A Bibliometric Study of the Publication Patterns of South African Scientists

By
Daisy Jacobs

MIS (University of Natal)

Supervisor
Prof. A.M. Kaniki

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Department of Information Studies, University of Natal, Pietermaritzburg, 1998

Declaration

I hereby state that the whole of this Dissertation, unless specifically indicated to the contrary in the text, is my own work and it has not been submitted for any other degree in any other University.

Candidate D. Jacobs

Signature

Dedication

This dissertation is dedicated to my mother, Annie Thomas and my daughter Donna who have been the inspiration for all my achievements.

Abstract

One of the legacies of the apartheid system was the discrepancy in funding and support for various activities, including research work in science and technology based on racial grounds. Some institutions of higher learning and research institutes were favoured more than others in terms of resources. Presently, despite the fact that there is national democracy, previously disadvantaged institutions with their culture of minimal research and poor publication output continue to produce inadequate quantities of research and publications while the historically developed universities are at the forefront of research and publication.

This research is a bibliometric study of the publication patterns of South African scientists. The subjects were academic scientists from ten selected universities of the Eastern Cape, Western Cape and KwaZulu Natal, which vary considerably, with regard to standards of education, quantity of publications, development and overall progress.

The general purpose of this study was to investigate the patterns used by scientists in publishing the results of their research, provide valuable information and play a significant role in evaluating the research and publication patterns of scientists from these different institutions

The study collected two sets of data through lists of publications and a questionnaire. The questionnaire was pretested and the comments of the respondents enabled the investigator to make the necessary revisions in the subsequent questionnaire.

The questionnaire was sent to 350 full-time academic scientists in the departments of physics, chemistry, botany, zoology and biochemistry / microbiology in the selected universities. Out of the 350 scientists, 174 responded. Twenty one returns were discarded, hence only 153 were used in the data analysis. Further data was obtained from the Science Citation Index and the Foundation for Research Development.

Data were analysed using descriptive statistics, one way ANOVA and Pearson Chi-Square test. The results obtained in this study showed that the five null hypotheses were rejected. It was found that there was a: -

- direct relation between academic rank and productivity; academic status and productivity
- direct relation correlation between prestige and productivity
- higher impact of "A" grade scientists over non-"A" grade scientists
- significant difference in productivity between areas of science that are funded and areas which receive little or no funding.

Acknowledgements

I wish to express my sincere gratitude to my supervisor Prof.A.M. Kaniki under whose efficient guidance this study was conducted. Without his enduring dedication, patience and untiring efforts this dissertation would not have been completed.

Secondly, I wish to express my thanks to Mr. M.M. Kalubya of the foundation year, UNITRA for his generous contribution towards the statistical analysis, as well as his valuable encouragement.

Thirdly, I am indebted to all those scientists from the universities of the Eastern Cape, Western Cape and KwaZulu Natal for their patience and good will in responding promptly. I would like to add my special thanks to those who took the trouble to add notes of encouragement towards my efforts. My thanks go to Dr. William Blankey of the FRD, for sending me the lists of "A"-Grade scientists and other vital information.

I wish to thank Dr. Cora Ovens of the University of the Orange Free state for helping out with the citation analysis. I would also like to thank the ever cheerful Darlene for her willing help at all times.

My sincere thanks also go to the library staff of the University of Cape Town, University of Natal and the University of Stellenbosch for making their resources available to me.

Finally, my sincere thanks go to my husband, Jimmy, whose encouragement and cheerfulness kept me on track, and kept the home going while I was away working on this thesis; my daughter, Donna, who was patient and supportive and worked many hours proof reading my work and encouraging me to go on even when things looked bleak; my son, Ashley, the computer wiz who spent weeks shaping this dissertation; and my son, Leslie, for his organisation of all the data.

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List of Abbreviations

ACRL - American College and Research Library

ANOVA - Analysis of variance

ASLIB – The Association for Information Management

CSIR - Centre for Scientific Information and Research

DNA – Di-ribonucleic acid

Df - Degrees of Freedom

Ed - Education

F- Frequency

FRD - Foundation for Research and Development

GDP - General Development Programme

Hod - Head of department

IDRC - International Development Research Centre

ISI – Institute of Scientific Information

K-R 20 - Kuder-Richardson 20

LISA – Library and Information Science Abstracts

MIS - Master of Information Science

MIT - Massachusetts Institute of Technology

MRSP - Main Research Support Programme

M.Sc. - Master of Science

NAS - National Academy of Science

Ph.D. - Philosophiae Doctor

R & D - Research and Development

SABINET - South African Bibliographic Information Network

SCI - Science citation Index

Sig.- Significance

SPSS - Statistical Package for Social Sciences

SSCI - Social science citation Index

STC - Scientific and Technical Communication

STI - Scientific and Technical Information

SS – Sum of Squares

UCT - University of Cape Town

UNECA – United Nations Economic Commission for Africa

UNESCO - United Nations Educational, Scientific and Cultural Organisation

UNITRA - University of Transkei

Chapter 1
General Introduction and Background to the Study

1. 1 Introduction

Scientists are both consumers and producers of information. Information is critical to the performance of their tasks, while at the same time they have the professional imperative to publish and the personal goal of contributing to the pool of knowledge to be accessed by others (1). Shalini has argued that the publishing of scientific papers satisfies a scientist's psychological need for recognition and acceptance (2). Scientists interact using formal communication channels by publishing papers in journals and presenting papers at conferences and at national and international forums. This is a cyclical process of production, transference and consumption of information. The publishing of research results in the form of an article or paper is an act of information transfer.

Scientific activities, as observed by Alabi (3) have been growing tremendously in most of the third-world countries. Similarly, Saracevic (4), reckoned that the rate of scientific activities in most developing countries had been tripling compared with the doubling tempo in the developed countries. Odeinde and Alabi have argued that while scientific and technical activities have increased, little or no attention has been paid to the need for a corresponding increase in spending on scientific information (5). Although their argument is more than a decade old and referred specifically to the Nigerian situation, the situation is similar if not worse, for the rest of Africa. This is especially so when one looks at the current economic problems faced by most African countries, which are unable to even meet the basic requirements of their people, let alone spend money on the production of scientific information. This phenomenon has given rise to an observation by Garfield (6), that most scientists in the west are not aware of research going on in countries collectively called the "Third World". What they do know about Third World science, explained Alabi (7), is dominated by the research of one or two Third World research Superpowers - India and Argentina.

This observation is quite appropriate for South Africa (SA), which in essence, has been described as both first and third world. Although the latter part is very much underdeveloped compared with the standard of other Third World countries, the former (developed part), is well advanced as far as scientific research and growth are concerned.

One reason for this could be that scientists from some of these third world countries fail to publish the results of their research altogether or may not do so in reputed international journals. This is also true about South Africa which, although has a lot of scientific research and production activities, the country having been "closed off" meant little was "known" outside. It is generally accepted that there can be no science without the necessary communication associated with it. An aspect of scientific communication includes the generation, utilisation and transfer of scientific information. Unlike research in other fields, such as the humanities or social sciences, research in science is a group effort, that is, a scientist needs to consult and interchange ideas with other scientists during the planning and performance of research. In other words, communication in one way or another takes up a significant fraction of a scientist's working life. A study conducted by Passman (8) in the early sixties about information communication found that chemical scientists spent about 17 hours per week on scientific communication as compared with 14 hours working on equipment. Menzel (9) reported that university scientists set a quarter of their working day in scientific communication, that is, they divided their time equally between receiving and giving information.

According to Jacobs (10), scientific communication of information is considered under two main headings - formal sources such as books, journals and reports and informal sources such as colleague, conference attendance and telephone calls. While formal sources of information are designed to circulate among large groups of people, the informal sources of information are designed to meet the needs of small numbers of individuals. Growth in scientific activities depends on the sharing of scientific knowledge.

Information is the main input and output of every scientific activity. As Ranch (11) explained, information and documentation are the most important means of control and access to scientific results. In general, scientific documentation is a central element in the memory of human knowledge.

Woodward (12), emphasised the need for information and documentation and explained that if these ceased to fulfil any of their essential roles, communities would face serious problems in the future development of science. Although science and scientific information are international, most developing countries do not have access to the pool of information available in the world market. It is therefore, expected that in order to cope with the pace of development, information should be made readily available if and when required. One of the methods of determining the information needs of scientists and the process by which they meet these needs is to study the pattern of communication and publication of their research results.

1.2 Foundation for Research Development (FRD)

In South Africa, the Foundation for Research Development (FRD) is the official body that is responsible for the programme of developmental support to tertiary institutions in order to enhance effective and relevant training in science and technology. It was founded in 1984 as part of the Council for Scientific and Industrial Research (CSIR) to act as a funding agency for excellent researchers and research projects at tertiary institutions. Various programmes provided support for research groups and postgraduate students, in many scientific disciplines at universities countrywide, with the aim of developing the scientific and technological human resources needed for the future.

According to one of the FRD reports, most of the funding went to a few tertiary institutions with little prospect of support for black scientists and students who had not been given the opportunity to excel. In 1986 efforts were made to rectify this imbalance, but it was only in 1988 that action was taken.

The Research Development Programme (RDP) aimed at historically black universities was launched, and in 1989 a pilot programme aimed at science and mathematics tuition in black secondary schools was initiated. In October 1990 the FRD became independent of CSIR, and its main mission and responsibility were to develop human resources in science and technology needed to ensure a prosperous future for all South Africans.

FRD evaluated and graded researchers who applied for such a process with relevant information that would show the individual's outstanding research performance, which could be compared with national and international standards of similar research. The individual's scientific stature was judged by the quality of publications, patents and internal reports, by invited contributions to conferences both national and international, collaboration with fellow scientists in inter-disciplinary or highly complex advanced fields. He/she was further judged by the ability to attract others, including postgraduate students, to his/her research activity, by the candidate's research leadership and by those scholastic activities related to research. The candidates were required to supply a full biographical sketch and a list of the applicant's publications which were relevant for the purpose of assessing him/her. A panel of four specialists in the field judged each applicant. (See further discussion in section 1.2.2)

It is easier to justify funding for excellent research at universities that have a critical mass of skilled scientists and advanced facilities than those that do not. It is very important to maintain this funding if South Africa is to be at the forefront of scientific developments in Africa. However, the challenge is to build up an infrastructure at other institutions for effective education and training of adequate number of scientists, technologists and educators, and to develop expertise in identified areas at these institutions to meet the demands of the future. The way to achieve this is by establishing the nature and levels of quality and quantity of research output in the form of publications by scientists at various academic and research institutions, and then planning future scientific output.

According to South Africa's Green Paper on science and technology, studies of international indicators show that science and technology are absolutely vital components of economic and social progress. As such, it explained that "many of the industrialised countries spend more than two percent of Gross Domestic Product (GDP) on Research and Development (R&D)" (13). The newly industrialised countries tend to emphasise an increase in spending for the development of Science and Technology. The South African spending figure for Science and Technology shown by the Green Paper (14) is 0,75 percent of GDP which reached a maximum of 1,04 percent in 1987 and has declined steadily since then. This is in sharp contrast with all countries with a successful industrial development track record. A downward trend of this nature augurs very badly for a country like South Africa, which still suffers from the strangulation of the apartheid era. At this juncture, South Africa needs to create and adopt new and imaginative policies to address these questions and to captivate the imagination of the public about a new vision and goal for science and technology.

1.2.1 Scientific work and the FRD

According to a statement from FRD (1997), the Foundation invested resources for research development in higher education and museums (15). The object of the foundation was to support and promote research through funding, human resource development and the provision of the necessary research facilities. This was to facilitate the creation of knowledge, innovation and development in all fields of science and technology for the improvement of the quality of life of all the people of South Africa.

The main functions and duties of FRD were to promote the development of appropriate human resources and research capacity in the areas of science and technology. In order to support and promote research in the various sectors, funds were obtained both locally and from abroad and these funds were allocated to promote multi-disciplinary collaboration and to support and promote research by the awarding of contracts, grants, scholarships or bursaries to persons or research institutions.

The foundation facilitated and promoted, nationally and internationally, liaisons between researchers and research institutions and thereby encouraged participation in international scientific activities through maintaining membership of appropriate international science organisations. One of the areas where the foundation took keen interest was the inter-institutional co-operation in research. FRD, therefore made available scientific knowledge or technology through the various mediums and administered supports and monitored the operation of national facilities for the provision of an information infrastructure linking research institutions in the sharing of research information and knowledge.

As part of the whole transformation of South Africa, the FRD and related institutions like the CSD has also been going through a process of change. As from November 1 1998, it became part of the new structure, the National Research Foundation (NRF). The Main research support program (MRSP) of the FRD was designed to advance excellence in research at South African institutions by providing progressively increasing support with improving standards in research achievement, creativity and initiative (16). However, years of the apartheid system resulted in neglected and, in some cases, shunned institutions, which, if they had been developed creatively and purposefully, could have made far greater contribution to a higher standard of living of many people on the subcontinent.

1.2.2 National Research Foundation (NRF)

According to the National Research Foundation Bill, the foundation's main objectives are the following:

- The establishment of a consolidated and co-ordinated system for supporting research, human resource development and infrastructure provision in all fields of science and technology, as well as indigenous technology.
- The promotion of the quality and relevance of human resource development for science, technology, indigenous technology and innovation, acknowledging the needs of different scientific and technological disciplines and the importance of multi-disciplinary research.

- The co-ordinated redressing of imbalances regarding the development of human and institutional resources.
- The promotion of economics of scale through co-ordination and sharing of facilities. (17)

1.2.3 FRD rating

To minimise the risk of investment, the entry requirements to qualify for FRD funding in the open Research Programme and programmes within most of the directed themes were:

- a valid rating in one of the categories A,B,C,P,Y, L or NR (non – rated)
- acceptance of a research plan that outlines the proposed research and the anticipated outcomes of the research within a funding cycle (18) .

As stated in the introductory remarks at the beginning of section 1.2, a researcher who wished to be evaluated was required to submit information such as a short biographical sketch, names and addresses of nominated referees for comment by the university or organisation concerned. Besides the names of the referee, the applicant was required to provide the names of three researchers who were active researchers in the applicant's field, who were regarded by the applicant as peers and who might be invited by the FRD to assist in evaluating him/her as a researcher. Finally, the researcher was required to submit a full biographical sketch of himself/herself with a list of the applicant's publications which were relevant for assessing him/her as a researcher. This included articles in journals, technical reports, conference proceedings, and patents. The researcher might also have been asked to provide a concise description of the work done, a summary of the results achieved and an explanation of the significance of the work..
Candidates were requested to specify what they regarded as their major research achievements and enclosed supporting documentation where appropriate. It was imperative to give full details of postgraduate students who obtained their MSc and PhD degrees under the candidates' supervision, and those of research students currently working under their direction.

Once the FRD rating team was satisfied by the criteria required for rating an individual researcher, he/she could be placed under one of the categories. An established researcher might be rated as A, B, or C or researcher with potential of becoming established soon may be rated as P, Y, or L. By rating the individuals in this way, FRD believed that research support should primarily be person based, as it is largely the quality of the researcher and his team members that would ensure good research.

1.3 Rationale for the study

The output of any research process is the research results obtained. For many types of research, the results only become valuable when they are made known to individuals or organisations that can apply them. One of the most important official modes of reporting these results, says Lancaster (19), is in scholarly journal articles.

According to a statement made by Gibbs (20), people are central to any effective system of innovation, and this area of human resource development had been sorely neglected in South Africa during the last few decades. Apartheid system of education has had its worst consequences in denying black people access to science-based careers. The developers of South Africa's Green Paper on science and technology, referred to earlier imbalances in the way science and technology were pursued in schools, colleges, technikons and universities. Black students attained matriculation exemption with physical science and mathematics as subjects at a rate of 1/60 to that of white students. The result has been that there are very few black scientists, engineers and technologists.

One way to contribute towards the redress in this area is by strengthening research and publication in all the higher institutions, which in turn will bring about industrial innovation and entrepreneurship within South African firms as well as enlightenment in research and academic institutions. In order to achieve and retain this goal, South Africans must generate new knowledge and apply the existing reservoir through scientific and technological activities. This is achieved through planned and sustained scientific research and publication.

To do this, however, there is need for a country to understand the nature and level of scientific productivity through bibliometric study of publication patterns of scientists.

According to the National Research Foundation Bill, it is generally accepted that "the capacity of a country in science and technology is directly related to its potential for development and progress, and for promoting the quality of its people" (21). In order to realise this however, there is a need for a country like South Africa, or part thereof, to understand the nature and levels of scientific productivity among scientists through the bibliometric study of their publication patterns.

1.4 Statement of the problem

One of the legacies of the apartheid system was the discrepancy in funding and support for various activities, including research work in science and technology. Some institutions of higher learning and research institutes were more favoured than others in terms of resources. The historically black universities were established because of the apartheid policy, and were therefore seen as "apartheid institutions". Because of this they had to cope with many additional problems such as upheavals and high dropout rates. The failure rate among students mostly resulted from struggle by students against the "system", which discouraged investment in these institutions. Most of the students who joined these institutions came from a poor schooling system, resulting in inadequate knowledge of subjects such as mathematics, science and English. To make matters worse, many lecturers were perceived to be uncaring in their attitudes towards students.

These institutions were isolated physically, politically and academically, hence it was far more difficult to establish an infrastructure for research, or attract renowned academics to work in these institutions. A situation of this kind gave very little opportunity to expose staff and students to other institutions. This cycle of deprivation continued until the recent political changes in 1990s. Consequently, the productivity in some of the science fields and in some institutions lagged behind others. One of the key areas for the enhancement of development in South Africa is improved productivity in science and technology.

The South African government has recognised this potential, and in an attempt to improve productivity, has embarked on a number of policy restructuring activities in the field of science of science and technology. One of this has been the reviewing of the funding and administration of science and technology research and information dissemination through the replacement of the previous FRD by NRF (from November 1, 1998).

As time passed it was felt that the work by FRD was not comprehensive as various agencies who were responsible for human resource development for science and technology, in particular at institutions in the tertiary education sector did not ensure an efficient national co-ordinated system. In order to rectify this situation, the National Research Foundation (NRF) was proposed and established.

As stated in 1.2.2 the NRF has taken the responsibility of providing for separate but co-ordinated divisions for natural sciences and engineering, social sciences and humanities, health sciences, and agricultural and environmental sciences. In addition to policy changes involved in the changing of FRD to NRF, a lot of other work needs to be done. For science and technology to have a positive impact in national development, it must be planned and there must be sufficient and relevant information to feed into this and future policy initiatives. While the FRD and CSIR have had the means for assessing scientific production among the scientific community, one may argue that most of the works that have come to the attention of these bodies have been those that have gone through the FRD process discussed earlier. It is therefore not inconceivable that many scholars and scientific fields may have been neglected.

One of the ways to cover this is through regular independent bibliometric studies. In South Africa few bibliometric studies have been done especially in looking at scientists at both previously advantaged and disadvantaged institutions and among previously advantaged and disadvantaged persons of all races. Bibliometric studies afford investigators the chance to study the quality and quantity of work done by scientists in the various fields.

A recent study by Ovens (22), on the citation patterns of the scientists of the University of Orange Free State, was noted, but represented only a single institution. Additionally, her work stressed the method of obtaining the relevant information. Another analysis was based on the nature of government publications at the University of Natal by Buchanan (23). In that analysis the author indicated that government publications were a means of communication between the government and the governed, but it has little relevance to the trend and quantity of scientific publications.

Assessment of scientific research performance therefore, has become a part of the standard procedure of science policy and research management. Comparative evaluations are made not just as a kind of "ranking game", but as indispensable aids to optimal distribution of resources under the constraint of ever tightening budgets and ever increasing costs.

Scientific research might be evaluated in various ways, such as peer review, comparison of research publications with international authority or through one's contributions to national and international conferences. However, most of the methods used to assess other intellectual activities seem inadequate in evaluating science, because neither cost-effectiveness analysis nor public opinion polls provide adequate measures of the merits of scientific achievements.

According to Gibbs (24), peer review is a widely used technique to help decisions about publication of manuscripts, promotions, and grant applications. There are however, serious objections questioning the validity of the peer review system.

Gibbs further argued that in developing countries, it was absolutely impossible to find peers who are both expert and unbiased. Gevers (25) said, "The quality of peer review we receive in core life science journals is appalling". According to him, the peers seem to expect even more from the Third World researchers than from American or European researchers. "It smacks of First Worldism".

Leslie (26) observed "almost everyone who has ever submitted anything to a journal had a horror story or two to tell". Armstrong (27) was also highly critical when he said that recent research showed that journal-reviewing practices were neither objective nor fair. He believed that peer review was simply a nice term for censorship, and it was not as fair as it appeared, nor was it helpful to scientific achievements.

Any objective and relevant assessment of scientific research performance must be based on the analysis of publications and their formal impact reflected in citations. When a scientist cites a given article, he/she indicates that the article is somehow relevant to the research performed. The citing author calls attention to some useful piece of information included in that article, a method, statistical result or whatever, and when an article is cited many times in a paper, it can be considered to have had a significant impact on the preparation of that paper.

