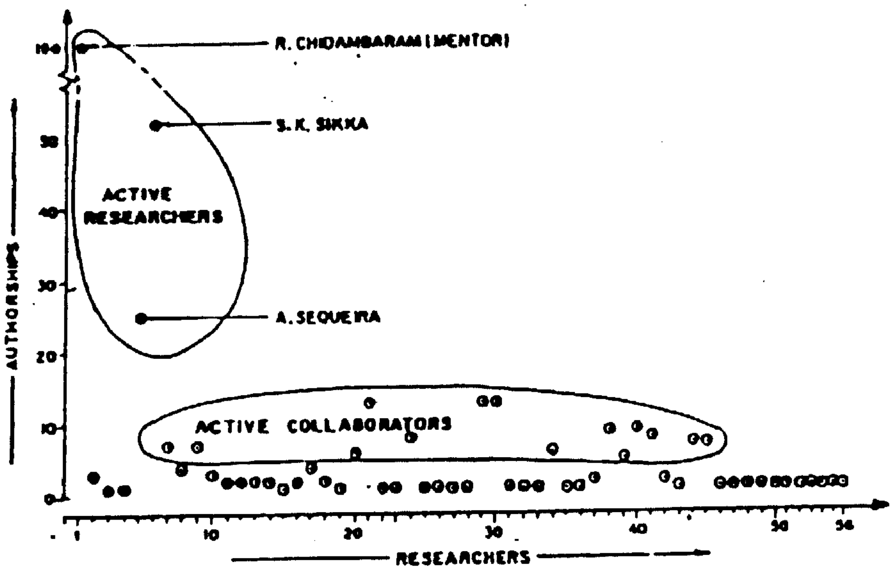

FIG. 5: RESEARCHERS ASSOCIATION IN CHRONOLOGICAL ORDER OF OCCURRENCE

Fig. 6

