Chapter 7

Conclusions and Suggestions

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The aim of the present bibliometric study was to discover a better and complete understanding of what is actually taking place in research at PRL. It has fulfilled its objectives of discerning the publication pattern and research trends of PRL. The results of the study will help those charged with making difficult choices about allocating the resources. It will also help in taking human resource decisions as regards the induction of faculty members in different divisions. Identification of well cited non-subscribed journals and not cited/very less cited subscribed journals will help in taking subscription decisions in the coming years, resulting in optimum fund utilization. Thus knowing the use of library resources by the doctoral students will help in taking future decisions about the collection development.

In the process of discerning the publication pattern and the research trend at PRL, following conclusions can be drawn from the consolidated findings of the study.

1. The research output of PRL in terms of publication record and invited talks summing upto 2518 gives an average of about 250 publications per year. Out of these, 1318 papers in journals give an average of about 130 papers published in journals per year. The average number of academic faculty members being 60, gives the output of 2.17 papers per faculty per year.

2. The result of the present study shows that the multiple authored and double authored papers are on the rise in PRL, especially from 2000 onwards probably due to ease of contact through emails and ease of collaboration in terms of writing and editing using the computers and the internet. In 1961 Price had predicted the disappearance of single authored papers. Fifty years hence, this trend is more than obvious as scholarship becomes interdisciplinary, leading to greater cooperation among individuals and institutions. High

percentage of multi-authored and double authored papers in journals is in accordance with the world pattern.

3. Comparing the data of collaborative papers in journals and conference proceedings, international collaboration is higher in journals than in conference proceedings. National collaboration is almost the same in journals and conference proceedings. Domestic collaboration is higher in conference proceedings than in journals. For conference proceedings, national collaborative papers are more than double of international collaborative papers. The reason could be that funding is available for national conferences but it is more difficult for international conferences.

4. Out of the articles published in journals, a very high number of articles are in international journals and very few are in national journals and lesser still are as chapters of a book. Thus, most preferred mode of publication of PRL scientists is Journal. The journals most preferred by PRL scientists for publication are **Physical Review A** followed by **Current Science** and **Physical Review D** during 1997-2006.

5. Out of the 20 most preferred journals, 4 are Indian – Current Science, Journals of Earth System Science, Pramana, and Bulletin of Astronomical Society of India. All others are international journals of high impact. Thus there is clear preference to publish in international journals because it brings recognition.

6. The study reveals that Theoretical division is most productive in terms of papers published in journals and invited talks delivered. Geosciences division comes second in all the three categories of the research output. Astronomy division produced maximum number of papers in conference proceedings.

7. Thrust areas in Astronomy at PRL are *Solar Physics, Variable and Peculiar Stars* and *Normal Stars*. Thrust areas of research in Geosciences and Planetary Sciences at PRL are *Hydrology and Glaciology, Solar System Objects*, *Meteorites* and *Geochronology*. In Space Sciences, maximum number of papers were published on *Atmospheric Dynamics*

and Meterology followed by *Ionosphere* and in Theoretical Physics maximum number of papers were published on *Quantum Optics, Leptons* and *Quantum Mechanics.*

8: Very few articles were published in the subject of *Condensed Matter.* No research was done on the topics *Acoustics, Heat Transfer, Physics of Gases* and *Rheology.*

9. The most prolific researchers are : Prof G. S. Agarwal, followed by Prof. R. Ramesh and Prof A. K. Singhvi during the period of study followed by researchers like Prof. A. Jayaraman, Prof. Shyam Lal and Prof. V. K. B. Kota. It is interesting to note that quite a few of these highly productive researchers held senior adminsitrative positions at PRL like Director, Dean or Chairman of a Division.

10. The sample of this study does not follow completely the Lotka's Law of scientific productivity. This could be due to the fact that collaborative authors each get the count of one paper instead of giving credit to only the first author or giving proportionate credit according to the number of collaborative authors.

11. The citation analysis of the bibliographies of theses submitted by the doctoral students at PRL revealed the preference for electronic resources from 1997 through 2006 which confirms the findings of earlier studies. During 1997-2000 period e-resources had just started appearing on the web and print resources dominated the scene completely. During 2001-2006, the electronic documents took up considerable proportion of the print documents' share of the total number of citations. By 2006 use of electronic resources had increased so much that proportion of print and electronic resources cited seemed almost equal.

12. This citation analysis of bibliographies of theses also revealed that journals comprise major part of the documents cited, followed by Books and Other Documents. From 1997 through 2006, the use of the non-subscribed journals is on the rise. In 'Other documents' category, most used are the 'Reports' followed by 'Proceedings'.