Tsuda (28) carried out a study on the use of information by scientists and found that the major information sources used by leading Japanese scientists were through personal contact with colleagues and attendance at meetings, rather than the exchange of pre-prints. South African scientists, like their counterparts in other parts of the world, have been publishing the results of their findings in reputable international journals. Since most of these scientists belong to the Science Association of South Africa, it is equally probable that some of their research findings are being published in various South African journals of sciences.

By analysing and counting reference citations in these journals, it is possible to determine which journals are cited frequently and partly determine why. The quality of a scientist's research should also be considered in relation to peers, available facilities at one's disposal, quality of the publications, its effectiveness, that is, how often a publication has been cited by peers as evidence of the relevance of such a publication. To evaluate the achievement of a scientist in the field of animal husbandry, or a particular institution for example, requires answering questions such as "do farmers make use of scientist's and institution's products of animal-breeding programs?"

"Have other institutions adopted his/her research procedures and do they participate in its networks?" Furthermore, "have such research and publication been able to attain positions of responsibility in their own institutions?" Such tangible results are expected from "A" grade research and other research considered highly relevant.

1.5 Purpose of the study

The general purpose of this study, therefore, was to investigate the patterns used by scientists in publishing the results of their research. The scientists included in this study were from the universities of the three provinces of the Eastern Cape, Western Cape, and KwaZulu - Natal. No such comprehensive bibliometric study representing the scientists from the well established as well as previously disadvantaged institutions of South Africa has been carried out so far, hence the need for a study of this kind.

Research of this nature would enable a researcher to investigate and observe the quality and quantity of research done. This study was therefore aimed at determining the fields in which there was little research or none at all. Most of the data were obtained from researchers themselves by means of an open-ended questionnaire. This enabled the researcher to draw the attention of policy makers in the different organisations and funding agencies such as FRD and CSIR to take necessary steps to improve and rectify the situation. This could be achieved by putting up programmes to encourage greater research and publications in critical areas where there may currently be paucity of research.

1.5.1 Objectives of the study

The following were the specific research objectives

(i) To determine whether or not academic rank, status and prestige (personal, departmental, and/or institutional) have any impact on the level of productivity of South African scientists.

(ii) To determine whether or not "A" grade scientists in South Africa have a higher impact in their individual fields than other scientists.

(iii) To determine the levels of productivity within different areas of science in South Africa.

(iv) To determine whether or not the level of funding and/or the prospects of getting funded has any influence on the level of productivity in each area of science in South Africa.

1.5.2 Research questions

The following research questions were generated in order for the researcher to achieve the set objectives.

(i) Is there any relationship between academic rank and productivity of South African scientists?

(ii) Does scientist's prestige (personal, departmental, and/or institutional) have any influence on productivity of South African scientists?

(iii) Is there any relationship between academic status and productivity of South African scientists?

(iv) Do "A" Grade scientists' research and publications influence other scientists more than those of non-"A" Grade scientists?

(v) Are there any differences in productivity among the different areas of science?

(vi) Do prospects for funding affect the level of productivity in all areas of science?

(vii) Does the level of funding affect the level of productivity in all areas of science?

1.5.3 Null hypotheses

The following null hypotheses directed this study.

(i) There is no direct relationship between academic rank and productivity of South African scientists.

(ii) There is no direct relationship between the attainment and sustenance of prestige (personal, departmental, and/or institutional) and productivity among South African scientists.

(iii) There is no direct relationship between academic status and productivity of South African scientists.

(iv) Research publications of South Africa's "A" grade scientists do not have a higher impact on the research and publication of other scientists than those of non-"A" grade scientists.

(v) There are no significant differences in productivity between areas of science with more or less funding.

1.6 Justification of the study

Similar to scientists from developed countries, South African scientists generally make some positive effort to publish results of their research in the various fields. Realising that the only way of drawing attention of other scientists and people in authority responsible for their promotion, as well as funding agencies that support such research, the scientists do make public the results of their research efforts. Some of them reveal new discoveries while others duplicate their research with those of a similar nature carried out in other parts of the world.

There is also an expressed need in South Africa for greater numbers of scientists to do research in fields which have either been neglected or the potential of which has not been exploited. It is important to recognise that one of the indicators of the development of any country is the amount of research and discoveries in new technology and easy ways of carrying out tasks. This is because new technologies, which are a consequence of such research, make jobs cost-effective and less time consuming, thus enhancing the quality of life. By conducting this study, therefore, the researcher hoped to inform the scientific community at different locations and in different sectors of science of their contribution to South African development.

Another justification for the study was that by finding out the fields in which less research is done, authorities can effectively plan to encourage scientists from the less developed and most needed fields to work harder and produce greater quantities of relevant research. In order to do this they may need to encourage them by providing the necessary aids, monetary or otherwise. It was hoped that a detailed research of this nature would be able to discover the fields in which research is flourishing and the fields in which research is least developed or non existent. Also, the results of this research will highlight the disparity of research at the different institutions and the causes for this.

According to a statement from the FRD, South Africa had 45 "A Grade" scientists out of 1064 graded scientists in May 1997, that is, four percent of the total number (as in Table 1). The latest list of these of "A" Graded scientists in September 1998 was 46. These are researchers who are recognised nationally and internationally for their outstanding achievement and endeavours in research development.

Table 1

FRD ratings

UNIVERSITIES	A	B	C	P	Y	L	NR	TOTAL
CAPE TOWN	19	45	76	8	13	6	14	181
DURBAN-WESTVILL		4	17		1	4	8	34
FORT HARE			3		1		3	7
MEDUNSA			1				7	8
NATAL	5	26	52	4	20	4	12	123
NORTH WEST			1			1	1	3
NORTH			8		3	2	7	20
ORANGE FREE STATE	2	10	42		16		9	79
PORT ELIZABETH		4	15		7		7	33
POTCHEFSTROOM		9	25		5	2	11	52
PRETORIA	2	26	65	3	17	1	24	138
RAND AFRIKAANS	5	8	17	1	9		6	46
RHODES		9	18		5	1	2	35
SOUTH AFRICA	1	4	7		1		1	14
STELLENBOSCH	1	17	45	3	12	2	9	89
TRANSKEI			4			3	7	14
VENDA						1		1
VISTA			1		2		2	5
WESTERN CAPE		2	10		7	4	3	26
WITWATERSRAND	10	35	60	4	19	1	20	149
ZULULAND			4		1		2	7
TOTAL	45	19	471	23	139	32	155	1064

NR = Non-Rated

The ratings of these scientists change every year and those who wish to be rated need to apply every year. This ensures that scientists remain at a highly productive level. Those who wish to be recognised for their work and rated highly need to be vigilant and work ceaselessly. Appendix A provides a typical example of an application form used for the rating of scientists.

The South African Bibliographic Information Network (SABINET) provides the information concerning the publication of the scientists by the use of any and all the access points. It is the centre of South Africa's information network, which connects all the information centres to itself and at the same time enables the individual centres to be connected to each other and also to networks outside the country.

An examination of the current contents and the SABINET list of titles and authors for South African scientists and technologists showed that there were a few journals in which these scientists published. This study therefore hoped to investigate reasons for the pattern of publishing. By delving into the type of literature that is published, and the channels or publications within which they are published, this researcher hoped to present an insight into the various areas in which the scientists work and the areas that seem to be neglected and the reasons for both.

One the official organisation in South Africa - the Centre for Science and Information Research (CSIR), was started in 1976 for the purpose of encouraging scientific research in the country. The CSIR had some data on the scientific research, but was not deemed comprehensive enough. This study therefore hoped to find out if there was bias in the type of research done and whether that had any impact on a developing country like South Africa.

1.7 Delimitations of the study

This study was limited to the investigation of the publication patterns of scientists in the Eastern Cape, Western Cape and Kwa Zulu - Natal only for a period of five years (1992 - 1996). This was the period just before the political transition to a democratic South Africa and the period soon after the introduction of democracy. This was the period when South Africa was welcomed by other countries and the scientists felt free to work openly in their fields of research and collaborate with scientists, both within and outside the country. The ten universities of varied levels found within these three provinces are representative of the other universities in the country, hence it was believed that the findings of this research could be generalised.

Found in this area were the well established institutions like University of Cape Town, University of Natal, and Rhodes University, and the disadvantaged institutions like the University of Zululand, University of Fort Hare and University of Transkei. Bridging the gap between these was the University of Durban Westville. See section 5.1.

The University of Stellenbosch which is a well established Afrikaans university, was included and enabled the researcher to compare the publication patterns of the South African scientists from the advanced institutions with those of the historically disadvantaged institutions in the field. The study therefore, concentrated on the publishing activities of the academic and research staff - professors; associate professors; senior lecturers; lecturers and senior research associates from these universities. Since these ten institutions are comprised of both well established as well as some of the historically disadvantaged institutions (HDI), the researcher hoped to study the reasons for the quality and quantity of publications from different historical backgrounds. The responses from one of the HDIs was poor, but since the other similar institutions have responded slightly better, it was decided to use the data. Refer to section 3.4.1 page 86.

1.8 Definitions of terms used

Academic rank

The level at which each scientist or researcher is working in the respective department that is, whether he is a lecturer, senior lecturer, associate professor or professor.

Attainment

With reference to this study, attainment is reaching a set goal against accepted criteria.

Bibliometrics

The application of various statistical analyses to the study of patterns of authorship, publication and literature use. Pitchard (29) explained bibliometrics as the means of counting and analysing the various facets of written communication. In the context of this research, bibliometrics is a method by which we hope to measure publication productivity; effectiveness of publication; the grading of scientists and how it affects further research.

Citation analysis

It is referred to that area of bibliometrics that deals with the study of relationships among cited documents.

Impact (scientific, research/academic)

Impact of a scientist is defined by the frequency at which he/she is invited to guide others in research and the frequency at which he/she is cited and/or invitations to speak at conferences and seminars.

Prestige (academic)

Within the context of this study, prestige is the distinction that comes from achievements and success, that is, the overall evaluation of a scientist's lifework.

Productivity (scientific)

Refers to the amount of research output and publication that a researcher has done. It is often measured by counting the number of papers, books, chapters in books, reviews and reports produced by a scientist over a given period of time.

Publication

Publication is the act of making known to the public the research results through formal channels such as journals, books, publications and reports.

Publication pattern

Within the context of this study, publication patterns is defined as the various steps an individual goes through in the process of publishing the results of his research.

Research output

This is the quantity of research that a scientist is able to carry out within a defined period.

Status (academic)

Within the context of this study, academic status is defined as a scientist's position and/ or standing in the academic arena with regards to his/her qualifications. It is closely linked to prestige of the individual scientists.

Sustenance (of productivity)

Sustenance can be understood as maintaining the momentum of research productivity

1.8.1 Structure of the study

Chapter 1 outlines the research problem and the purpose, and the parameters of the study, The literature relevant to the study is reviewed in chapter 2, the research methodology and data collection methods are described in chapter 3. Chapter 4 is used to explain data analysis and presentation of findings. The interpretations of the results, implications and recommendations are found in chapter 5. Appendices are situated after the list of works cited (Bibliography).

1.8.2 Summary

In this introductory chapter, the problem area with which the study concerns itself has been articulated and the purpose of the study, including its justification, the hypotheses on which it is bound and its limits have been described. Brief definitions of terms used in the study have been provided and the structure of the study briefly delineated.

This chapter was also aimed at elucidating the publication needs and achievements of scientists from the various academic institutions of South Africa. A scientist from a well-established and well-equipped university like that of University of Cape Town, has the motivation to research and publish his works for the benefit of others. Other less fortunate institutions have marginalised facilities, and they do not have access to necessary information and equipment.

This chapter therefore discussed the need to obtain information and the steps taken by scientists to publicise their research results. The various machinery that deals with the evaluation of scientists into a particular category according to the quality and quantity of their publication are also discussed.

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Chapter 2
Review of Related Literature

2.1 Science, scientific research and communicating scientific information

Communication and information, explains Palmer (1), are intrinsic to the practice of science. Research stimulated by new information, is sustained by a continuing flow of information and, when completed, again yields new information. This, in turn, generates a fresh cycle of creativity and discovery.

Shera (2) defines research as an intellectual process whereby a problem is perceived, divided into its constituent elements and analysed in the light of certain basic assumptions; valid and relevant data are collected; hypotheses (if any) are rejected, amended, or proved through objective testing. The generalizable results of this process qualify as principles, laws or truths that contribute to man for his understanding of himself, his works, or his environment. Research, stated in another way is the systematic attempt to discover new facts or new relationships among facts, through the formulation of a preliminary explanation or hypothesis, which is subjected to an appropriate investigation for validation or disproof (3).

One of the rules that governs research is the rule of objectivity. Research is the stern disciplinarian that is, not because it is recondite or esoteric, but because it leaves no place for the subjective. Scientific information has no value if it is not communicated and utilised. Atherton (4) is of the opinion that the work of scientists and researchers necessitates effective communication, in order to:

(i) stimulate thought and action by interaction with other people's ideas, knowledge, experience and achievements;
(ii) promote continuous awareness of what others are doing;
(iii) diminish the probability of unwitting duplication

(iv) provide introductory and background information for work in unfamiliar fields;

(v) provide specific information and data for the work in hand.

Atherton further argues that although meetings, conferences and exhibitions are useful for spreading ideas and facilitating contacts, exact information requires presentation in documentary form. For this reason, reckons Ongus (5), journals play a vital role in the communication of scientific information. Authors require their work to be visible to the scientific and technical community. It should be visible, first in the literal sense, in that it should be physically visible and conspicuous to colleagues, and also to the authors themselves. The article is often the only tangible product of intensive research, in the same way as a table is the product of a carpenter, who would not be as happy with the sketch of a table.

Line (6) asserts that the need of authors for visibility extends little beyond the current awareness period of two or three years into the article's existence. He further states that authors are more concerned with status, both in its own right and, critically, because in the academic world advancement depends largely on it. Under normal circumstances, the owners of articles want their work to be in a form that carries credibility with their institutions, their colleagues, research granting bodies and potential future employers. They also want their work to be made available quickly, mainly to establish priority.

Consumers of research publications tend to be similar to the authors, although this is not true in technology, where there are many consumers who do not produce and vice versa. They have, however, different requirements according to whether they are publishing literature or using it.

Scientific research and publication are the backbone of any country, more especially for a developing country like South Africa. From the various aspects of its existence, it is believed that the future of South Africa will depend largely on the ability of its people to work together to create wealth by manufacturing its own goods.

They need to be innovative and creative in the development of new technology. It is believed that new developments in agriculture, food technology, medicine and health are the results of collective research of scientists and the publication of their results. Research and publication in the area of primary health of rural South Africa is of paramount importance.

Besides the above reasons, publication of research plays a major role in the advancement of faculty members in the various departments of science as well as in the accreditation and assessment of science graduate programmes. Even a prospective student's selection of a particular scientific field or a researcher's decision to join a particular faculty may be influenced by the quantitative and qualitative measures of research productivity in that department. By publishing their research results, particularly in peer-reviewed journals, faculty members not only communicate research results and place them in journals of record, but also bring prestige to themselves, their schools, and their parent institutions (7)

In recent years, several studies have examined characteristics of the publication patterns of various scientific fields both in the USA and Europe. Examples of diversity of these studies include gender differences and publication patterns, productivity and faculty size productivity levels between academic librarians and Library and Information Science faculties.

A study conducted by Garland (8) on the gender differences in scholarly publication in Information Science for the years 1978 to 1988 found that the proportion of Information Science-oriented literature produced by women was one-third of that produced by men. And though there was a lowering of production of publication by women in higher rank, such as professors, there was a rapid increase in the production by women in lower rank such as senior lecturer level.

It was noticed that at lecturer level this percentage almost tripled. Watson (9) carried out research to compare the quantity of publication in Library and Information Science by the teaching staff and the academic librarians for the 1979 to 1983 period. He found that 21 percent of the articles examined were authored by Library and Information Science staff and students. His findings were consistent with that of a study covering 1967 through 1977 period. The subsequent separate studies conducted by Swigger (10), Hart et al (11) and Muarski (12) on Institutional Affiliations and Characteristics of Authors found that from 18 to 23 percent of authors sampled were Library and Information Science educators. Thus, the conclusion they all drew was that the educators always outnumbered the practising librarians in their research output.

According to Gray and Perry (13), no less than other kinds of information and perhaps more than most, information resulting from science is a vital resource, especially in a country such as South Africa, where third world conditions predominate with a rapidly developing population and ever decreasing resources. Scientific information is the result of scientific research; the results of basic research are of direct interest mainly to other research workers, but the results of applied research and development concern virtually all types of information users in various fields.

Throughout modern society the need for scientific information is increasingly evident. In the manufacturing industry, applied research is the starting point of development, whether it leads to new and improved products or materials or to new and improved processes and techniques for making them. A builder needs to master the results of research into new building materials, methods, and equipment. A food processing researcher needs to familiarise himself/herself with new methods of preservation and treatment. A production engineer needs to know about new methods of measurement and new ways of making his/her products or handling the flow of work.

In the past, the South African scientists were to a large extent, at a disadvantage, in that many of them were working in an isolated environment, where many had little or no contact with people engaged in the same work as themselves. However, with the advent of the new political dispensation, the emphasis is on the need for scientific research and publication within the international arena. It is now up to each individual institution to ensure that its' academics are up to-date with their research, especially in fields where research had been neglected. This is one of the best ways for South Africa to level itself with other nations of the world.

One of the key proposals of the Green Paper on Science and Technology (14) is the creation of a National System of Innovation (NSI). In order to succeed in this vision, higher education and research need to be properly integrated and develop organic links with other sectors of NSI.

South Africa has 21 universities and within them are the historically disadvantaged universities shaped by the politically motivated differentiation policies of apartheid. Although these universities have expanded rapidly over the past decade and train the bulk of black students, they have limited research capacity. This lack of a significant research capacity has contributed to their poor level of international networking. One of the key roles of the national development programmes should be to produce sufficient human and physical resources and provide a national infrastructure for research and development programmes.

The Green Paper explains that South Africa has a "unique geographical location which provides wonderful opportunities for astronomical, biosphere, environmental and Africa-specific science endeavours and extensive scientific networks" (15). These extensive scientific networks can serve the long-term needs of parts of the scientific community. It is up to the policy makers to ensure that the researchers in this country are exposed to facilities that would enable them to forge ahead in their science oriented research and publications.

2.1.1 The scientific journal - Its origin and development

Before the foundation of scientific academies in the middle of the seventeenth century, there were no scientific periodicals, and "natural philosophers" conveyed their ideas and accounts of their work and experiments to one another by means of letters. The idea of recurrent publication had been established for half a century before any publication, which we can recognise as periodicals, appeared. The majority of these early publications attempted to report the events of the day and might be more appropriately described as dissertations or better so, newspapers of today. As forerunners of the periodical, they established certain precedents of form, as well as methods of compilation and distribution.

According to Kronick (16), until well into the seventeenth century, scientific communication was carried out primarily by word of mouth, private letters, manuscripts and printed books. It was then the founders of periodicals desirous of furthering scientific research decided to acquaint scientists quickly with the latest discoveries being made. These men devoted themselves to what they considered the thankless chore of editing articles written by other scientists. Thus, the first journal was published in Paris on Monday, January 5,1665 (17). After much deliberation, it was decided that the journal would be a weekly publication, in view of the fact that news ages quickly. According to Yagello, it was at about the same time that the State of Monopolies was adopted in England, thus establishing the basis for patent laws in all countries (18). As scientific societies were established, the publications of printed transactions or memoirs constituted a significant part of their work. These general periodicals that covered the fields of science were adequate as long as scientific activity was slow; but when it accelerated during the 18^{th} century, such publications proved inadequate. The volume of material that was submitted, made it impossible for the secretaries of various societies to evaluate its worth. Furthermore, argues Ihde (19), the financial resources of the societies did not permit the printing of all the material that was accepted; hence publication frequently lagged behind by several years. In spite of a setback from 1665 to 1792, a series of 111 volumes were published. The journal was reprinted in Amsterdam and also in Paris, and was imitated in other countries.

By the end of the 18th century, journals sponsored by private individuals had been established, some of them of a general nature while others were restricted to a particular field of science. Lorenz Von Crell (1744-1816), who was professor of Chemistry and counsellor of mines in Helmstadt, published the earliest journals, which restricted their pages to chemistry. The titles and emphasis of his journals changed frequently. Even in this early period, the patterns of obsolescence varied considerably between sciences, explains Kronick (20), and while medicine had a low rate of obsolesce, a new discipline such as chemistry could exhibit it to a higher degree.

According to Ihde (21), Berlinisches *Jahrbuch fur Pharmacie* (1795 -1840) is considered the earliest chemical annual. Similar annuals featured prominently until the end of the century, when abstracting journals began to take on special importance. The first abstracting journal in the field of chemistry was "*Pharmaeutisches Centrablatt*", founded in 1830. In the words of Jacobs (22), abstracting journals are the lifeblood of chemical literature as chemical abstracts are capable of keeping chemists abreast of the current literature. More importantly is that their indices make it possible to carry out searches systematically and exhaustively.