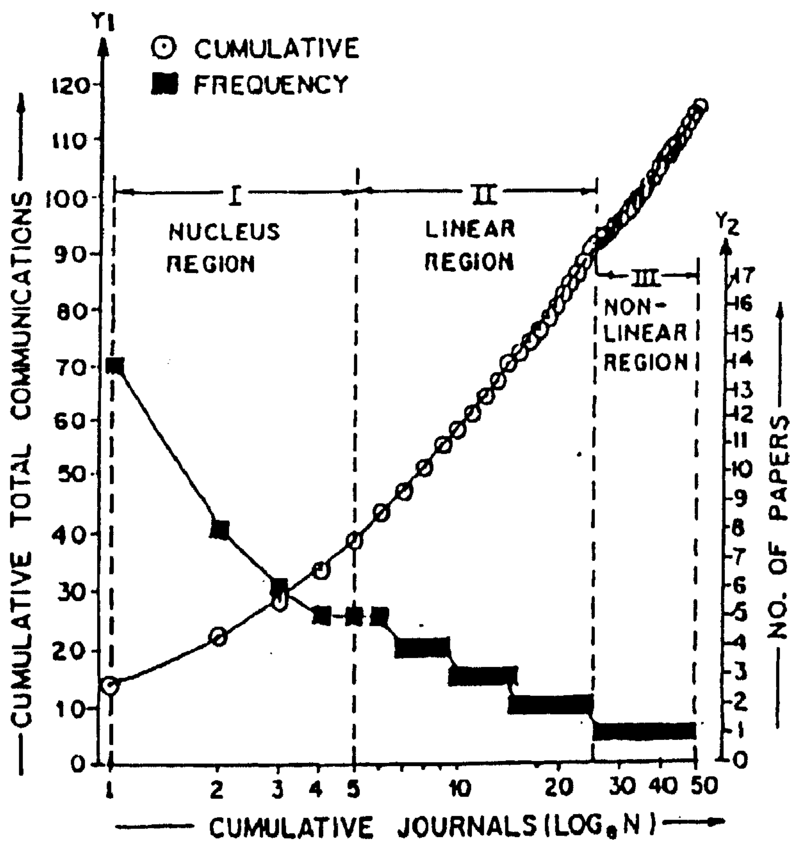

FIG. 6: BRADFORD - ZIPF BIBLIOGRAPH

Fig. 4

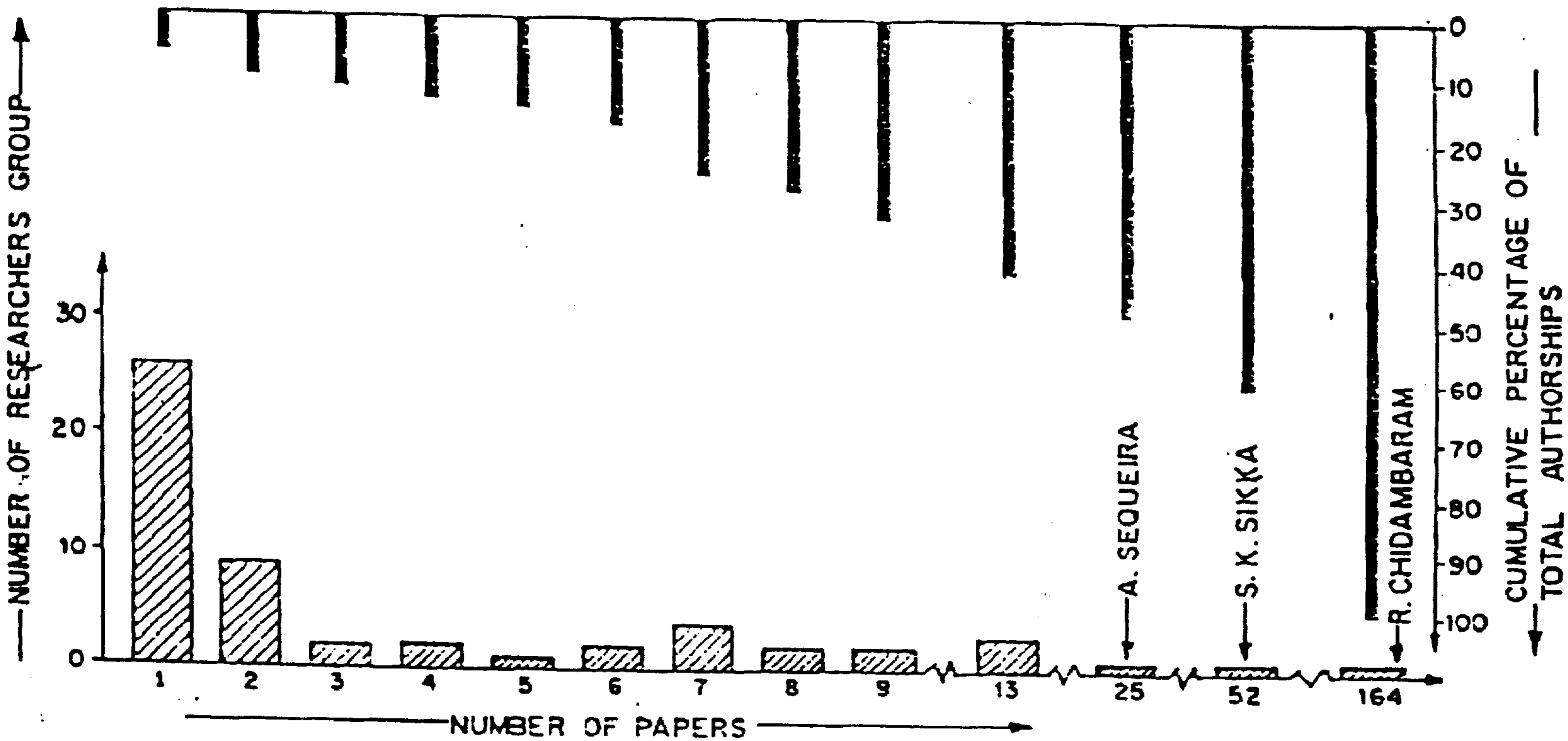

FIG.4: AUTHOR PRODUCTIVITY