13. It seems number of citations appended at the end of research article or a thesis is subject specific. Space Sciences students have given maximum number of citations followed by Geosciences. Astronomy and Theoretical Physics students tend to cite less number of sources.

14. Important result of the present study is that a set of core journals (10 most cited journals) account for more than 50% of the total number of journal citations used. However there is a considerable variation amongst the four subject areas. .

15. No Indian journal appears in the Core Journal Group in Astronomy, Theoretical Physics and Space Science divisions. Only in Geosciences division two Indian journals are amongst the top most cited journals.

16. In each subject area two most cited non subscribed journals (currently) were identified for further follow-up, to find out which of them may be subscribed by the institute. These are - *Information Bulletin on Variable Stars and Astrophysics & Space Science* for Astronomy division, *Journal of Hydrology and Limnology & Oceanography* for Geosciences division, *Canadian Journal of Physics and Chemical Physics Letters* for Space Science division and *Optics Communication and Annals of Physics* for Theoretical Physics division. Attempt was also made to identify those journals which are subscribed by the institute but have been cited only once or twice in the 10 year study period. These are *New Astronomy, New Astronomy Reviews, Physics World* and *Radiation Measurement*

17. It was also found from the number of PRL citations, that in Space Science Division and Geosciences Division, PRL research is cited more than in Astronomy and Theoretical Division.

The above conclusions clearly indicate that the present bibliometric study has fulfilled its objectives and further added to the existing knowledge corpus of this subject field. The researcher hopes that this information will be useful to the institute's decision makers for future research planning.

Suggestions

a) The policy makers will find the information about the quantum of research (PRL research output in journals per faculty per year) useful which will aid in taking steps to increase this publication rate so as to improve the ranking amongst the other research institutes in India as well as abroad.

b) The publication output of PRL during 1997-2006 shows that international collaboration needs to be developed by publishing more international collaborative papers. This could be achieved by more scientists attending and presenting their research results in international conferences which would lead to more collaboration. As international joint authored papers tend to be cited more often, increased international collaboration would increase the citation rate of PRL papers.

c) Collaborative ties with other institutes in the country need to be strengthened too so as to make the optimum use of the national facilities available and increase the number of national collaborative papers.

d) Scientists of PRL should be encouraged to contribute chapters in books, as books have long lasting impact on students and play an important role in diffusion of knowledge.

e) The high productivity of Theoretical Physics division could be due to more number of faculty and students in the division. Induction of more faculty members in other divisions could help in increasing the overall productivity of PRL.

f) Higher productivity might have direct correlation with more number of journals subscribed pertaining to Theoretical Physics. It is interesting to note here that out of all the currently subscribed titles of journals, Theoretical Physics has the maximum number of journals. Hence, more journals should be added in other subject areas as well to increase the overall productivity of PRL.

g) The subjects which attracted very few papers in the ten year period clearly indicate that these are not an active area of research for PRL. The reasons for non-active research areas could be looked into.

h) The findings of the present study confirm the earlier studies carried out by Pelz and Andrews (1976), Fox (1983) and Price (1986) that motivation to publish comes from recognition and prestige. Recognition by way of promotions and additional adminstrative

positions, it seems resulted in higher productivity of scientists. Thus quicker growth of scientists in terms of promotions could lead to more productivity of PRL scientists.

i) Citation analysis of bibliographies of theses shows that more than 60 % of journal citations come from top 40 journals (10 in each subject division). It would be worthwhile to explore reallocation of funds to other more needed databases or archives like WoS or JSTOR.

j) Subscribed journals cited only once or twice during 10 year period could be replaced with non-subscribed journals cited more often by the students.

k) Inter-division citations are not visible in the bibliographies of theses during the 10 year period of study. Availability of articles published by PRL scientists through the institutional repository created in 2006, could remedy that. However, doctoral students should be encouraged to use and cite the PRL research work.

After arriving at the above conclusions and suggestions, the researcher feels appropriate to furnish a few pointers to the areas of future research. Going through the various studies during the literature survey, the researcher found that very few bibliometric studies have been carried out in the field of Geosciences and Space Sciences. These would be interesting subject fields to study. Also, citation analysis of the papers published by the scientists of PRL would help in determining CFY of PRL. PFY (papers per faculty per year) and CFY (citations per faculty per year) are considered to be more objective indicators to assess the impact of any research institute as compared to the total number of papers and total number citations. Comparative study may be undertaken of research institutes in similar research domain. Collaborating institutes can be identified so that non-collaborating institutes can be taken into the fold of collaboration which in turn may lead to increase in number of publications and number of citations for PRL.