By the early part of the 19th century the continuing rapid growth of organic chemistry rendered current journals inadequate and resulted in the establishment of national chemical societies. Technological improvements helped make possible the proliferation of publications of these societies. According to Klooster (23), journals became increasingly specialised, reflecting the parallel specialisation of chemistry as well as new area for the chemical periodical. The last decade of the century was remarkable for the publication of twenty-five new journals, thirteen German, three French and five English. Notable among these was Gren's *Journal der Physik*, which first appeared in 1790 in Halle and Leipzig and which, strictly speaking, is the first journal specially devoted to physics, since Rozier's *Observations* included material from other scientific fields. One of the prestigious journals *Philosophical Transactions* of the Royal society of London, which originated in 1798 offers its distinguished services to science throughout the world.

2.1.2 The invisible college and scientific communication

Scientists use a variety of channels of communication to acquire information. A number of studies have investigated this within a particular discipline or group of disciplines. Dhakar (24) studied sources of information used by physicists. Her findings were that review articles, abstracting and indexing periodicals were the first sources to be consulted, in that order, in seeking scientific information. Consultation with experts, senior scientists and colleagues came next in the order. According to Parker and Paisley (25), Herner was the first to carry out an in-depth study on the formal and informal use of information by pure scientists. Herner's findings showed that pure scientists depended on literature, while applied scientists were 'colleague dependent' in seeking information (26). Investigating the communication channels used by bioscientists, Bernard and his associates (27) came to the conclusion that scientists depended largely on printed and published sources of information.

Wood (28), was of the opinion that scientists engaged in research and development (including academic workers) make constant use of formal channels, particularly scientific journals and abstracting publications, while the applied and industrial scientists find oral communication with colleagues in the same organisation to be more useful. Both Skelton (29) and Wood (30), confirmed from their findings that research scientists make use of an "invisible college" (consisting of people with similar interests and a number of information communication channels). Through the "invisible college", explained Jacobs (31), the natural scientists are able to use sources of information such as exchange of prints, reprints and manuscripts, telephone calls, discourse at conferences and local meetings, guest lectures and informal newsletters. According to Price (32), colleges are held together by highly influential people, who over the years have accumulated a large quantity of useful and up to date information.

The status of an individual within his / her organisation is a key factor in information transfer. Although informal communication networks are widespread, explained Ford (33), they tend to operate at senior level; junior members of a system tend to rely heavily on formal channels.

A number of researchers have traced the communication of scientific information during various stages of research process. Smith (34), reckoned that scientists relied heavily on personal, informal channels of communication to obtain ideas, current information and feedback during the initial problem conceptualisation stages. During the second stage of methodology development and data collection, informal sporadic contact with colleagues to obtain information on specific research problems occurs concurrently with exhaustive searching of formal literary sources of information. During the final stages of interpretation of data and presentation of findings, scientists informally present their findings, initially at small gatherings and later to larger and more formal audiences to obtain valuable feedback and critical peer assessment.

2.1.3 Scientific and technical communication

Information analysis was developed to assist scientists and engineers to use the past works of others systematically in order to make progress in their own research efforts. The working scientist or technologist often employs the past work of others in a form different from that in which it was originally made available. The difference may branch from a major intellectual reworking of the information, to a mere culling and refiling of documents or clues to documents, but the latter can be an important aid to efficiency. Three centuries ago, this " personal store" of information consisted of correspondence, notes, and shelved books, undoubtedly, with scribbling in the margins. With the advent of the scientific journal at the end of the 17th century and of basic abstracting and indexing services in the early 19th century, personal stores of information expanded to include collections of references and files of reprints. Eventually review articles digesting families of papers, data tabulations and compendia became available to make increasing quantities of primary information accessible in forms that could be used more efficiently than could the "raw" publications of the original investigators.

Ferguson (35) explained that scientific and technical communication (STC) is the process in information science that focuses on the collection, storage, retrieval and dissemination of scientific and technical information (STI).

Communication originated in the scholarly traditions of scientists disseminating the results of research to their colleagues. Communication goals had traditionally focused on the steady improvement of information flow within disciplines, i.e., in the existing social structure of science. In Goodman's opinion, technology involved the extension of STI systems outward to the diverse communities of interdisciplinary users who want and need information products for applied problem-solving (36). Berul (37) showed that there are specialised information-seeking habits related to individual scientific disciplines.

Perhaps the most significant aspect of scientific and technical communication was its origins in the traditional disciplines. STI was produced with the aid of traditional disciplinary communication systems for the support of research and development. It is the direct result of efforts of the scholarly community of scientists and engineers based partly on the contributions to knowledge by their predecessors. It is also the product of a disciplinary process in which progress is derived from the collegial activities of problem identification and selection, hypothesis formulation and testing, open publication of results, and the evaluation of work by qualified colleagues. The essential character of research and publication process is summarised by Rawski who said:

> It is not in the nature of things for any one man to make a sudden violent discovery; science goes step by step, and every man depends on the work of his predecessors. It is this mutual influence, which makes the enormous possibility of scientific advance. Scientists are not dependent on the ideas of a single man, but on the combined wisdom of thousands of men, all thinking the same problem, and each doing his bit to add to the great structure of knowledge which is gradually being erected. (38)

This style of science communication was created to bridge the gap between diverse groups with interests in using related information for the solution of problems. The result according to Crane (39), was that information became a commodity for use across disciplinary boundaries by individuals from differing disciplines.

2.2 Scientific information in development

Information is a fundamental resource for development. Kularatne (40) reckoned that even when the necessary information is available, not everybody benefits from it. There are sectors in society that are better informed than others. In South Africa, the majority of the population live in rural areas. It has been stated that there are 410 million people in Africa, 350 million or 80 percent of whom live in rural areas (41). The importance of scientific information is obviously the potential to which it is able to better the lives of people both in the rural and urban areas. One of the concerns about scientific information therefore, is, how do we measure its' impact on the development of a particular region or sectors in a region?

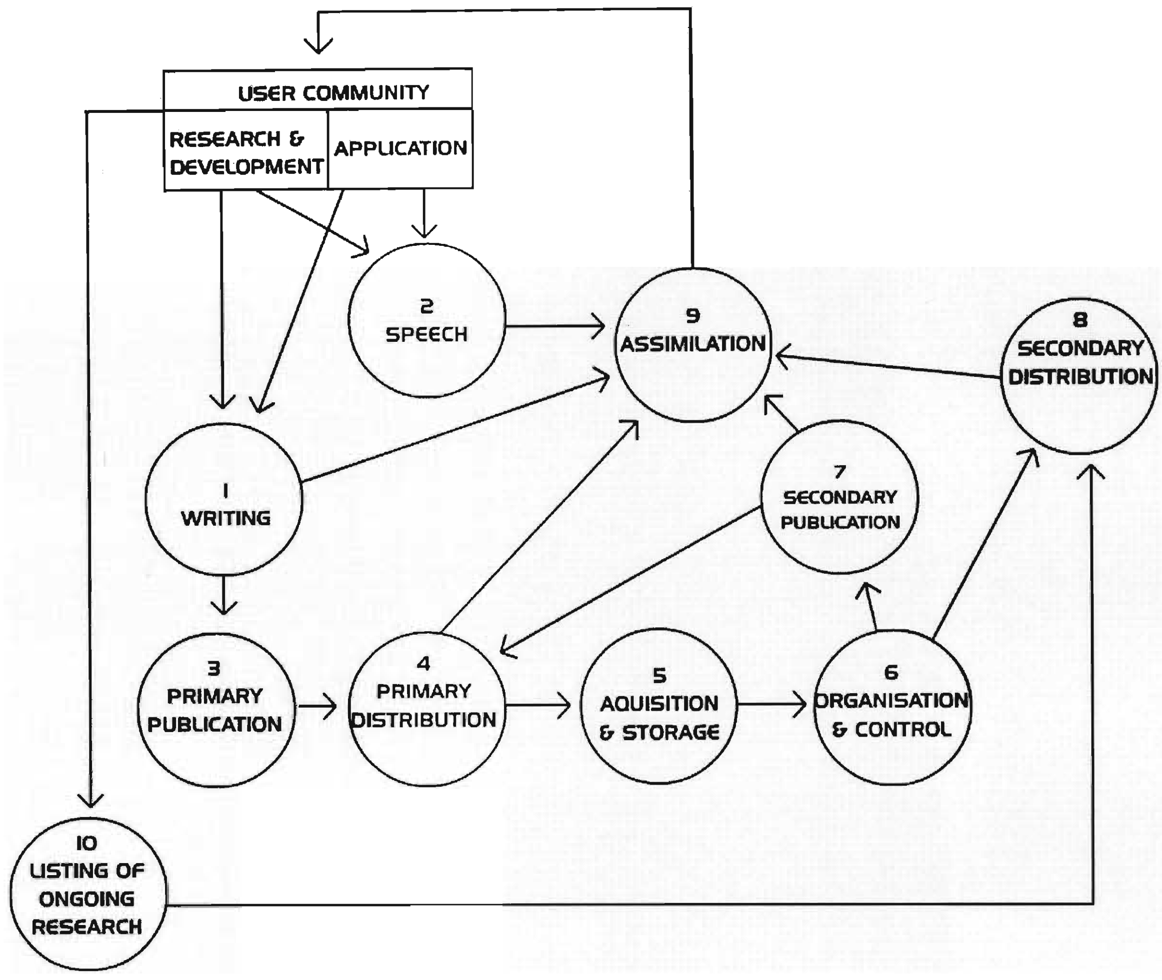
This is a question that many policy-makers and funders in South Africa are asking in the current economic climate of increasing accountability. The same question is echoed in international circles of the International Development Research Centre (IDRC). The IDRC is a development assistance agency of the federal Canadian government, which for many years has been funding information services in developing countries.

According to McConnell (42), impact is defined as "demonstrating the social, cultural, economic, political, environmental and other benefits that are associated with the consequences of making effective use of information". In order to measure the impact factor, one needs to ask the following question, " what is the function of the information so generated by a particular research?" "What development need does it attempt to fill?" "What other factors affect development in the region and the sector of interest?" Qualitative studies can set the framework for answering the questions, but to determine the impact of any causative factor such as information on development in a way that can be used to compare its impact with that of other factors, we need to assess impact quantitatively, we need to measure it. Unfortunately, measuring the impact of information is not simple, because the value of information may not accrue at its immediate point of use but at some future time.

The most important channels by which the results of research and application activities are disseminated in science and other fields are depicted at the microlevel in figure 1.

Figure 1

Scientific research and communication "cycle"



Adapted from: Lancaster and Smith (1978: 368)

The box headed "User community" includes two components: those individuals who are involved in (a) research and development (b) the application of the results of research and development. The communication problem represented in this diagram is that of disseminating the results and experience of research, development and application activities rapidly and efficiently to those individuals who require and profit by this information.

As the figure shows, various members of the "user community" report the results of their research and development activities. Some of this information when assimilated, stimulates new research or applications. The publication and communication process represented in the diagram is thus a continuous and regenerative cycle. Science cannot survive without an efficient publication and communication cycle to support it.

According to Baglow and Bottle (43), scientists are responsible for the literature problem in science and the more eminent they are, the greater is their contribution to it. Luukonen (44) found that the majority of chemical publications come from academic institutions. A study carried out by Matheson (45) found that the distribution of productivity among scientists, i.e. the proportion of scientists who write one paper, two papers, three etc. in a given interval of time - does not vary much from country to country, and hardly at all since the invention of the scientific journal in 1665. The number of scientific periodicals has, however grown enormously since then. Scientists gain prominence by acknowledgement as authors of important work. This prominence largely depends on how much they publish in important journals. Braun and Schbert (46) are of the opinion that highly-ranked journals maintain their position to the extent that they publish important papers. The study by Luukonen (47) confirmed that scientists are reward-oriented and attempt to publish in the most prestigious journals possible, seeking an optimal level in the hierarchy of publications.

Ranking of academics and researchers in South African institutions are important for students, research funding organisations, researchers and the institutions in which they work. Quality and prestige of any particular institution is measured by the excellence of its staff both in their academic work and research. For students, and in particular for postgraduate students, working with highly graded academics is indicative of post-graduate employment opportunities. Graves (48) argued that grading may be used as a proxy for employment opportunities since they may serve as a screening device for employers and an indicator of research quality by students.

It is believed that reputable and multinational companies compete strongly for the acquisition of post-graduates of reputable institutions such as Harvard and Massachusetts Institute of Technology, in the United States, by offering positions to their students well in advance of their graduation year. An additional reason for doctorate students to keep an eye on university rankings is the fact that in many countries doctoral bursaries are based not only on the merit of the candidate but also on the quality of the supervisor.

Pouris (49) said that research funding organisations, such as FRD and HSRC are keenly interested in the grading of scientists as well as institutions. One of the primary conditions for obtaining grants and bursaries for research is the evaluation of the individual by FRD. The only other way to obtain FRD funding by scientists is by working together on a project either the research is inter institutional or intra institutional and this would provide opportunity for the group to be evaluated.

Resource limitations and prudent use of public money call for a distribution of funds placing priority in research with perceived socio-economic benefits. Such research is based on the identification of the areas of today's research that are likely to provide the knowledge base for the important technologies and industries of tomorrow, and on the employment of good research teams in identified areas. FRD has stressed the importance to inter-institutional research and are willing to invest funds on collaborative work. A comprehensive list of graded scientists and the institutions in which they work provide a guide to where these research teams can be found and an indication of the way research funds should be distributed among the various institutions.

FRD has been the main funding organisation for scientists in South Africa. It encouraged and rewarded scientists who were research-oriented and produced publications at regular intervals. Scientists who were in need of a financial grant to carry on with their research projects were rated by FRD, after which they were given the required funding. Besides this, FRD also granted funds to groups of scientists who needed financial assistance for ongoing or new research.

2.3 Productivity (academic and research) and scientists

Scientific productivity is referred to as the amount of research output and publication that a researcher has done. It is often measured by counting the number of papers, books, chapters in books, reviews and reports produced by a scientist over a given period of time. This is because, says Rao (50), the data on the number of publications by the authors can easily be collected and is also quite reliable. Narin's 1976 study concluded that "scientific talent is highly concentrated in a limited number of individuals", and therefore, the science policy should be designed to encourage the most productive scientists (51).

Productivity has been linked to various factors, such as age and subject specialisation, and economic indicators, such as government expenditure on civil research and development. According to Budd and Seavey (52) prestige and productivity go together and can be summed up as a "scientist's lifework". According to Price (53), the distribution of productivity among scientists, who write one paper, two papers, or three, in a given interval of time does not vary much from country to country. A study by Bottle and associates (54) showed that professors in Britain and France are prolific producers of papers with no significant difference in productivity between the two countries. There is a big difference in the productivity of the middle ranks, i.e., associate professors and senior lecturers, in British universities who produce a mean of 2.1 publications per year more than their American counterparts.

A study done by Pouris (55) showed that the criteria used for ranking academic institutions in South Africa 'range from opinion surveys to measures of research productivity as proxied by publication counts in a sample of reputable journals'. Price was of the opinion that the best researchers tend to have many publications, and only rarely will these be trivial and uncited (56). Prestige seems to be one of the driving forces that encourages these scientists to publish profusely.

2.3.1 Academic or research level and scientific productivity

Bentley (57), Blackburn, Behymer, and Hall (58) who conducted separate research on motivation for research of academic scientists found that academic rank was a significant predictor of faculty research productivity. On the other hand, studies conducted by Guyer and Fidell (59), Over (60), and Wanner, Lewis, and Gregorio (61) came up with the conclusion that academic rank had no influence on departmental research productivity when other relevant variables were taken into consideration. Although most studies suggested that research interest highly correlates with research performance, one analysis of a recent national survey conducted in the United States by Blackburn and Tien (62) showed that research interest does not predict publication well. Also, research interest correlates negatively with research involvement.

Variations in study samples, differences in statistical techniques, and variations in the measures of staff research performance probably all contribute to these contradictions. Moreover, along with the conflicting findings, there is the problem that the measures of the two correlates - academic rank and research interest - imprecisely measure motivation.

Academic rank and research interests emerge in faculty studies as proxy measures of both extrinsic and intrinsic motivation. For example, given the evidence that publication does not stop at full professor level as they can seek promotion to higher levels within professorship. But when a promotion reward is no longer present, Finkelstein (63) concluded that intrinsic rather than extrinsic motivation plays the pre-eminent role for publishing. By including research interest as one of the indices of intrinsic motivation, Behymer (64) tested the effects of intrinsic and extrinsic motivation on productivity. He concluded that intrinsic rather than extrinsic motivation determines academic research performance. The other possible reason can be thought of is the monetary benefit that comes with publication. Also, there are some publish for the pure joy of researching and publishing.

A study conducted by Cooper (65) revealed that promotion was the driving force behind faculty research and publication. He believed that promotion upgraded the faculty members in status and pay. In addition, one can view the system of faculty ranks as an intermittent schedule of reinforcement. Under such a schedule, the desirable behaviour, in this case publishing, is not always reinforced by a promotion. The system of academic ranks can thus be treated as one particular type of an intermittent schedule - the fixed interval schedule - because the desirable behaviour of the academics will not be reinforced until the passage of a specified period of time.

As a fixed interval schedule, theoretically, the system of ranks should influence the productivity by the response rate of the research behaviour and length of the post - reinforcement pause. Based on the behavioural reinforcement theory, explained Cooper and associates (66), the expected publication rate remains low in the early period of the interval in rank because no promotion reward is conferred. But towards the end of the interval, the publication rate rises due to the closeness of promotion.

Promotion could be the motivating factor in the research publication of academics in the early part of their career, but as one progresses in the profession, this could only be a partial cause. In South African conditions, promotion cannot be the sole motivating factor in the case of research and publication. For example, there are professors who may have reached the pinnacle of glory where promotion does not count any more, or they may have retired from active service, yet they continue to research and publish. It is therefore not generally accurate to conclude that promotion is the only motivating factor in research and publication. External rewards such as salary increases, peer recognition, pure enjoyment and a continuing dedication to search for truths and to share them via the accepted outlet of journals are other and varied reasons for research and publications.

Institutions promote productive members of the department. Consequently, academic staff members who are professors or associate professors are "academic winners", as they are individuals who have demonstrated their research ability. That is, a selection function is operating that eliminates those who do not succeed, namely, low producers.

2.3.2 Academic or research status and scientific productivity

According to Price (67), there is a relationship between the importance of the scientist and the logarithm of the number of papers he has published during his life. It is seen that scientists who publish a large number of publications during the course of their lives, also publish more within a limited period of time, as compared to other scientists. Kreteschner (68) agrees to the fact when he says that the rank of a scientist is influenced by the number of publications he publishes within a given period. Allison and Steward (69) state that the high rate of publication among certain categories of scientists can be attributed to the accumulative advantage they have due to their position. For example, the same authors argue, heads of departments seem to be the most productive researchers in certain institutions. Ninety-three (93 percent) of HODs, that is 13/14, while only 15.6 percent researchers published more than 27 papers in ten years. There may be two explanations for that. Firstly, it may be assumed that the most productive scientists become HODs, and secondly, HODs are "owners" of almost all scientific results scored in the departments headed by them.

2.3.3 Personal, departmental and/or institutional prestige and scientific productivity

The prestige of institution and personal prestige induces scientists to do research and publish. This is evident in the case of South African scientists who hail from either of the two sets of South African universities - one historically advantaged the other historically disadvantaged. Most of the research done by the scientists can be attributed to those scientists who hail from the well-established and prestigious institutions. Hence one of the assumptions that can be made is that prestige must be one of the reasons for them to publish.

According to Broadus (70), research output as proxied by the number of publications in a sample of reputable journals, can be used as a criterion for rating universities. Research in the frontiers of science becomes effective only through being published, evaluated and incorporated somehow in the stock of knowledge.

In addition, universities and researchers maintain their reputation and increase their scientific exposure by publishing in appropriate journals.

Scientific information becomes useful in human affairs, says Becker (71), when it is transformed through processes such as scholarly review or education. In arenas such as health and social services, information transformation also includes real-world implementation that involves individual or organisational change. In order for the successful use of information in the development of scientific and technologic achievement in South Africa, there should be concerted efforts, guided by strategies collectively referred to as "knowledge utilisation". Becker and Shaperman (72) are of the opinion that knowledge utilisation requires individual and organisational change which can be both mechanically difficult and psychologically threatening for those considering the implementation of some new programme or procedure. Knowledge utilisation requires resources - money, materials, and personnel for any significant change, especially if the change takes place within a complex, organisational or social environment. Adopters of innovations must be convinced that the innovation will work in their particular setting, meeting specified needs over time without excessive adverse effects or unreasonable cost.

Communication in science normally occurs within disciplines. Hagstrom (73), is of the opinion that each professional in science and technology establishes priority and obtains the rewards of recognition in the scientific community as their new contributions are added to the data of science. Speciality groups within disciplines retain a certain degree of independence related to their information because of unique methods and techniques essential for handling phenomena and problems particular to each. At the same time, argues Himsworth (74), information generated for one discipline becomes useful for interdisciplinary purposes; that is, within the professional society or one of the specialities such as high-energy physics, cell biology or polymer chemistry. These subgroups constitute examples of areas where information dissemination crosses each disciplinary boundary for research purposes.

Traditionally, the goal of information communication was focused on the steady improvement of information flow within disciplines, that is, in the existing social structure of science. According to Goodman (75), technology involved the extension of the scientific and technical information (STI) system onwards to diverse communities of interdisciplinary users who want and need information products for applied problem solving. User studies showed that there was specialised information - seeking habits related to individual science discipline.

Goodman further argues that the communication system of science and technology is composed of similar elements regardless of discipline (books, conference proceedings, technical reports, journals). They are dynamically interrelated, so that as information flows through each system, delays in publication and "information filtering" activities are encountered. Lin, Garvey and Nelson (76) are of the opinion that much of the communication function is devoted to the simultaneous management and compensation of these control machines, which support the social organisation of disciplines.

Scientists and engineers communicate in similar ways, for example in written form, in publications, orally in speech, and symbolically, in algorithms, formulae and data. According to Jacobs (77), they use a variety of means, both formal and informal; for example professional journal articles, letters, computer programmes, books and reports.

As described earlier, departmental prestige and scientific publication go together. Prestige is defined as the overall evaluation of scientist's lifework and a researcher's prestige can also be affected by the status of his or her collaborators (78). Merton's(79) "Mathew effect" describes the disproportionate credit the more prestigious members of a collaborative group receive. Regardless of an eminent member's actual contribution to the paper or placement in the list of authors, readers tend to associate the work with this individual, thus enhancing his or her prestige over that of the co-authors. This, Cole and Cole (80) call the hypothesis of "accumulative advantage," in which those who are initially successful have greater opportunities for future success.

Allison (81) explained that prestige is awarded for productivity. Fox's (82) review of studies of scientists' publication productivity found many variables to be involved, ranging from individual-level characteristics such as age, motivation, and work habits, to environmental variables such as graduate school attended or current institutional affiliation, to feedback processes, such as those that promote prestige. Fox noted that locations that provide strong patterns of co-operation and opportunities for internal communication were associated with increased productivity, as were opportunities for students to publish collaboratively with a sponsor.

Prestige is another driving force that prompts authors to publish in foreign journals. Many of the bibliometric studies have been conducted in other countries, providing a theoretical context for this research. Mehrotra and Lancaster (83) found that about half of the papers of Indian scientists are published in the United States. Bhavani (84) and Shalini (85) also confirmed this trend. According to the latter, journals are viewed by Indian geo-physicists as the most preferred medium of communication. Hangrove (86) also reported similar findings regarding publishing preferences among Asian rice growers. Lancaster (87), argues that many scientists in developing countries prefer to publish in foreign journals rather than in their native journals for the sake of prestige and recognition. Garfield (88) agreed with Lancaster when he said that only 17 percent of Latin American research articles were published in local languages (Spanish and Portuguese). It was observed that a major portion of publications was found in smaller journals.

A study conducted by Ashoor and Choudhry (89), found that although publications were scattered throughout a large number of journals, the majority of publications were published by a small number of journals. Such journals may be considered the nucleus zone of scientific literature that must be accessible to the scientific community in a country.

2.4 Measuring scientific productivity and its impact

There are several possible ways of measuring the productivity of a researcher or a scientist and the influence or impact of his work among his/her peers and society in general. The most commonly used is the counting of the total number of citations relating to a scientist's work.

The most obvious (and most commonly used) is to count the total number of citations the author received or to relate the number of citations received to the number of items published (impact). However, explains Lancaster and Associates (90), one could argue that a preferred measure of a writer's influence is the extent to which his work is cited outside his own field or better, the number of different subject fields that draw upon his work.

Another method of evaluating a scientist's productivity and its impact is by counting the number of postgraduate students that he/she attracts to research under him or her, since students study a scientist in advance before committing themselves under him or her. The characteristics they pursue are those of personality, co-operation, a scientist who is recognised in his field by his peers, and one who is committed to his profession and willing to share his expertise with his students. In short, students wish to work with scientists who are highly esteemed by other experts in the field.

According to Alvarez-Ossorio, Gomez and Martin-Sempere (91), national journals will never improve if the best scientists do not publish in them. The same criteria can be applied to South Africa. The problem is largely common to journals written in languages other than English. The presence of those journals in the Science Citation Index is rather scarce and so their possibilities of being cited, or more precisely, considered in citation analysis are comparatively low. This lack of citation, it was felt, was not due to the lack of quality, but lack of exposure, as domestic journals are often chosen for publication in order to reach local audiences, particularly in industry and in the agricultural sector.

A look through the data sample and their publication patterns showed that the well-established scientists, mainly the "A" grade scientists, tend to publish in foreign journals in order to reach a larger audience. Another reason for this kind of behaviour in South Africa may be explained by the fact that publishing in domestic journals takes far too much time before the articles are finally accepted and published.

2.4.1 Citations in the flow of information

In order to understand the role of citation, it is essential to know what citation is. Garfield (92) defined citation as a reference to one's document by another as a source of information support for a point of view, or as an authority for a statement of fact. Baird and Oppenheim (93), were of the opinion that an author in citing a document in his/her work is referring to previously published work that is relevant to the argument the author wants to make. The author may either be criticising the earlier item, building on it, or simply using it to enhance his or her argument. The author may also cite simply to imply that he/she has read widely around his / her subject. Authors use citations to illustrate, elaborate, build on or criticise. The author believes the earlier item is relevant and wishes to draw the reader's attention to it. The main reasons that authors cite an earlier paper are for paying homage to pioneers in the field; giving credit to related work; quoting earlier papers that offer corroboration for one's ideas or claims; or citing a major figure because that makes the research look more respectable. A citation therefore links the earlier cited paper to the later one that cites it, meaning there is a semantic relationship between the whole / part of the cited document and the whole / part of the citing document.

According to Liu (94), citation studies have evolved into two major schools of thought "Normative theory and Microsociological perspective". The normative theory school views citation as a merit-granting process and, therefore, citation analysis can be employed as quality indicators for evaluating the influence of an individual researcher, academic institution, or publication.

Crane (95) argued that the use of citation linkage is merely an approximate, rather than an exact measure of intellectual debt. Dieks and Chang (96) thought the influence of an article is not solely determined by its scientific significance, but also by other extrinsic factors such as the locale of the author. Garfield (97) further argued that the citation picture is not a definite one, simply because scientific merit is not always the sole reason an author will cite a paper published in a particular journal. Factors such as the reputation of the cited author and the visibility, prestige, and accessibility of the cited journal may affect, to a greater or lesser degree, the work an author chooses to cite. Both Brooks (98) and Sandison (99) believed that citation is a complex behaviour. But according to Hooten (100), no one really knows, not even for some frequently cited authors, exactly why people cite some of their works more than others.

Liu (101) suggested four possible reasons why some scientists are not cited.

(i) Physical accessibility - if one is not aware of an article or cannot obtain it, it will not be read.

(ii) Cognitive accessibility - if one faces difficulties in understanding an article, or cannot read the language in which it was published, identification of its content, quality, and significance will be unreliable.

(iii) Perceived quality - if an article is considered to be of poor quality, it may be less likely to be cited. It is possible that a poor quality publication may invite negative citation.

(iv) Perceived significance - if an article is not scientifically significant, it may be less likely to be cited, even though it is physically and cognitively accessible.

2.4.1.1 Citation analysis

Citation analysis has been identified as one of the few techniques that has been imported from information science into other disciplines, but the uses to which it is put and its importance as an analytical technique within the host discipline have not been explored. Martin and Irvin(102), Irvin and Martin (103) and Irvin and Martin(104) have stressed that the practice should only be used as one of several approaches, in other words, like any other indicators, citations should be used with care.

Citation analysis is considered a major tool for the evaluation of research programmes. The use of citation for mapping disciplines has been justified by Small (105), White and McCain (106) and McCain(107). Small reckons that citations serve as a kind of language system, which can be deployed with greater flexibility than ordinary language. Cited documents as concept symbols may be freely combined and juxtaposed and not hampered by the customary rules of logic and syntax. According to White (108), citing an author is in some ways like voting for a candidate, it does not matter to some scholars why the votes were given; what matters are the tallies and patterns that emerge over the whole electorate.

Baird and Oppenheim (109) believe that the highly acknowledged individuals are also heavily cited. Certain individuals do get intensively acknowledged by authors for their guidance and mentoring. Cronin and his co-workers have developed a new term for this kind of study called "Influmetrics" - the science of measuring influence (110)

Although citation analysis has been used quite extensively, critics have questioned both the form and method of many studies found in the citation analysis literature. One major criticism explained Liu (111), was that while counting an author's citation numbers, citation analysis ignored the underlying purposes of why an author cited them.

May (112) was of the opinion that the purpose of selecting citations is to serve scientific, political and personal goals, and not to describe intellectual ancestry. In addition to persuasive purpose, reckoned Gilbert (113), another reason for giving references, is to provide justifications for the positions adopted in the papers, and to demonstrate the novelty of one's results with emphasis on the importance of the author's research.

Small (114) proposed a symbolic approach to citation analysis in which cited documents were perceived as 'concept symbols', that is, authors cite works that embody ideas they discuss in their papers. He observed a very high 'uniformity' percentage in the symbols associated with highly cited papers in chemistry, but lesser uniformity among core papers in DNA research. Small further stated:

> the citations not only decide the acceptability of the knowledge claim contained in the paper, but also to an extent, define what the claim is, by mentioning or noting that aspect of the paper which the citing author wishes to recognise and legitimise. Hence, documents assume meaning and significance through usage; and, what is regarded as scientific knowledge is mediated by collective use (115)

2.4.1.2 Citation analysis validity

Price (116) is of the opinion that a paper which has been cited many times is more likely to be cited again than one which has been cited fewer times. It follows then that an author of many papers is more likely to publish again than one who has been less prolific.

Citation analysis is often used as a method for measuring the utility or impact of the scientific work of individuals or groups. Although criticisms of citation analysis have often been voiced and the need for in-depth studies pointed out its usefulness as a handy tool, at least in the investigation of groups of authors or papers, it is accepted by many.

According to Small (117), cited documents are concept symbols. This approach treats citations in the context of the writing process in science. Within the text of the research report, each reference is physically connected to a set of words (the citation context) which describe or comment on a concept or finding presented in the cited work. What is said in the citation context is not determined exclusively by what was reported in the cited work. A citing author chooses a particular aspect of the older work for reference, and expresses that aspect in his / her own way.

According to Merton's theory of cumulative knowledge, the frequency of citations could be a measure of relative importance or quality of the cited author (118). It is believed that there is a considerable body of evidence to suggest that citation count correlates with a variety of subjective and objective performance measures. Myers (119) examined lists of the most frequently cited authors in Psychology with fifteen independent measures of eminence and found that citation frequency was a good index of a scientist's esteem. The research done by Cole and Cole (120) made the most important contribution by showing that high citation counts correlated positively with recognised quality indicators, such as prestigious awards, Nobel Laureateship and reputational ability. It follows then, that the research that scientists cite in their own papers represents a roughly valid indicator of influence on their work. Virgo (121) supported citation analysis in her study saying that citation analysis is a consistent and accurate predictor of important scientific papers - better on the average than the individual scientist's judgement. This conclusion can be considered reasonable if one considers that citations actually reflect a consensus of a large group of readers as compared to the evaluation of a single individual.

The most comprehensive work advocating citation analysis was done by Narin (122). In his study of the use of publication and citation analysis in the evaluation of scientific activities, he reviewed twenty - four studies showing that citation counts as well as other bibliometric measures, correlate well with various rankings of eminence.

This theory is supported by Garfield (123) who said that since authors refer to previous material for support, they distinctly show that the act of citing is an expression of the importance of the material.

A study carried out by Lawani and Bayer (124) provided new evidence on the validity and usefulness of citation criteria. Their research results consistently showed that highly rated papers are highly cited over the first five years after publication. The study further showed that peer assessment and citation rates are, in general, highly correlated.

2.4.1.3 Critique of citation analysis method(s)

Many critics have rejected citation analysis as meaningless numerology. Protagonists however, have been equally cavalier in ignoring and dismissing critics as uninformed, misguided non-believers. According to Broadus (125), the first recorded criticism of the citation method occurred when Brodman denounced the citation method in 1944. This attack though well cited, was not well conceived, but indirectly she achieved what she wanted. The fact that the paper has received so many citations can be used as evidence that cited materials are not always the best.

Both MacRoberts and MacRoberts (126) and Lambert (127) listed a number of criticisms. They believe that the extent to which citations can be relied on as an indicator of active use is uncertain and the limitations imposed by some editors on the length of papers tend to reduce the number of citations. It is believed that researchers have a tendency to use and consequently cite the literature which is most easily available . Some authors include references not primarily because of their relevance, but because it is polite to do so. Again, variations in citation rate are related to the type of publication, nationality, time period, size, and speciality.

2.4.2 Bibliometrics

The term 'bibliometrics' has a recent origin. Alan Pritchard coined it in 1969. But its usage can be traced back to the 1890s. Before 1969 it was called "statistical bibliography". Statistical bibliography as a concept was considered unsatisfactory because it could be misinterpreted as bibliography on statistics.

Perhaps one of the earliest attempts involving statistical methods for studying subject scattering was found in Cole and Eagle's work, which is an example of bibliometric study under no name. They tried to evaluate statistically the bibliographical citations of comparative anatomy, covering the period 1550 - 1860 in order to ascertain the growth of literature on the subject. Hulme (128) was the first to coin the term statistical bibliography. While delivering his two classical discourses at Cambridge University to quantify the growth of scientific knowledge and thereby to assess the overall development and growth of modern civilisation, Hulme used statistical measuring techniques which he termed as "Statistical Bibliography".

As stated earlier, statistical bibliography was considered unsatisfactory because it could be misinterpreted as bibliography on statistics. On the other hand, Lawani (129) argues that bibliometrics is unambiguous and analogous to such established terms as 'econometrics', and 'scientometrics'. The concept "bibliometrics" has two roots: "biblio" and "metrics". The term "biblio" is derived from the combination of a Latin and Greek word "biblion" equivalent to Bybl (os) meaning book and the word 'paper' was derived from the word Byblos, a city of Phoenicia noted for export trade in paper. The word "metrics", on the other hand, indicates the science of meter, i.e. measurement, and is derived either from the Latin or Greek word "metricus" or "metrikos" respectively, each meaning measurement.

In coining the term bibliometrics Pritchard defined it as "The application of mathematics and statistical methods to books and other forms of written communication". (130). This means bibliometrics is a sort of measuring technique by which interconnected aspects of written communications can be quantified. Fairthorne (131) described it as "quantitative treatment of the properties of recorded discourse and behaviour appertaining to it". Later, in 1972, Pritchard further elucidated bibliometrics as "Metrology of the information transfer process and its purpose is analysis and control of the process". He argued that measurement is "the common theme through definition and purpose of bibliometrics" and "the things that we are measuring when we carry out bibliometric study are the process variables in the information transfer process".

The British Standards Institution (132) defines Bibliometrics as "the study of the use of documents and patterns of publication in which mathematical and statistical methods have been applied. Hawkins (133) saw bibliometrics as "Quantitative analysis of the bibliographic feature of a body of literature".

Potter (134) defined it as "the study and measurement of the publication patterns of all forms of written communication and their authors". Sengupta (135) defined it more explicitly as "organisation, classification and quantitative evaluation of publication patterns of all micro-communication along with their authorships by mathematical and statistical calculus". And further, Shrader (136) considered it "the scientific study of recorded discourse". According to Hertzel (137) "bibliometrics is the science of recorded discourse which uses specific methodologies, mathematical and scientific, in its research in a controlled study of communication". She further states that it is the body of a literature, a bibliography quantitatively or numerically or statistically analysed, a bibliography in which measurements are used to document and explain the regularity of communication phenomena.

Nicholas and Ritchie (138) in their 1978 study stressed that the scope of bibliometrics is to provide information about the structure of knowledge, and how it is communicated.

According to their classification, bibliometrics is divided into two broad groups

(i) descriptive bibliometrics

(ii) behavioural bibliometrics.

Descriptive bibliometrics generally describes the characteristics or features of literature; while behavioural bibliometrics examines the relationships formed between components of a literature. O'Connor and Voos (139) stated that the scope of bibliometrics includes studying the relationship within literature or describing literature. These descriptions mainly focus on consistent patterns involving authors, journals, subject or language. Stevens (140) treats bibliometrics as a quantitative science and divides it into two basic categories - descriptive bibliometrics which is used to describe productivity and evaluative bibliometrics to count literature usage of a specific topic, subject or discipline. Evaluative bibliometrics is further divided into reference count and citation count.

In order to make his points clear, Stevens further adds that descriptive bibliometrics includes the study of the number of publications in a given field or productivity of literature in the field. This is done to compare the amount of research in different countries, the amount produced during different periods, or the amount produced in different subdivisions of the field. This kind of study is made by a count of the papers, books and other writings in the field or, often, by a count of these writings which have been abstracted in specialised abstracting journals. The evaluative bibliometrics includes the study of the literature used by research workers in a given field. Such a study is often made by counting the references cited by a large number of research workers in their papers.

The growth and development of bibliometrics as a subject has been tremendous. It has grown into a distinctive research area, a steady growth of relevant literature. This has become possible because the field has motivated many researchers from other disciplines to work on various facets of bibliometrics.

According to Sengupta (141), bibliometrics lies between the border areas of the social and physical sciences, its techniques have extensive applications in sociological studies of science, history of science including science policy, study of science and scientists and also in different branches of social sciences. Some of the areas where bibliometrics techniques are consistently being applied are enumerated as following:

(i) to identify research trends and growth of knowledge of different scientific disciplines;

(ii) to estimate comprehensiveness of secondary periodicals;

(iii) to identify users of different subjects;

(iv) to identify authorship and its trends in documents on various subjects;

(v) to forecast past, present and future publishing trends;

(vi) to identify core periodicals in different disciplines.

(vii) to forecast past, present and future publishing trends;

(viii) to predict productivity of publishers, individual authors, organisation and country or that of an entire discipline.

A search through the literature indicates that there have not been many bibliometric studies of South Africa's literature, except for a few fragmented ones. A study done by Pouris (142) in 1989 based on the evaluation of the academic institutions in South Africa did not compare the publication productivity of both well developed and lesser developed institutions. This study was concerned with institutions that were well established. A recent study by Ovens (143) on the citation patterns of the University of the Orange Free State scientists was based on just one academic institution. The main thrust of the study was to find out where scientists became aware of articles cited in their publications and also to find out where they have obtained these articles from. The conclusion of her study was that the library played a very small role in making scientists aware of articles they needed. Many developed countries have had bibliometric studies conducted in order to evaluate the rate of publication in various fields. Although South Africa is in its' infant stage of democracy, it has joined the nations of the world by competing with experienced sportsman, politicians and the like.

It was considered important for South African scientists to realise the tough competition in the field of research and publication. This researcher therefore, felt the importance of doing a comprehensive and evaluative study (bibliometrics) to distinguish between the disciplines that are in the forefront of research and publication and those that are far behind in this exercise in various universities in South Africa.

2.4.2.1 Bibliometrics and scientific communication

Siddiqui (144) explained that both communication and bibliometrics have been used as an effective analytical technique in Library and Information Science research. Research through citation studies has been conducted for a very long time for various purposes.

One area that has received particular attention is the relationship between faculty publication patterns and the presence of doctoral programmes. A study done by Kim (145) found higher production rates at both the institution and individual level in schools with doctoral programmes. Both Garland and Rike (146) reported that those working with a doctoral programme publish significantly more than those working in departments without one, and the quantity of the scholarly publication depends on the size of the faculty, prestige of the institution and the teaching load. The research results of Varlejs (147) showed that there is a greater relationship between the faculty's publication patterns and the presence of doctoral programme. An earlier study by Hayes also showed a significant relationship between the presence of a doctoral program and the average yield of faculty publications. Hayes concluded that 'perhaps the most clear-cut result is the importance of a doctoral programme in creating an environment that presumably encourages publication' (148).

Among the most powerful science indicators are those derived from the analysis of scientific and technical communication patterns in the disciplinary literature. Ferguson (149) reiterated that publications are based on the formal process of reporting research results for peer review and objective evaluation. The data for analysis is located in the professional journals, monographs, books, conference proceedings, and personal correspondence of scientists.

Inevitably, those authors who cite the works of others must give recognition to those authors upon whose work theirs has been built. Meadows (150) reckoned that indebtedness for ideas is given through the footnotes and bibliographic references in each publication.

Until the mid 1990s, very little attention was paid to the efficiency of the research system in all the South African universities, although the well established universities such as University of Cape Town, University of the Witwatersrand and University of Natal were progressing with adequate resources and facilities at their disposal. These institutions and their scientists were ranked according to the research input and publication output.

The usefulness of any discipline is measured through the research completed in that discipline. Numerous studies have been attributed to be in other countries, about publication patterns of scientists based on the type of journals they choose to publish in, and the language in which they publish. This study was concerned about the various factors that encourage scientists to publish as well as the obstacles that prevent them from publishing.

Le Coadic (151) has argued that scientific information is considered to be the 'blood' of science. This means that the vital principle for the scientist is to communicate his research results to others through his/her publishing activities. Unfortunately, the articles written by third world authors in the national journals do not get many citations because these journals are not well known and are not in the international indices. Another problem experienced by the Third World scientists is the accessibility to journals that are indexed or cited outside the country. Under-representation in the Science Citation Index or any other databases should not deter scientists from the third world from researching and publishing their results. It needs to be taken as a challenge and publish more in order to be recognised and accepted in the future.

2.5 Summary

Scientific research and the publication of the research results are the backbones of any developing country, especially so for South Africa which has just emerged from an era of apartheid after almost four decades. The scars of the evils of apartheid are still visible in the fields of science and technology.

Unlike the countries of the Northern hemisphere - Europe and America, where science and technology developed and spread gradually into all corners of the country, in South Africa the growth and development of science took a definite direction towards the older, well established academic institutions. The universities of the former homelands were some how neglected in this respect and the academics themselves were migratory in nature. This also has added to the lack of the tradition of well-established research. Research and scientific studies are being encouraged in South Africa, as in the fast-developing countries, for planning strategies and for rapid progress. One of the notable changes in the social organisation of scientific research here has been the rapid spread of collaborative research and teamwork that has emerged during the last couple of years.

In this research, bibliometrics is used to study the publication patterns of the scientists in South Africa. Through this research it is hoped to discover the reasons for publications in certain institutions and the lack of it in other institutions. Citations analysis is used to study the impact of the graded and non-graded scientists during the interval of 1992 to 1996.

Citation analysis is considered as a major tool for the evaluation of research programmes and bibliometrics is defined as the study of and measurement of the publication patterns of all forms of written communication and their authors.

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Chapter 3
Research Methodology and Data Collection Techniques

3.1 Introduction

The central task of any research is the design of the research project. According to Kothari (1), a research design is the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. It constitutes the collection, measurement and analysis of the data.

The main purpose of this chapter, therefore, was to elaborate on the research methods used and how the researcher conducted the study. The research design, the scientists involved and the instruments used have all been described in detail. Two different methods were used to collect data about the study population. Firstly, data collection involved requesting lists of publications from the curricula vitae of the scientists, and secondly, a questionnaire that was designed to collect additional data which could not be obtained from those respondents who sent only their publication lists and not their curricula vitae.

The general purpose of this study was to investigate the patterns used by scientists to publish the results of their research. The scientists included in this study were Professors, Associate Professors, Senior Lecturers, Lecturers and Senior Research Associates from the departments of botany, biochemistry/microbiology, chemistry, physics and zoology. Only scientists from the universities of the three provinces of the Eastern Cape, Western Cape and KwaZulu-Natal were included in the study as the universities found in these provinces were a fair representation of the scientists in the universities of South Africa.

In order to achieve the desired goal, the following research objectives were set.

(i) To determine whether or not academic rank, status and prestige (personal, departmental and/or institutional) have any impact on the level of productivity of South African scientists.

(ii) To determine whether or not "A" grade scientists in South Africa have a higher impact in their individual fields than other scientists.

(iii) To determine the levels of productivity within different areas of science in South Africa.

(iv) To determine whether or not the level of funding and/or the prospects of being funded has any influence on the level of productivity in each area of science in South Africa.

Research Questions

(i) Is there any relationship between academic rank and productivity of South African scientists?

(ii) Does a scientist's prestige (personal, departmental and/or institutional) have any influence on productivity of South African scientists?

(iii) Is there any relationship between academic status and productivity of South African scientists?

(iv) Do "A" grade scientists' research and publications influence other scientists more than those of non-"A" grade scientists?

(v) Are there any differences in productivity among the different areas of science?

(vi) Do prospects for funding affect the level of productivity in all areas of science?

(vii) Does the level of funding affect the level of productivity in all areas of science?

The null hypotheses of the study were as follows:

(i) There is no direct relationship between academic rank and productivity of South African scientists

(ii) There is no direct relationship between the attainment and sustenance of prestige (personal, departmental and/or institutional) and productivity among South African scientists.

(iii) There is no direct relationship between academic status and productivity of South African scientists.

(iv) Research publications of South Africa's "A" Grade scientists do not have higher impact on the research and publication of other scientists than those of non-"A" grade scientists.

(v) There are no significant differences in productivity between areas of science with greater funding as compared to those with less funding.

A study of this type, according to Martyn and Lancaster (2) is referred to as a study that is concerned with indirect or unobtrusive methods of studying phenomena of interest to librarians and other information practitioners. Analysis of records and types of research include bibliometric studies.

Advantages of carrying out studies of this nature, as enumerated by Bailey (3) are as follows: -

(i) They allow research on subjects to which the researcher does not have physical access, and thus cannot use any other method;

(ii) Occurrences over a long period of time can be studied. Many times the objective of the research is a trend;

(iii) Most involve a relatively low cost and are therefore inexpensive when compared to large-scale surveys

These types of studies also have their disadvantages, which are: -

(i) Data must be adjusted for comparability over a long period of time, especially if some external events cause changes that are so drastic that the unit of analysis used for the entire period produces misleading results;

(ii) Coding difficulties arising from differences in length and format may sometimes occur;

(iii) They are limited only to verbal (written) patterns. Non-verbal patterns cannot be directly observed but may be inferred (4).

3.2 The research design

As stated above the aim of this study was to investigate the publication patterns of South African scientists. A combination of the survey method and content analysis of documentary evidence was considered suitable.

3.2.1 Study population and sampling

The study was designed to investigate the publication patterns of South African Scientists. But the limitation of time and complete lack of resources made the task unmanageable for the researcher. Hence the population of the study had to be limited to the academic and research staff from the universities of the Eastern Cape, Western Cape, and KwaZulu- Natal. Academics in the ranks of professors, associate professors, senior lecturers, lecturers and senior research associates of these institutions were included.

This limitation of the study population to the three provinces, in a way, was a considered deliberate sampling of the population of South African scientists. The scientists chosen from the six fields had specialised in more than thirty two areas, hence it was felt necessary to limit the fields chosen. The limitation to six fields of science could therefore be considered deliberate sampling of the science fields. But when it came to actual collection of data, all persons who fell into the prescribed group, that is, provinces and fields of science were included in the study. Therefore in the strictest sense of the concept and process, no sampling was done, except self-selection with respect to responding to the researcher's request for data.

The information concerning the names and positions of these academics was obtained from the university calendars of the respective institutions for 1997. The length of time that each individual has been in the varied ranks and the research and publication that they have done was obtained either by self reporting in the questionnaire or from their curricula vitae which the scientists were requested to supply to the researcher.

There are ten universities within the three provinces. Only scientists from the departments of physical and natural sciences (physics, chemistry, zoology, botany and biochemistry/microbiology) were chosen. It was thought an enormous and unmanageable task, in terms of resources and time, if all the scientists from all the fields of science were chosen for the period of five years, 1992-1996 to be studied, hence the sample was limited to natural and physical sciences.

Further, the study population consisted of scientists from the well-developed universities such as the University of Cape Town, University of Natal and University of Port Elizabeth. The historically under-developed universities such as the University of Zululand, University of Fort Hare and the University of Transkei are found in this selection of universities. The University of Durban-Westville is the bridging institution between these well established and the least developed universities. Included in this group of institutions is the well-established and typical Afrikaans University of Stellenbosch.

3.2.2 The instruments

A manual search through the Science Citation Index (SCI) was done for a preliminary assessment of the cited articles of South African scientists. However, this search was disappointing, as most of the South African authors' publications were not cited in the SCI. This is because only articles from selected journals (journals with high impact) are chosen, as the SCI does not favour non-English journals. And again, articles, which are published in any of the non-scientific journals, will not be cited in the SCI. Another point about the citation found in the SCI is that only scientific articles, which are considered to have high impact, will be chosen while the some of the articles by the same author might not be listed. Hence, in order to obtain a complete list of all the journal articles, conference papers and technical reports produced and published by these scientists, the researcher thought it better to approach the scientists either directly or through correspondence.

Face to face and telephone interviews as methods of collecting data were considered but rejected because of the wide geographical distribution of the members of the population. The Universities of Stellenbosch, Western Cape and Cape Town are more than 1300 kilometres from where the researcher works. The nearest university is the University of Fort Hare, which is about 350 kilometres away. Another disadvantage for collecting data by means of interviews was the fact that some of the questions were personal and the scientists may not have felt free to discuss these over the telephone. Furthermore, it would have been almost impossible to find appropriate times for interviewing a substantial portion of the population.

The first data collection instrument thus used to elicit data from respondents was a personal letter addressed to each scientist individually by the researcher (Appendix B). It was accompanied with a letter from the supervisor (Appendix C) explaining the purpose of the research and the need for the collection of the publication lists. Included was a self-addressed, stamped envelope. Three hundred and fifty letters were sent to the scientists of the study population requesting them to send a copy of their publications list from their curricula vitae.

One hundred and fourteen scientists sent their publications' lists. After three weeks had elapsed, another set of letters was sent to those who had not responded. A further 15 lists of publications were sent by the scientists. Thus, the researcher received a total of 129 lists of publications or 37 percent. Further telephonic attempts to persuade scientists to send their list of publications to the researcher were unsuccessful.

3.3 Pretest of the questionnaire

It was considered important to test the validity and reliability of the measuring instruments. The validity of a test, reckons Toucan (5), is the extent to which a test measures what it purports to measure. Validity, when associated with measuring instruments, refers to the question, "Does the instrument measure what it is supposed to measure?" An important attempt to bring a set of common expectations and language to the validity arena was an effort of the American Psychological Association in 1966 (6).

To understand the shortcomings in any research situation, it is helpful to consider two principles: internal validity and external validity. A study has internal validity if the outcome of the study is a function of the programme or approach being tested, rather than the result of other causes not systematically dealt with in the study. A study has external validity if the results obtained would apply in the real world to other similar programs and approaches. External validity affects our ability to credit the research results with generality, based on the procedures used.

Gay (7) observed that "validity is the most important quality of any test". In order therefore to be valid, an instrument has to be reliable. Reliability refers to consistency of measure. In other words, it simply reflects the consistency of the measuring instrument used on two separate occasions to give the same response. Popham and Sirotnik further argue that tests which may be reliable may or may not be valid (8). In determining reliability it would be desirable to obtain two sets of measures under identical conditions and then compare the results.

One should note that the only difference between a validity coefficient and a reliability coefficient is that the former is based on agreement with an outside criterion and the latter is based on agreement between two sets of results from the same procedure.

In order for the instrument to be valid, it has to be reliable. In a test-retest method, employed in this case, reliability is estimated by the same test being administered twice to the same group with a time interval between the two administrations.

The researcher administered a pretest of the questionnaire to a sample of thirty five members in the different departments of physics, chemistry, botany and zoology at the University of Transkei, South Africa. The names of these academic staff were obtained from the University calendar for 1997. Selection was random. A copy of the questionnaire (Appendix D) that was coded and accompanied by a cover letter (Appendix E) were distributed to each scientist. Fifty one percent of the sample population (18 respondents) filled out the questionnaire. The average time required to fill out the questionnaire was 12.35 minutes. The comments of the respondents enabled the researcher to make the necessary revisions in the data collection instrument.

In order to evaluate the internal consistency and reliability of the instrument, and due to time constraints, the researcher decided to use Cronbach (1951) alpha. The Kuder-Richardson method also estimates the reliability of test scores from a single administration of a single form of test by formulae, one being called the Kuder-Richardson 20. It is used for tests for which answers are either right or wrong. The Cronbach (1951) alpha method is a generalisation of the K-R 20 formula or rating scales and is used for questionnaires that use a Likert-type response format.

The internal consistency of the scale, estimated by Cronbach (1951) alpha (9), was 0.98, an indication of high internal consistency. Thus, the instrument was considered valuable with potential for use in research anywhere else.

3.4 The procedure of data collection

Until 1994, collaborative research in South African tertiary institutions was fairly uncommon, especially in previously disadvantaged institutions and/or between staff from advantaged and disadvantaged institutions. Emerging institutions and in particular the historically black institutions, with minimal linkage to the advantaged tertiary institutions and without any research culture to fall back upon, found it difficult to carry out research on their own. Hence, there is a great deal of disparity in research output of the historically white and black universities.

The scope of this present study was to measure the research output of scientists from different institutions and to ascertain the reasons why some scientists have developed a high degree of research culture and publication while others are lagging behind.

This investigation also looked at the reasons behind the lack of research productivity among certain scientists and fields of study; reasons such as lack of motivation, lack of funding, lack of facilities for research and lack of guidance and leadership. In so doing, this study hoped to establish patterns of publication among the scientists.

3.4.1 Administering the questionnaire

Although not specifically requested, some scientists sent their curricula vitae, from where some of the required data was obtained. However, there were some respondents who willingly sent their list of publications, but had not included their curricula vitae. In view of this, it was essential to send a questionnaire to all the scientists to obtain personal information concerning their academic rank, professional qualification, number of years of teaching in the field, and the number years of research and their comments on the field of research which were relevant variables for the stated research problem, objectives, research questions and hypotheses.

Once the design of the questionnaire had been completed and checked, a copy of a covering letter and the questionnaire were mailed to all of the members of the study population using addresses obtained from the respective university calendars. The letter briefly explained the purpose of the study and requested recipients to oblige once more and complete the questionnaire and return it to the researcher as soon as possible using the stamped and self-addressed envelopes provided for the purpose. Three hundred and fifty questionnaires were distributed to the academic and research staff in the science fields identified earlier from the universities of the three provinces. The questionnaires were coded to check the percentage of return from each institution as well as to send reminders to those who did not return the completed questionnaires. However, confidentiality was strictly maintained by the researcher. Out of 350 questionnaires sent 135 were returned in the first round.

After a set period of seven weeks had elapsed, another set of the questionnaire and another set of self-addressed, stamped envelopes were posted or hand-delivered to all members of the population from whom no completed questionnaire was received. After three weeks, the second set of 39 completed questionnaires arrived. Thus the total number of returned questionnaires were 174 (50%). Out of these, 21 questionnaires were discarded as they were incomplete. This left only 153 questionnaires usable in the study. Another set of questionnaires and self addressed and stamped envelopes were sent through a staff member to two of the institutions, whose responses had been very poor, but still received no response from them. According to Bless and Hingson-Smith (10), and Bailey (11), collecting data through questionnaire has many advantages, but at the same time, one of the disadvantages is the very low response rate. Babbie (12) was of the opinion that although a response rate of 60 percent is good, a response rate of 50 percent is adequate for analysis and reporting. Since the total returns were 50 percent, the researcher felt that this was adequate to continue the study.

There were very few returns from those universities termed 'historically disadvantaged'. On the whole, the scientists were very co-operative and many were willing to send a second set of data if the first set did not arrive safely.

A coding key was drawn up in which numerical values were assigned to all limited answer options in the questionnaire with 9 representing “No response” and 0 representing “Not applicable”. This data was entered on a data matrix designed using the Statistical Package for Social Sciences (SPSS) for Windows.

In order to test the different research hypotheses, the study employed several independent variables and statistical techniques. Descriptive statistics (Means, standards of deviation and proportions) was used in determining the characteristics of the population of the study and inferential statistics, one-way Analysis Of Variance, (ANOVA) was performed to see if there were significant differences between the productivity in relation to rank, status, prestige and funding. Standard deviation was also used to observe the variability of productivity within each rank. Bonferroni multiple comparisons test was used in order to confirm the significant differences between three or more variables, and in this case, the significant differences between the productivity of professors, associate professors, senior lecturers, lecturers and research associates. (see appendix G). Also Pearson Chi-square tests were used to determine the degree of association and confirm the results obtained from the ANOVA tests.

3.5 Summary

The research methodology and data collection techniques employed in the study is described in detail in this chapter. All efforts were made to test the validity and reliability of the instruments in order to test the performance of the scientists in research and publication and the work related to their status within the universities, as well as to elicit their impressions and perceptions about funding and related issues. Two kinds of data were collected, a list of publications from the curricula vitae and self-administered questionnaire. These in turn provided the researcher with the necessary data to meet the stated research objectives, answer the stated research questions and test the stated research hypotheses.

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Chapter 4
Data Analysis and Presentation of Findings

4.1 Introduction

The general purpose of this study was to investigate the research and publication patterns of academics in the different universities of the three provinces of Western Cape, Eastern Cape and KwaZulu-Natal. The universities of three provinces appeared to be a fair representation of scientists from all the universities of South Africa, as they included the various types of universities, namely, scientists from the historically advantaged universities, as well as historically disadvantaged universities.

In addition to investigating the research and publications, it was the intention of the researcher to determine whether research and publication of the scientists were affected by their rank in the department, their status, the funding available and the institutional prestige. Another important aspect was to investigate the citation impact of scientists on others.

To study these variables, four research objectives were formulated. Seven research questions were posed in order to accomplish the research objectives. Based on the research questions, five null hypotheses were formulated.

In order to achieve the desired goals, the following research objectives were set:

(i) To determine whether or not academic rank, prestige (personal, departmental and/or institutional) and status have any impact on the level of productivity of South African scientists.

(ii) To determine whether or not "A" grade scientists in South Africa have a higher impact in their individual fields than other scientists.

(iii) To determine the levels of productivity within different areas of science in South Africa.

(iv) To determine whether or not the level of funding and/or the prospects of being funded has any influence on the level of productivity in each area of science in South Africa.

Research Questions

(i) Is there any relationship between academic rank and productivity of South African scientists?

(ii) Does a scientist's prestige (personal, departmental and/or institutional) have any influence on productivity of South African scientists?

(iii) Is there any relationship between academic status and productivity of South African scientists?

(iv) Do "A" grade scientists' research and publications influence other scientists more than those of non-"A" grade scientists?

(v) Are there any differences in productivity among the different areas of science?

(vi) Do prospects for funding affect the level of productivity in all areas of science?

(vii) Does the level of funding affect the level of productivity in all areas of science?

The null hypotheses of the study were as follows:

(i) There is no direct relationship between academic rank and productivity of South African scientists

(ii) There is no direct relationship between the attainment and sustenance of prestige (personal, departmental and/or institutional) and productivity among South African scientists.

(iii) There is no direct relationship between academic status and productivity of South African scientists.

(iv) Research publications of South Africa's "A" grade scientists do not have higher impact on the research and publication of other scientists than those of non-"A" grade scientists.

(v) There are no significant differences in productivity between areas of science with greater funding as compared to those with less funding.

In order to study these variables, the researcher initially looked through the Science Citation Index (SCI) manually because there was no SCI online in July 1996, either at the university where the researcher is working or at the University of Natal, Pietermaritzburg campus where the researcher was registered for her doctoral research. The initial aim of the manual SCI search was to attempt to identify publications by South African scientists, and to see the citation patterns of these publications. The researcher anticipated that she could partially establish a scientist's productivity (extent of publications of each South African scientist in international and local journals) and the extent of the impact of his/her works on others (frequency with which particular publications were cited) either within the author's own or related fields. This process would have been in line with some of the techniques used in assessing academic and research productivity. Rao (1) for example argues that the number of publications by an author can easily be collected and counted and this is also quite reliable.

However, only articles published in journals, which meet SCI publishers' criteria, are indexed in the SCI. This meant that local and other journals that may well have been relevant to South Africa were not indexed in SCI. Therefore, in order to obtain a list of articles on other academic publications from South African scientists included in the study population, the researcher decided to request the scientists for their lists of publications. The researcher assumed that the scientists being bound by academic ethics would provide genuine lists of items asked for and that in fact the lists would provide the researcher with part of the data required for the study.

In April 1997, the researcher sent out 350 letters together with a letter from the supervisor, requesting the scientists in the departments of the ten universities of the three provinces of Eastern Cape, Western Cape and KwaZulu-Natal to send lists of their publications from their curricula vitae. The addresses of these scientists were obtained from the respective university calendars. The letter explained in detail the purpose of collecting the lists of publications.

Out of 350 letters that were sent out, 129 scientists replied and sent copies of their publications' lists. Some of them (junior scientists) wrote back to say that they had no publications as yet and hence, could not send any lists. Some of the other scientists replied saying that they were too busy. But all those who sent their lists of publications were very generous, some of them even sent their curricula vitae. By the end of August 1997, a total of 129 lists were collected.

As the researcher felt that more information was required in order to study the productivity, status, rank and other demographic information, a second set of data were collected. For this a self administered questionnaire, together with a stamped self addressed envelope were posted or hand-delivered to all the members of the study population. Included along with the questionnaire was the letter from the researcher explaining the need for this second data collection.

The questionnaire was then sent to 350 full-time academic scientists in the Departments of Physics, Chemistry, Botany, Zoology and Biochemistry / Microbiology in the universities under the three provinces of Eastern Cape, Western Cape and KwaZulu - Natal. Out of the 350 subjects, 135 answered the questionnaire. A further reminder brought another 39 more, thus making the return 174 or 50%. Among the 174 returns, only 153 were used in the data analysis. Twenty one returns were discarded, as they did not include complete answers.

The respondents were asked to indicate the time spent on research, teaching, administration, their opinions on the influence of an "A" graded scientist in an institution as well as their opinion on the influence of funding on research and publication. A Likert-type scale of 5 to 1, with 5 being "strongly agree" and 1 for "strongly disagree" was used for collecting opinion data.

The data required to study null hypotheses one, two and three were obtained from the completed questionnaire. For the null hypotheses four and five data was collected from FRD and Science Citation Index respectively, together with the data collected by means of the questionnaires.

4.2 Data reduction

A coding key for data from the questionnaire was drawn up in which numerical values were assigned to all limited answer options with 9 representing "No response" and 0 representing "Not applicable" or "Do not know". In the case of documentary data available from scientists' curricula vitae, these were analysed through content analysis. Data was then entered on a data matrix designed using the Statistical Package for the Social Sciences (SPSS). The data were then analysed using descriptive and inferential statistics as described in the update edition of the SPSS (update 7-9). Descriptive statistics (Means, standards of deviation, and proportions) were used in determining the demographic characteristics of the population of the study.

Inferential statistics (one-way ANOVA) was performed to determine the differences between and among demographic characteristics of the study population. Pearson Chi-square tests were used to determine one-way ANOVA tests. Further analysis of results was done using Bonferroni multiple comparison tests to determine the significance of data collected from the second and third parts of the questionnaire. The second part provided data on research and publication productivity, while the third section supplied data on prestige (both individual and institutional), available funding and factors that motivated publication and research.

The data relating to limited option questions were initially analysed in terms of frequency of responses. Marginal frequency distributions were produced for all limited options and bar graphs or pie charts were developed to express these frequencies graphically.

A combination of content analysis and qualitative coding was used to interpret the responses to open questions. Gay (2) described content analysis as "the systematic, quantitative description of the composition of the object of the study" and he distinguished between simple content analysis involving frequency counts and more complex analysis that might be used to investigate bias in a text. MacDonald and Tipton (3) discussed the use of quantification, such as recording the number of times a topic is mentioned to establish its' importance in a text or document.

Responses to open ended questions and the category of 'other' as a response to a question could not be pre-coded. Fielding (4) described a method of qualitative coding that could be used to interpret these types of response. His method consisted of two steps. The first step involved identifying different concepts as they appeared in the responses to questions in the set of questionnaires and the second step involved sorting the concepts into categories. The researcher adopted this method for the interpretations of the results of the questions in section two.

4.2.1 Subject areas of respondents:

The 153 respondents who took part in this study were distributed among the Departments of Botany, Biochemistry / Microbiology, Chemistry, Physics and Zoology. Out of these scientists, 24 or 15.68 % were botanists, 26 or 17.00 % were biochemists/microbiologists, 39 or 25.49 % were chemists, 29 or 18.95 % were physicists and 35 or 22.87 % were zoologists.

Table 2

1. Distribution of the respondents according to departments

Department	Number	Percentage
Chemistry	39	25.49%
Zoology	35	22.87%
Physics	29	18.95%
Biochem/Microbio	26	17.00%
Botany	24	15.68%
Total	153	100%

4.2.2. Distribution of respondents according to academic rank

Respondents were classified according to rank such as professors, associate professors, senior lecturers, lecturers and senior research associates. The number of professors although much greater than that of associate professors and senior lecturers, was equal to that of the lecturers. However, this does not appear to be a true reflection of the academic distribution within the different institutions. A glance at the university calendars of some of the well established universities indicated that there are more professors than lecturers, while the situation is just the opposite in the previously disadvantaged universities where there are more lecturers than professors. Therefore, on finding the average of the two kinds of universities, the percentage obtained in this study appears to be representative.

In analysing the academic rank of respondents, there were 47 or 30.71 % professors, 27 or 17.64 % associate professors, 30 or 19.60 % senior lecturers, 46 or 30.06 % lecturers, and three or two percent senior research associates. Although these scientists belonged to five departments their fields of specialisation extended to 36 areas.

The responses obtained were arranged according to the various Departments the respondents belonged to such as Physics, Chemistry, Botany, Zoology and Biochemistry / Microbiology and according to rank of the respondents, such as professors, associate professors, senior lecturers, lecturers and senior research associates.
Table 3 below shows the distribution of respondents according to rank.

Table 3

Distribution of respondents according to rank

Rank	Number	Percentage
Professor	47	30.71%
Associate Professor	27	17.64%
Senior Lecturer	30	19.60%
Lecturer	46	30.06%
Senior Re. Associate	3	2.00%
Total	153	100%

4.2.3. Respondents' distribution based on institutions.

Out of the 153 scientists who answered the questionnaire, 10 out of 34 scientists were from the University of Natal, Pietermaritzburg; 13 out of 30 scientists from the University of Port Elizabeth; 16 out of 38 scientists from Rhodes University, and 9 out of 24 scientists belonged to University of Fort- Hare. Twenty one out of 50 scientists who responded were from the University of Cape Town and 18 out of 38 were from the University of Stellenbosch.

There were 12 out of 30 scientists who responded from the University of Durban-Westville and 19 out of 33 from the University of Natal, Durban. Fourteen out of 34 completed questionnaires were returned from University of the Western Cape, 2 out of 19 from the University of Zululand and 19 out of 20 from the University of Transkei. Thus, a total of 153 completed questionnaires from the 10 universities were received.

4.2.4 Teaching and research experience

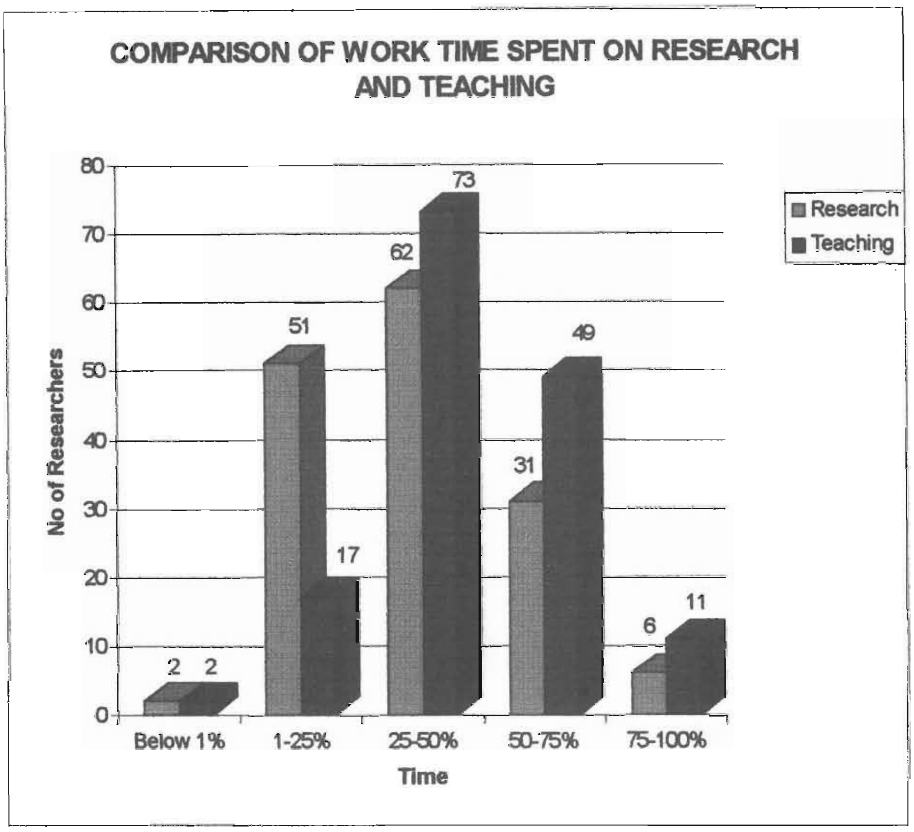
It was considered important to know the length of time each scientist had been teaching and doing research. An obvious factor about a person's productivity, prestige and other related issues of concern in this study is the length of time over which one has been in the academic and or research field. Therefore, respondents were asked to indicate the duration they had been teaching at a college or university.

In answer to the question relating to the respondents' length of time spent in academia and/or research, 25 scientists said that they have been teaching for over 30 years, while 15 had been teaching for between 25 to 29 years. Twenty five respondents indicated that they had been teaching for 20 to 24 years and 20 of them for the last 15 to 19 years. Seventeen said that they were teaching for last 10 to 14 years and 25 of them had been teaching for less than nine years. Twenty three scientists had been teaching for less than four years and two respondents had been teaching for about a year.

Fifty of these scientists taught less than nine years in the college or university. Those scientists who had been teaching for less than nine years at college or university level are thought to be in the process of establishing themselves in academic work and full time teaching. Analysis of the question "How long have you been doing research?" showed that 30 of these scientists had less than nine years of research to their credit, indicating that several of these years may have been spent on completing their doctorate, or on post graduate studies.

Figure 2 below shows a comparison of the time spent on research and that spent on teaching by researchers in this study.

Fig. 2



4.2.5. Administrative and management responsibilities

One of the key issues or variables that arose out of the literature review and which was of interest to this research was that of administrative responsibility and its relationship with productivity. To facilitate the testing of possible relationships between the two variables (productivity and administrative responsibility) among the scientists, respondents were asked to give an indication of the time spent on administrative and management responsibilities. Out of the 153 respondents, eight or five percent indicated that they spend 75-100 % of their time on administrative work. The only deduction one can make from this statement is that these scientists may be Executive Deans or Directors of Schools. Seventeen or 11 % of the respondents indicated that they spent 50-75 % of the time in administrative work. These could be Heads of departments (HODs).

If the HODs spend about two thirds of their time, on the average, in administrative work, there is much less time left for research as the heads of departments also teach a certain number of hours during the week.

However, according to Allison and Steward (5), 93 % of the HODs published much more than other scientists while in that position. They claimed that some of the HODs delegated some of their teaching duties to other staff members in order to find sufficient time for their research. This is contrary to the present research, which showed that the HODs spend almost 3/4 of their time doing administrative work, and hence they cannot spend more time doing research than some of the professors who have no administrative posts. Forty two scientists indicated that they spent 25 to 50 % of their time doing administrative work. Some of these could be HODs. If this is the case and with the accumulated advantage that Allison and Steward said could be added to their time to produce high percentage of research output. Eighty-eight or 58 % of respondents indicated that that they do very little or no administrative work. These are thought to be lecturers or senior lecturers.

When asked if they had held an administrative position during the period 1992-1996, 71 or 46 % of respondents answered negatively, while 82 or 54 % answered positively. This showed that more than 50% of the respondents held administrative posts and hence they are senior academics. Comparing the results of Allison and Steward's (6) research, this researcher agrees with their conclusion that most productive scientists become HODs and HODs are "owners" of almost all scientific results scored in the departments headed by them, thus enabling them to add to their publication lists.

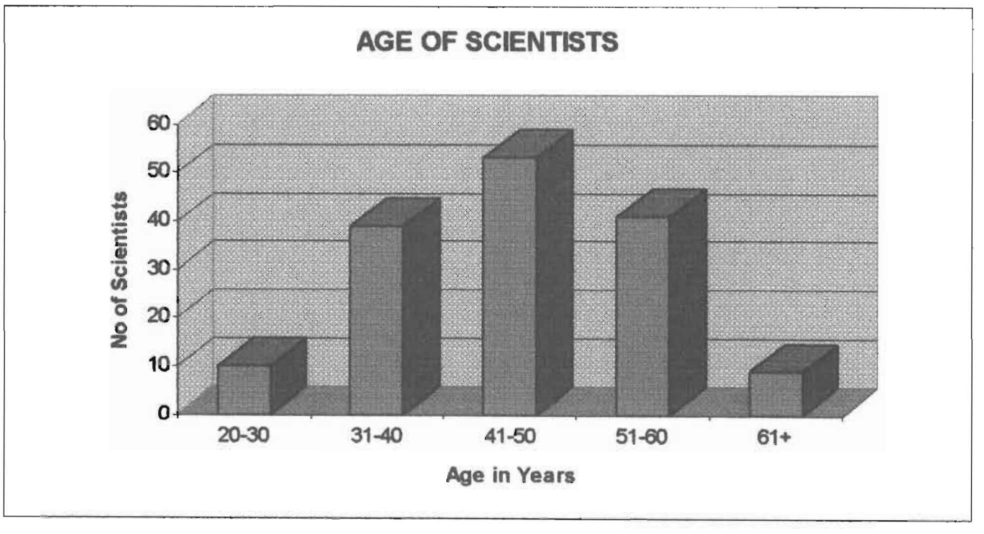
4.2.6 Distribution of respondents according to age

As might be expected, there is a steady increase in the number of papers in a scientist's bibliography as he/she grows older and gains more experience. However, the annual rate of production per scientist seems to vary only slightly.

Similarly, more senior scientists have longer publication lists. Knowing the ages of the scientists would facilitate the testing of the relationship between the publication productivity and the years of research.

In answer to the question related to their age, 10 or seven percent indicated that they were between 20-30 years, 39 or 25 % indicated that they were between 31 and 40 years. Fifty three or 35 % of the scientists were between the ages of 41 and 50, showing that the highest number of the scientists in the study group belonged to this age group. Twenty seven percent of the scientists indicated that they belonged to the age group of 51 to 60 and eight or five percent were above 61 years old. Analysis of the data collected showed that the most productive scientists belong to the age range of 40 to 60 years. A possible explanation for this phenomenon is that by this stage, the scientists have established themselves both academically and in terms of research and publication.

Fig. 3



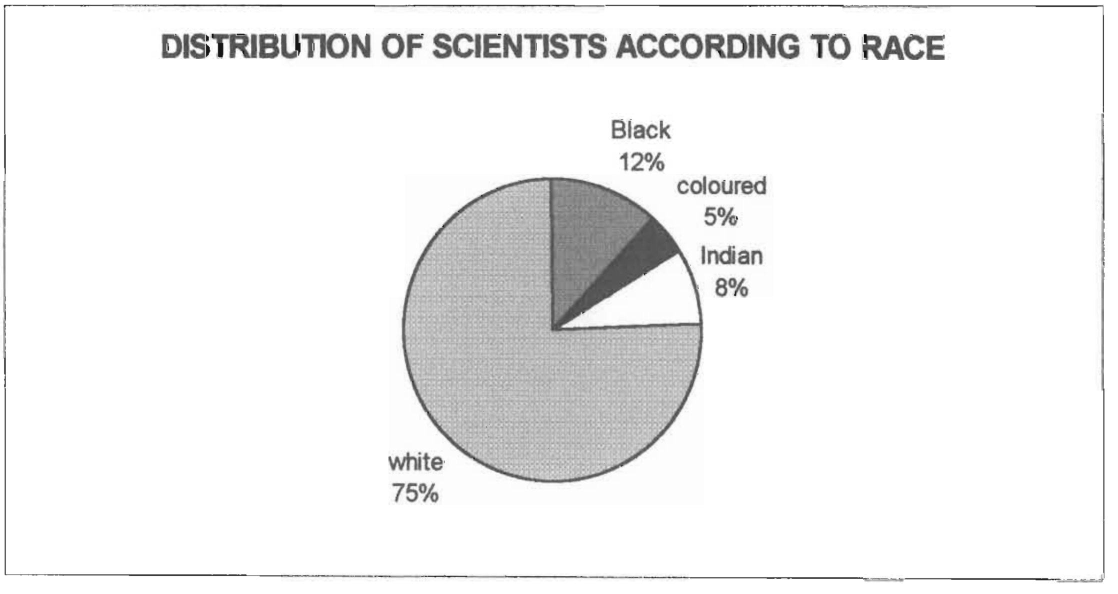
4.2.7 Racial composition of the respondents

Due to the apartheid laws of the past government, it was imperative for this study to establish the racial composition of the scientific community of South Africa. Consequently, it was important to look at issues that will relate to the transformation of the scientific community.

Therefore data was collected on the racial composition. Seventy five percent of the respondents were White, eight percent Indian, five percent Coloured and 12 percent Black. This apparent difference in distribution of respondents showing that there are more white scientists than black scientists is due in part to the poor responses of scientists from the historically disadvantaged institutions. The implications of this is further discussed in section 5.4, page 153.

The ratio of the percentage of Black scientists is much higher, but due to the poor response to the questionnaire by the scientists at the historically disadvantaged universities, the figures are low as shown below.

Fig. 4



4.2.8 Respondents' distribution according to gender

One of the key issues that came up in the literature review was the question of gender as the South African research community is considered to be preponderantly male. Garland's study on the gender differences in scholarly publication in Information Science found that women produced only one-third as compared to men (7). Further it was found that women in higher rank published much less compared to women at a lower rank.

Lecturers published three times more than the senior lecturers. In order to test the variable relating to age and productivity concerning the South African women, it was considered relevant to ask a question of this nature.

The data collected on gender was analysed and it was found that out of 153 respondents only 23 or 15 % were females and 130 or 85 % males. Of the 23 female respondents, there was only one professor and four associate professors. A conclusion that may be drawn from such results is that women are not encouraged to excel or that their work is not appreciated. Promotion to a higher rank encourages one to work harder to forge ahead and it is thought that promotion of females may be occurring at a very low rate, or not at all.

4.3 Testing the hypotheses

In order to test the hypotheses, one way Analysis of Variance (ANOVA) was used. ANOVA compares the mean squares of two or more groups. It uses variance, or the spread of scores in a distribution, of group means as a measure of observed differences among groups. ANOVA is a family of inferential statistical procedures that treats hypotheses and protects against possible type 1 error which can occur when using the t-test and the number of groups or categories increases. It is a parametric procedure, based on three basic assumptions: firstly, the samples are drawn at random; secondly, the samples are derived from normally distributed populations; thirdly, the variances (as well as means) of sampled populations are equal or nearly so.

One way ANOVA is an investigation of a single factor. ANOVA tests a null hypothesis stating that there is no difference in the dependant variable resulting from any of the factors or independent variables. It divides the deviation of a score from the population mean into two parts: the deviation of the score from the sample mean and the deviation of the sample mean from the population mean.

$$F = \frac{\text{Between Groups Variance}}{\text{Within Groups Variance}}$$

In the ANOVA tables which follow, the first column, *source*, refers to the variable being studied. The term "between groups" (BG) variance, refers to three or more groups. The "within groups" (WG) variance refers to the variability measure based on scores within a group. The "total" is a measure of the variability around the grand mean.

Degrees of Freedom (df) are calculated for the first row by subtracting one from the total number of scores, (n – 1), in this study, 153 – 1 = 152. The sum of squares (SS), is the sum of the squared deviations from the mean.

$$SS = \Sigma (X - \overline{X})^2$$

The mean square (MS), is obtained by dividing SS by df in the same row. The F value is obtained by dividing MS for between groups by the MS for within groups. The F value indicates whether or not there are significant differences between (or among) the means being compared (8)

4.3.1 Null hypothesis 1: ***There is no direct relationship between academic rank and productivity of South African scientists.***

The above hypothesis was aimed at determining whether there was a correlation between academic rank and publication productivity of the South African scientists. To test this hypothesis various data as indicators of academic productivity and rank were collected. In section 4.3 of this thesis, data representing the academic ranks of respondents were presented. This required bi-variate analysis with that of productivity among scientists. The various indicators of productivity among scientists, as noted in the literature, include presentation of papers at national and international conferences, publication of papers in national and international journals and the number of research students supervised to completion, to mention but a few. In this section, data relating to participation in national conference is analysed. Respondents were asked about the number of national conferences or seminars held in South Africa that they attended.

4.3.1.1 National conferences attended during the period 1992-1996

The results according to rank and productivity in Figure 5 shows that professors have attended 208 or more national conferences while associate professors have attended 106; senior lecturers have attended 104 and lecturers have attended 184.

The difference between the number of conferences attended by the scientists in the study group decreases in frequency according to the ranks with the exception of lecturers who have attended slightly more than that of senior lecturers. On the average, it was found that each scientist attended four national conferences with a slight variation, the highest being, 4.4 (208/47) conferences per professor, 3.9 (106/27) per associate professor, 3.5 (104/30) per senior lecturer and 4 (184/46) by lecturer. The results obtained is shown in figure 5 below.

Fig. 5

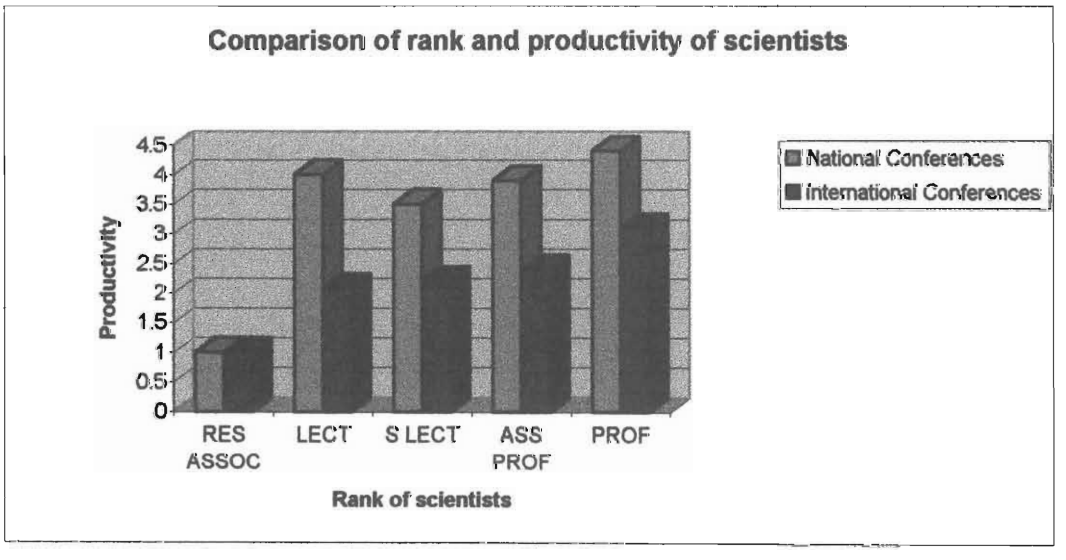


Fig. 5 above shows the attendance of national conferences by the scientists. As expected, more professors attended national conferences compared to the other category of scientists. The new finding of this study is the attendance of a larger number of lecturers in relation to associate professors and senior lecturers. Therefore, according to this study, productivity (attendance at national conferences), decreased with a decrease in rank, with the exception of lecturers who attended more national conferences than senior lecturers and associate professors. As stated by Cooper (9) in section 2.3.1, promotion could be the driving force behind this behaviour of lecturers. Further, it may be assumed that the lecturers who are quite young in their academic and research career may present publications from their thesis as conference papers. Senior lecturers and associate professors indicate much less attendance at national conferences. An important reason for this behaviour among the senior scientists is that they give the opportunity to younger members of the departments to attend the local conferences, while they themselves wish to attend international conferences.

One of the possible logical reasons why associate professors and senior lecturers attended the national conferences less often may be that these two ranks are sometimes considered high enough by persons in them or that many of them from this category may have received promotion recently and therefore many feel they do not need to concern themselves until the time for their next promotion. However, based only on the data collected for this study and without clear indication from the literature of a similar situation, it is hard for the researcher to make a conclusive interpretation of these findings.

In order to investigate the differences in the research productivity of the scientists, the Analysis of Variance (ANOVA) was used. The results in Table 4 show a significant difference ($p < 0.05$) in the productivity between the professors and other scientists (Associate professors, Senior lecturers, and research associates). The table below shows this variance.

Table 4

ANOVA summary for national conferences attended

N = 153

Sources of Variances	**SS**	**Df**	**M S**	**F**	**Sig**
Between Groups	18.993	4	4.784	2.49	0.05*
Within Groups	282.589	148	1.909		
Total	301.582	152			

* significant, p<0,05.

According to the values obtained from the analysis of the data of the scientists on attending the national conferences, the calculated F value = 2.49. The value of n was 153 (namely the total number of scientists who were expected to attend the national conferences. Significance at 0.05 (95 % confidence level), that F – table showed (by employing a simple linear interpolation technique) that $F_{0.05}$ (4, 148) = 2.37.

Since the calculated F value was greater than $F_{0.01}$ (4,148), meaning that 2.487 > 2.23, then the result implied that there existed a significant linear relationship between the rank of the scientist and his/her productivity.

4.3.1.2. International conferences attended

In order to investigate the belief that since senior scientists have been in the research field much more than junior scientists, they have greater opportunities to make contact with scientists of good standing in the field both nationally and internationally, the respondents were asked to indicate the number of international conferences attended in the period 1992-1996. Furthermore, since only papers of international standards are accepted at international conferences, it was thought that scientists whose works were accepted at such conferences would be of high calibre in their respective fields. The results obtained by the analysis of the data showed that professors differ significantly in attendance of international conferences from the associate professors, senior lecturers, and lecturers. On the average, each professor attended three conferences (3.1), associate professor, two to three conferences (2.4), senior lecturer, two conferences (2.2), lecturer attended two conferences (2.08) during the given period and research associate, one conference . These results show that as the rank decreased, the productivity (attendance and contribution at conferences) also decreased..

Table 5

ANOVA summary for attendance at international conferences in South Africa

N = 153

SOURCE OF VARIANCE	**SS**	**Df**	**M S**	**F**	**Sig**
Between Groups	22.483	4	5.621	3.08	.O18*
Within Groups	270.197	148	1.826		
Total	292.680	152			

- Significant, p<0,05

The data collected concerning the attendance at international conferences were calculated according to the proportionality given above. In addition, one way ANOVA tests were carried out and the results shows that the calculated F value = 3.08. the value of n was 153 (the total number of respondents). At 0.05 significance level (at 95 percent confidence level, or five percent level of significance), the F table showed (by employing a simple linear interpolation technique) that, F.(1, n-2) = $F_{0.05}$ (4, 148), meaning that 3.08 > 2.38, then the results implied that there existed a significant difference between the rank of scientists and their productivity. These results provide further evidence that the scientists in different ranks differ significantly in their productivity, with professors performing better than the other groups.

This may be related to the fact that professors have more facilities and opportunities for research and contact with scientists both in the country and outside the country, which give them opportunities to be invited to attend more conferences.

4.3.1.3 Presentation of scientific papers at conferences outside South Africa

A study conducted by Herner (10) found that 83 % of the pure scientists at John Hopkins University were members of the major scientific and professional societies in their fields. This sort of membership gives them better opportunities to be invited to attend conferences that the junior members of the field. In order to assess whether all members of the science faculty are given opportunities to attend these larger forums, scientists were asked to indicate the number of conferences that they attend outside South Africa.

Figure 6 below indicates the total number of papers presented by each group of scientists as represented in the study, professors presented four papers on the average, associate professors, three papers, senior lecturers, three papers, and lecturers, two papers. The results show a noticeable difference between professors and other scientists in their pattern of publication.

Referring to section 2.3, in which Narin (11) concluded that "scientific talent is highly concentrated in a limited number of individuals," data from the present study appears to agree with him. Most of the publications and presentations by South African scientists are concentrated among the professors. Although this study did not specifically endeavour to find out why professors continue to be the most productive, even after attaining the highest academic accolade, this finding may reflect that South African professors of science, like their counterparts elsewhere, may in fact research and publish for their satisfaction, as mentioned by several professors from the study.

This is similar to the findings of Finkelstein (12) as discussed in section 2.3.1 of this thesis, which showed that intrinsic, rather than extrinsic motivation plays a pre-eminent role for publishing. This intrinsic reason motivates professors who do not expect any more promotions to continue to publish. The Lecturers, on the other hand, do most of their research and publication with the hope of promotion. Cooper and associates (13), reckoned that promotion was the driving force behind faculty research and publication.

Fig. 6

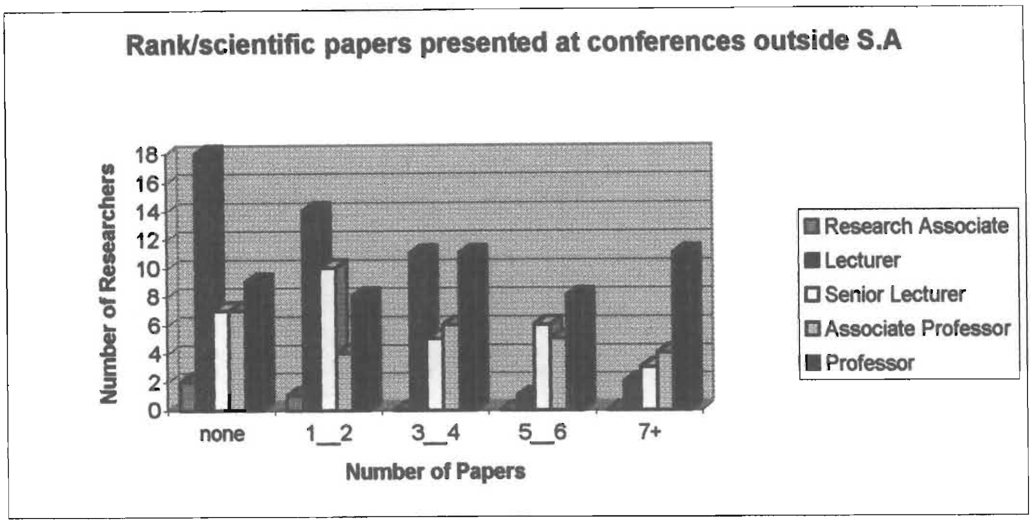


Figure 6 above and table 6 below are the results of analysing the data collected from respondents about the number of papers presented by them at conferences outside South Africa. Out of 47 professors, nine of them said that they have not presented any paper at conferences outside South Africa between 1992 and 1996. Eight of them presented between one to two papers, eleven of them, between three to four papers, another eight of them, between five to six papers and eleven other professors agreed to have presented more than seven papers. On adding up the total number of paper presented by them, it was found that they have presented 159 papers. This gives an average of 4.2 (159/38=4.2). In a similar way, on analysing, it was found that 20 associate professors presented 79 papers or an average of 4 (79/20=4), 23senior lecturers presented 84 or an average of 84/23 = 3.7 papers. Twenty eight lecturers presented 95 papers and on the average 95/28=3.3 and one out three research associates from the study population, presented a paper between 1992-1996.

Further analysis of the results in Table 6 shows a significant variation ($F = 4.65$, $df = 4, 148$; $p < 0.01$) which provides evidence that scientists differ significantly in the quantity of their publications according to the different ranks - professors publishing much more in comparison to associate professors, senior lecturers and lecturers publishing in decreasing order according to their ranks.

Table 6

ANOVA summary of scientific papers presented at conferences outside South Africa

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	47.317	4	11.829	4.65	0.001**
Within Groups	376.696	148	2.545		
Total	424.013	152			

** Significant, p<0,01

The table 6 above further confirms the results obtained by the analysis of the data collected. On analysing the data by means of ANOVA, a very strong significant difference is obtained. A significant difference of 0.001 portrays a high degree of confidence in the results obtained. In this case, one can confidently say that the results showing a marked difference between the production of scientists (presentation of papers) can be accepted with an assurance of 99%. And that the error margin only a mere 1%.

4.3.1.4 Scientists as invited guests at conferences.

One of the indicators of status, prestige and indeed impact in the academic field is invitation to present papers, conduct commissioned research, or contribution to an "exclusive" publication on a given topic. This in effect is what is referred to a solicited contribution, unlike unsolicited contribution, where a researcher or academic simply submits his work for review and consideration and he/she is either accepted for publications and or presentation or turned down. The assumption is obviously that a researcher who is invited frequently to international conferences, etc has made his/her mark in the field.

The indicators of the amount of impact one makes on his/her field is reflected by the number of times one is invited to present papers at conferences as mentioned above. Besides this to see if there was any relationship between a scientist's productivity in terms of the number of times he/she is invited as special guests, the respondents were asked to indicate whether they have ever been invited as special guests to present papers in a particular area.

Table 7

ANOVA Summary for scientists' invitation as special guests at conferences

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	5.043	4	1.261	3.96	.004**
Within Groups	47.075	148	0.318		
Total	52.118	152			

** significant, p<0,01

With reference to table 7 representing the scientists' invitation as special guests at conferences, the ANOVA summary shows the F = 3.96 df = 4, 148 is significant at the 0.01 level. These results indicate that scientists at various ranks – professors, associate professors, senior lecturers and lecturers differ significantly in the manner in which they attend or are invited at conferences to present papers. Scientists who publish profusely are well known and are often invited as guests of honour.

Sixty five scientists answered positively and indicated that they had been invited as special guests. On further examination it was found that that 18 of them were professors and 13 said that they were heads of departments. It is therefore assumed that these scientists having been in positions of authority and made sufficient contacts with the outside world often receive opportunities to be invited as special guests at conferences. This study therefore agrees with Allison and Steward (14) who stated that the high rate of publication among certain categories of scientists could be attributed to the accumulative advantage they have due to their position.

Unfortunately this study did not investigate why professors and HODs are most often invited to conferences and international forums but one can speculate that they have the contacts with other scholars in their fields.

4.3.1.5 Papers published as author or co-author in South African journals.

Scientific productivity is referred to as the amount of research output and publication that a researcher has done. It is often measured by counting the number of papers, books and reports produced and published.

Fig. 7

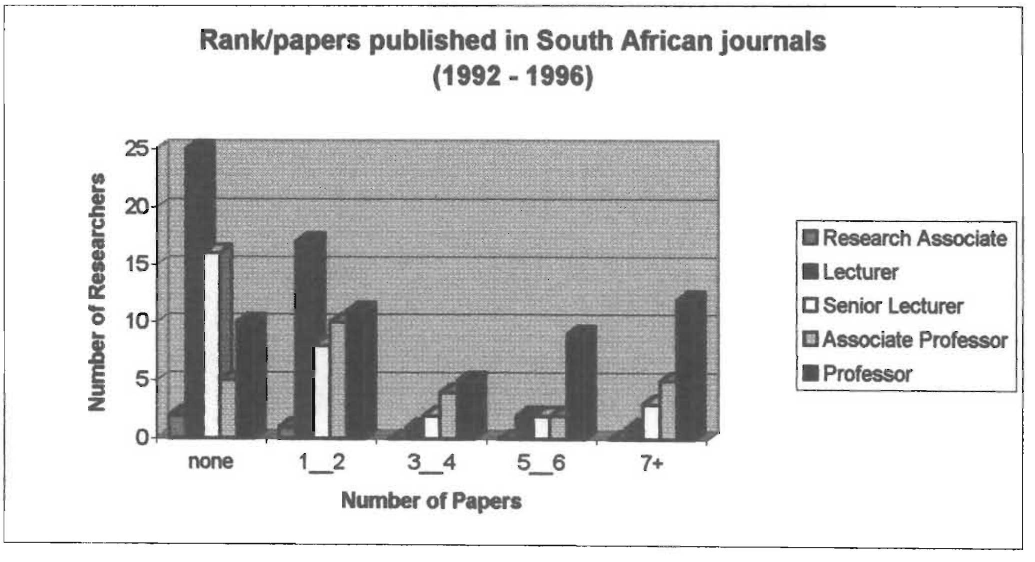


Figure 7 above represents publication pattern of scientists in SA journals. Professors have published profusely compared to the other scientists. The reason for this can be assumed as being due to the fact that since professors have established themselves as researchers they produce and publish more than other scientists. The associate professors and senior lecturers seem to produce less.

The figure above shows that out OF 47 professors, only 37 professors published in SA journals during the given five years. They published 164 papers with an average of 4.4 paper per professor. Twenty two out of 27 associate professors published 80 papers, with an average of 3.64 papers per person. Sixteen of the senior lecturers said that they did not publish in the SA journal, thus leaving 14 scientists in that category who published 54 articles, with an average of 3.9 articles per person. There was an average of 3.4 article per lecturer and 3.0 paper per research associate.

Table 8

ANOVA summary for papers published in South African journals.

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	87.581	4	21.895	6.25	.000**
Within Groups	518.301	148	3.502		
Total	605.882	152			

** Significant, p<0,01

The ANOVA summary presented in table 8 shows that the F = 6.25, and df = (4, 148) which is significant ($p < 0.01$). This is interpreted as evidence that scientists differ significantly according to rank in their production of publications nationally. In this study professors have more publications when compared with other scientists. In order, further to confirm the ANOVA tests, Bonferroni multiple tests (see appendix G) were conducted, which confirmed the results obtained by the ANOVA tests.

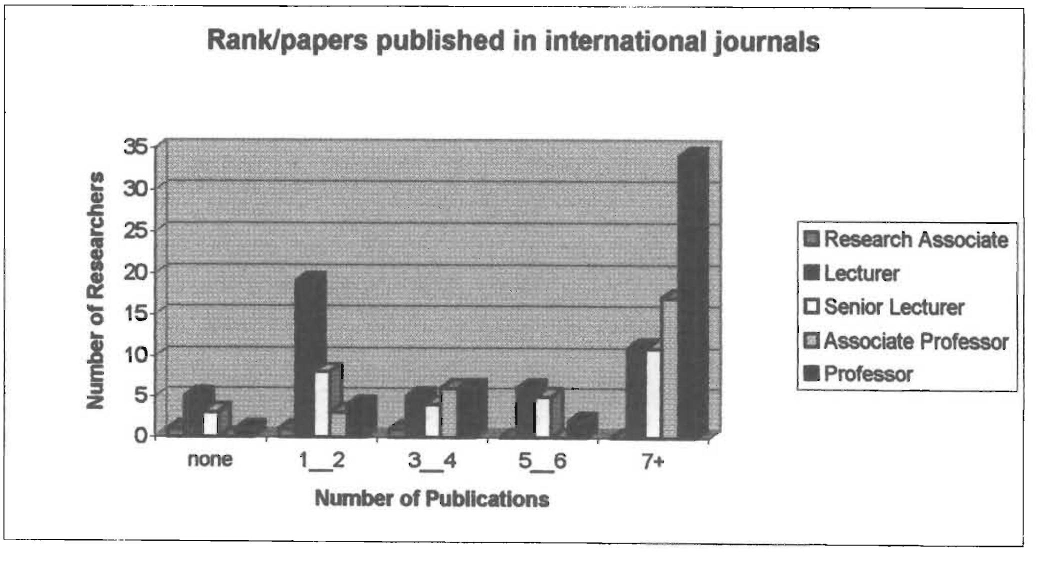
According to Alvarez-Ossorio, Gomez and Martin-Sempere (15) national journals will never improve if the best scientists do not publish in them. Analysis of the results presented in figure 7, show that professors publish more in South African journals compared to associate professors and senior lecturers. In contrast, a large number of lecturers also publish in national journals, the only difference being that they publish fewer numbers of research papers.

4.3.1.6 Papers published in international journals

Publishing in international journals requires good standards of research and the papers that are produced need to be competitive in the international markets. Scientists who publish in these journals are people of high research calibre from both the well-developed as well as less developed countries of the world, hence only papers that are of international standards are accepted. In order to find out the publication calibre of the South African scientists, they were asked to indicate the number of papers they have published as authors and co-authors in international journals.

Figure 8 shows the marked difference between the publication of professors and those of other scientists who are lower in rank. Professors have published remarkably high compared to other scientists. The associate professors are seen to have published more articles in international journals than in national journals. The reason for this rise in the publication of associate professors and the high level of publication of professors can be attributed to their higher rank.. This study agrees with Lancaster (16) who argued that many scientists in the developing countries prefer to publish in foreign journals rather than in their native journals for the sake of prestige and recognition.

Fig. 8



With regard to publication as author or co-author in international journals, the ANOVA summary in Table 9 shows that the F = 12.25, df =(4, 148), is significant at the 0.01 level. The very high significance differentiates the productivity of professors from those of other scientists who are lower in rank. As professors have many years of research experience behind them and many papers to their credit, they have the choice of publishing in international journals, while scientists who are lecturers still need to establish themselves in their respective fields and reach the required international standards.

Table 9

ANOVA Summary for papers published in international journals

N= 53

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	257.281	4	64.320	12.25	.000**
Within Groups	777.359	148	5.252		
Total	1034.641	152			

** Significant, p<0,01

ANOVA summary on table 9 represents the publication of scientists in international journals. Since the F value = 12.25 > than the critical value 2.34, there is a significant difference between the publication of scientists.

4.3.1.7 Evaluation and grading by FRD

With regard to evaluation of scientists by the FRD, as described in 1.2. of this thesis, factors such as publication productivity, collaboration with fellow scientists in inter-disciplinary or highly complex advanced fields, invited contributions to conferences (both national and international), ability to attract and supervise post graduate students and other academic activities were taken into consideration.

The FRD evaluation was used as a measure of the quality of their research and productivity. Therefore it was imperative to discover whether these scientists had been evaluated.

Out of 153 scientists, 84 indicated that they had been evaluated while 69 had not been evaluated. Scientists who satisfy the evaluation criteria in South Africa are graded as A, B, C, P, Y or L. The first three grades are awarded to scientists who are established researchers, while P, Y and L are awarded to those who would soon be established in their field of research. P is a special presidential award granted to exceptionally good younger researchers. There is another category, NR, the non-rated scientists who are considered by FRD for grading but not yet graded. These need to fulfil certain academic criteria before they can be graded. This ensures the quality of the scientists in their field of specialisation. By requesting the respondents to indicate their respective FRD grades, this study sought to discover whether or not the higher graded scientists were the more productive scientists.

Table 10

ANOVA Summary for FRD grading

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	136.491	4	34.123	13.08	.000**
Within Groups	386.149	148	2.609		
Total	522.641	152			

** Significant, p<0,01

The ANOVA summary shows significant ($p<0.01$) difference with F= 13.08, df =(4, 148). The high level of significance ($p<0.01$) indicates that the level of FRD grading is a key factor that influences academic rank and productivity.

The data collected from the respondents concerning the productivity of scientists who are graded and those of non-graded scientists was analysed. The results obtained shows a significant difference between the production of graded and non-graded scientists. Significant difference of 0.00, which is taken as 99% confidence. This simply means that there is less than one percent chance of error in the results obtained in this particular case, that is scientists who are graded are those with a strong research background and publication. Hence there is a marked difference between the publication productivity of the scientists who are graded by FRD and those who are not graded.

It was found that among the study population, there were seven "A" grade scientists, 11 "B" grade scientists, 14 "C" grade scientists, three "P" grade scientists, 11 "Y" grade scientists and 38 "L" grade scientists.

4.3.2 Hypothesis 2: *There is no direct relationship between the attainment and sustenance of prestige and productivity among South African scientists.*

The literature reviewed stated that prestige of institution and personal prestige induces scientists to do research and publish. In the case of South African scientists it is quite evident, as scientists who hail from the well established universities do more research and publish more (section, 2.3.3).

Hence, one of the assumptions that can be made is that prestige must be one of the reasons for publications. According to Broadus (17) in 2.3.3 research output in a reputable journal can be used as criterion for rating scientists and universities.

One-way ANOVA was used to discern whether there was significant difference between scientists in their attainment of departmental/institutional prestige and productivity. Prestige may be defined, in this study, as the distinction that comes from achievement and success, that is, the overall evaluation of a scientist's life work. This point is seen clearly in 2.3.3, where it is noted that most of the research and publication done in South Africa is by scientists who are associated with the prestigious and historically well-developed institutions. The Pearson Chi-square tests (Appendix F) were used to reinforce the ANOVA tests.

The relationship between presentation of papers at national conferences and prestige between the various groups of scientists can be seen in table 11. Attendance and presentation of papers at national conferences in South Africa was considered a reflection of prestige among the scientists. This trend can be seen mainly among younger members (lecturers) who have been doing research for less than 10 years who have opportunities to attend national conferences to gain experience with regard to informal contacts with senior researchers in their fields.

4.3.2.1 Presentation of papers at national conferences in South Africa

Table 11

ANOVA Summary for the presentation of papers at national conferences in South Africa

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	37.684	2	18.842	3.62	.029*
Within Groups	780.643	150	5.204		
Total	818.327	152			

Significant, p<0,05

The ANOVA summary depicts a significant difference in the presentation of papers at the 0.05 level. It is considered prestigious to present papers at national conferences by both senior and junior scientists. On analysing the data collected from the study showed that during 1992-1996, professors on an average produced five papers while associate professors produced 4.6 papers, and senior lecturers, 4.7 papers. Lecturers had 5 papers. Lecturers produced slightly more than senior lecturers and associate professors as they consider it prestigious to present papers at the national conferences.

Another important fact that came to light is the large number of lecturers from the prestigious institutions that responded and who also showed that they presented large numbers of papers. Although, the historically disadvantaged institutions have more lecturers in the science departments, in relation to the professors, in these institutions, the responses from them was poor. Out of the ten institutions, five were well established institutions while the other five belonged to historically disadvantaged institutions. Although, UDW and UWC were considered as medium institutions, their responses to the questionnaires, their productivity in relation to attendance and presentation of papers, publication of papers and the supervision of postgraduate students, set them apart from the scientists at historically advantaged institutions. To a certain extend, it can be said that the poor return of responses from the HDIs represent their attitude to research and publication.

4.3.2.2 Papers presented at international conferences in South Africa

Table 12
ANOVA Summary of papers presented at international conferences in South Africa

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	29.031	2	14.515	6.13	.003**
Within groups	355.440	150	2.370		
Total	384.471	152			

** Significant, p<0,01

The ANOVA summary above indicates that the F value of 6.13 is significant ($p<0.01$). On analysing the data collected from the scientists concerning the presentation of papers at international conferences, there was a marked difference between the number of papers presented by professors as compared to associate professors and senior lecturers. On the average, professors presented 4.8 papers, while presented 3.9 papers. Senior lecturers presented 3.7 on an average and lecturers presented 3.4 papers within the period 1992 – 1996.

The ANOVA summary representing attendance at international conferences in South Africa and the presentation of papers at these conferences showed that scientists differ significantly depending on the institutions in which they are employed. The $F = 6.13$, df = (2, 150) is significant ($p<0.01$), that is, there is a marked difference between the senior established scientists and the junior scientists who are either trying to complete their research or trying to reach a higher status. It is considered prestigious to attend and present papers at international conferences by both the category of scientists, although senior scientist receive much more opportunities than the juniors. The main reason for this is because the senior scientists have more contacts with outside the country than their juniors and hence have more opportunities to know of the various conferences being organised and secondly, they have a store of papers or can easily produce one to be send as soon as it is required. Since they also consider it to be prestigious to meet many outstanding scientists from all over the world, they keep constant contact with various conference organising bodies. Hence it is found that a greater number of professors and other senior scientists prefer to attend and present papers at international conferences.

4.3.2.3 Conference attendance abroad

Attendance and presentation of papers at conferences abroad is considered prestigious, as those scientists who attend and present papers at these conferences must produce publications which adhere to high international standards. With this in mind, the researcher wished to ascertain the percentage of scientists who attend international conferences abroad.

Table 13

ANOVA Summary for Conference attendance abroad

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	16.055	2	8.028	4.35	.015*
Within Groups	276.624	150	1.844		
Total	292.680	152			

* Significant, $p<0,05$

Analysis of the data collected showed that professors attended more conferences overseas than within South Africa. There is a significant ($p<0.05$) difference between the scientists who are at a higher rank than those below. Since the senior scientists have more contacts than the junior scientists, they may have more opportunities to go overseas and attend conferences.

4.3.2.4 Publication of scientific papers in the five years (1992 - 1996)

Table 14

ANOVA Summary for publication of scientific papers in the five years (1992 - 1996).

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	135.666	2	67.833	13.08	.000**
Within Groups	778.099	150	5.187		
Total	913.765	152			

** Significant, p<0,01

As earlier stated, prestige is considered a driving force that prompts authors to publish. In light of this, analysis of data collected for the period 1992 – 1996 showed that professors on the average had 5 publications followed by associate professors 4, senior lecturers 3.6, lecturers, 4. These results show that there was difference in the quantity of publication by the lecturers. Thus, it is evident that those with a high regard for prestige have a high productivity, such as professors. Lecturers, it is believed as eager young scientists, keen to become part of the research and publication field work hard to present and publish papers. As the ANOVA summary above indicates, there is considerable significance at the 0.01 level, showing that these results ($F = 13.08$, $df = 2, 150$) have a high degree of accuracy.

Many of the bibliometric studies conducted in other countries showed that scientists publish in foreign journals in order to attain a degree of prestige. In section 2.3.3, Mehrotra and Lancaster (18) explained that half of the papers of Indian scientists are published in the United States. Lancaster further argued that many scientists in the developing countries prefer to publish in foreign journals for the sake of prestige and recognition. Seeing this tendency of the scientists to publish in foreign journals, the researcher wished to find the trend of the scientists in the study population

4.3.2.5 Publication of papers in overseas journal

Table 15

ANOVA Summary for publication of papers in overseas journal

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	170. 733	2	85.366	14.82	.000**
Within Groups	863.908	150	5.759		
Total	1034. 641	152			

** Significant, p<0,01

A look at the ANOVA Summary presented in Table 15 shows that the F = 14.82, df = (2, 150) under 2 and 150 degree of freedom is significant at the 0.01 level. This means that scientists differed significantly from each other in their publication of articles in overseas journals according to the department or institution to which they belong. Professors were seen to publish more papers in overseas journals. Associate professors publish more in overseas journals than they do in national journals. Senior lecturers and lecturers did not publish as much in this category of journals as the other scientists.

4.3.2.6 Grade of the individual scientist

Table 16

ANOVA Summary for the grade of the individual scientist

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	37.385	2	18.693	5.78	.004**
Within Groups	485.255	150	3.235		
Total	522.641	152			

** Significant, p< 0,01

All the scientists in this study were asked if they were graded by FRD, and the answers given by them showed that there was a clear variation in the grading that they received. They were graded as "A", "B", "C", "P","Y", and "L". The details of the grading system have already been discussed in 1.2.1. of this thesis.

The results obtained in the ANOVA table above shows a high significance in the varied grade in which these scientists are placed. Grading by FRD is considered prestigious to individual scientists as well as to institutions. The F value of 5.78, df =(2, 150) is very significant (p<0.01), which means that some scientists are graded as "A" grade scientists while others are non-"A" graded. This leads to a marked difference in their research and publication productivity, where the "A" graded scientists publish profusely while the other scientists' research and publish to a lesser extent.

4.3.2.7 'A' Graded scientists in prestigious institutions

As we have considered prestige and publication productivity to be intimately linked, the researcher felt it necessary to investigate the number of "A" graded scientists (who are considered to have a high level of prestige) in historically well developed institutions, which may be regarded as being prestigious. Therefore, the respondents in this study were asked to indicate which institutions they worked in and whether or not they were "A" grade scientists.

Table 17

ANOVA Summary of 'A' Graded Scientists in prestigious Institutions

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	17.585	2	8.792	22.88	.000**
Within Groups	57.644	150	.384		
Total	75.229	152			

** Significant, p<0,01

The above ANOVA summary shows that the F = 22.88, under df = (2, 150) is significant at the 0.01 level. This indicates that many of the "A" graded scientists work at the historically well developed institutions, thus enhancing the prestige of both the university and themselves.

4.3.2.8 Publication by scientists in refereed journals for the maintenance of departmental / institutional prestige

The literature reviewed in this study shows that one of the main reasons scientists publish is prestige. Ashoor and Choudhury (19) in section 2.4 found that although scientists publish in a large number of journals, the majority of them are published in a small number of journals which are considered the nucleus zone of scientific literature.

Table 18

ANOVA Summary for sustained publication by a scientist in refereed journals for the maintenance of departmental/institutional prestige

N = 153

SOURCE OF VARIANCE	SS	Df	M S	F	Sig
Between Groups	9.671	2	4.835	7.36	.001**
Within Groups	98.565	150	.657		
Total	108.235	152			

** Significant, p<0,01

Table 18 represents the ANOVA summary showing that the F = 7.36, df = (2, 150) is significant at the 0.01 level. This indicates that scientists persistently published in refereed journals in order to produce work, which may be judged to be of high quality. By publishing in such journals they earn credit for their research and publication and thus are highly esteemed by colleagues and peers.

The significance at levels of $p<0.05$ and $p<0.01$ shows the extreme accuracy of the results, explaining that there is a direct relationship between the attainment and sustenance of (personal, departmental, and/or institutional) prestige and productivity among South African scientists. Although in this study and as reported in section 4.3.1.5 (Papers published as authors in SA journals) it was found that in fact South African professors in science also publish heavily in South African journals.

Further analysis of the results using Pearson Chi - Square tests and Bonferroni multiple comparisons test (Appendix G) agreed with the ANOVA results obtained.

4.3.3 Null hypothesis 3: *There is no direct relationship between academic status and productivity of South African scientists*

The objective of hypothesis three was to investigate whether there was a correlation between academic status (qualification such as Ph.D., M.Sc.) and the publication productivity of the academic scientists. Within the context of this study, academic status is defined as a scientist's position/standing in the academic arena with regards to his/her qualifications. It is closely linked to prestige of the individual scientists.

The status of an individual within his/her organisation is a key factor in information transfer. This may be due to the fact that, as explained by Ford (20), in 2.1.2 of this thesis. Informal communication networks are widespread, they tend to operate at senior level, while junior members tend to rely heavily on formal channels. If this is supported by the data in this study, the higher one's status, the greater the publication productivity.

Table 19 ANOVA OF STATUS

SOURCE OF VARIANCE		Sum of Squares	Df	Mean Square	F	Sig
✠National Conf. Attended In S.A	B G	8.34	4	2.085	1.052	0.38
	WG	293.241	148	1.981		
✠International Conf. Attended In S.A	BG	5.083	4	1.271	0.976	0.42
	WG	192.681	148	1.302		
✠ Papers At National Conferences	BG	31.931	4	7.983	1.502	0.2
	WG	786.395	148	5.313		
✠ Papers At International Conf.	BG	13.689	4	3.422	1.366	0.25
	WG	370.781	148	2.505		
✠Overseas Conferences Attended	BG	23.674	4	5.919	3.256	0.01**
	WG	269.005	148	1.818		
✠Papers Presented Overseas	BG	29.398	4	7.349	2.756	0.05*
	WG	394.615	148	2.666		
Papers Published in Last 5 years	BG	116.333	4	29.083	5.398	0.01**
	WG	797.431	148	5.388		
✠Invited Guest to Conference	BG	2.352	4	0.588	1.749	0.14
	WG	49.765	148	0.336		
Papers in S.A Journals	BG	89.571	4	22.393	6.419	0.01**
	WG	516.311	148	3.489		
Papers Published in O/S Journal	BG	153.099	4	38.275	6.426	0.01**
	WG	881.542	148	5.956		
Pop. Science Articles in S.A Journal	BG	6.473	4	1.618	0.706	0.59
	WG	339.292	148	2.293		
Pop. Science Articles O/S Journal	BG	0.832	4	0.208	0.33	0.857
	WG	93.181	148	0.63		
Have you been evaluated by FRD?	BG	7.977	4	1.994	9.869	0.001**
	WG	29.905	148	0.202		
What is your FRD grade?	BG	34.165	4	8.541	2.588	0.039
	WG	488.475	148	3.301		
A-rated Scientist in your Institution?	BG	1.073	4	0.268	0.536	0.71
	WG	74.155	148	0.501		
✠ Work influenced by S.A scientists?	BG	53.614	4	13.404	7.521	0.001**
	WG	263.771	148	1.782		

✠ = in last 5 years   O/s = Overseas   Pop = Popular

Conf. = Conferences   WG = within groups   BG = between groups

* = significant, p< 0.05   ** = significant, p< 0.01

At the 0.05 level of significance, the F statistical tables showed (by means of a simple linear interpolation technique) that $F_{0.05}$ (4, 148) = 2.37. This means that there were significant linear relationships between status of scientists and their productivity (Table 19)

Similarly, at the 0.01 level of significance, the F statistical tables showed that $F_{0.01}$ (4, 148) = 3.32, indicating that there were several significant relationships between status of the scientists and their productivity (Table 19).

This was evident both between groups (professors vs associate professors vs senior lecturers vs lecturers) as well as within the respective groups (within the same or different institutions).

Out of the 16 items analysed with regard to the relationship between status of the scientists and their productivity, seven items were found to be significant. They were the following:

(i) Attendance at overseas conferences
(ii) Presentation of papers overseas
(iii) Papers published in the last five years
(iv) Papers in S.A journals
(v) Papers published in overseas journals
(vi) Evaluation by the FRD
(vii) Influence of "A" grade scientists on the productivity of other scientists

The literature reviewed showed that status and pay are two very important variables in the productivity of scientists in the academic institutions. A study conducted by Cooper (21) as presented in section 2.3.1 of this thesis explained that promotion was the driving force behind faculty research and publication, as this upgraded the faculty members in status and pay.

Therefore, it is thought that most of the lecturers reviewed in this study attend conferences and present papers in the hope of receiving promotion, while professors publish profusely in order to maintain their status amongst their peers in the same field as well as for the satisfaction and joy of publishing.

The ANOVA Summary presented to answer question "How many conferences outside South Africa have you attended?" indicated that there was significant difference ($F = 3.26$, $df =(4, 148)$, $p < 0.01$), between groups – that is between scientists with higher status as compared to those with lower status at the 0.01 level. In this study, those scientists with a higher status are referred to as those with doctoral and post-doctoral qualifications, whereas those without such qualifications are referred to as being at a lower status. A similar result is obtained with regard to presentation of papers at overseas conferences.

Price (22) states that there is a relationship between the importance of the scientists and the logarithm of the number of papers he/she has published during his/her life. A look at the ANOVA Summary for the answer to the number of scientific papers presented in the last five years shows that the $F = 5.40$, $df = (4, 148)$ is very significant at the 0.01 level. This is so because the critical F value at 0,01 is 3.32. Since the result obtained in this study is much greater than this, it can be seen that there is a significant difference between the number papers published by the scientists with doctorates as compared to those without PhDs. With reference to the publication of papers in both national as well as international journals, the F values are seen to be very similar, and greater than the critical value as above. This indicates that scientists at a higher status research and publish significantly more than those at a lower status.

Those scientists who have been evaluated by the FRD showed that they were more productive in their respective fields, while "A" graded scientists were seen to significantly influence other scientists – in their own or related fields.

Additionally, a series of Pearson Chi-Square tests were done in order to further establish the relationship between the status of the scientists and their productivity.

4.3.3.1 Presentation of papers at international conferences

Fig. 9

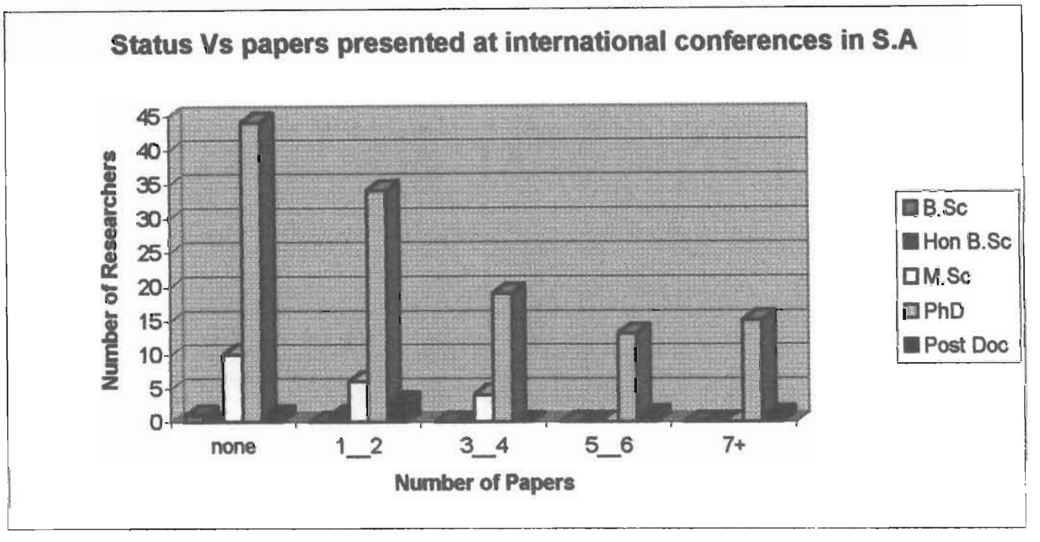


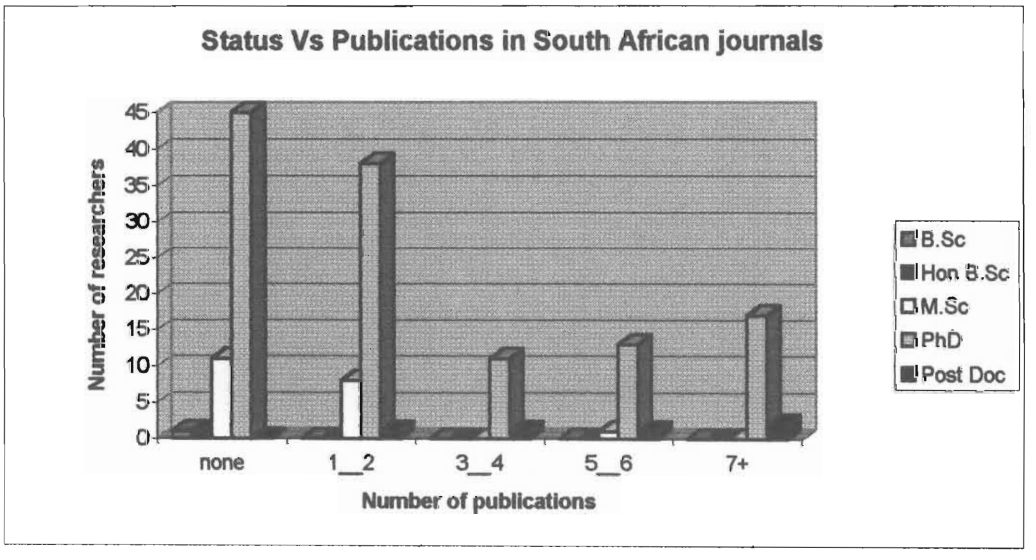
Fig 9 above shows the analysis of the data on the presentation of papers at international conferences. The scientists with Ph.D.s presented far more papers than those without Ph.D.s. A possible explanation for this behaviour may be that those who have their Ph.D.s can publish papers based on research already done for their PhD theses. These scientists may also be able to concentrate on further research for publications, while those scientists without PhDs still need to work towards achieving their post doctorate, a process that takes few years. The bar graph presents a significant difference in the presentation of papers between those with Ph.D. and those without Ph.D. Those scientists with PhD as well as with postdoctoral research are referred to as post doctorate.

Charts produced using the information provided by the respondents in fig.9 shows that those who have Ph.D.s produced the maximum number of papers while those who with less qualification, for example, honours in B.Sc. and B.Sc. graduates produced and presented the least number of papers.

4.3.3.2 Publication of papers in the South African journal

Figure 10 below represents the publication of papers by scientists as author or co-author in the South African journals. Those with M.Sc. produced four papers on the average, whereas scientists with Ph.D.s have produced more than thirty on the average. This signals a significant difference between the production of papers by those with higher status and those with lower status.

Fig. 10



An analysis of the results by one-way ANOVA showed that scientists with Ph.D.s, that is all those who are in the rank of lecturers and above, produced more papers than those without a Ph.D. As it was seen before, professors published far more than other scientists, the same principle can be applied.

The value of F= 6.42, df =(4,148) which is considered significant at the 0.01 level. Further, chi-square independent tests carried out confirmed the results obtained by one-way ANOVA.

The findings related to hypothesis three seem to support the following assertions:

(i) There is a direct relationship between academic status and productivity of South African scientists.

(ii) There is more research and publication among scientists with Ph.D.s who are involved in postdoctoral work than among those scientists without such qualifications.

Lecturers, although less qualified than professors and associate professors, seem to publish at a high rate. The reason for this can be can be assumed to be the hope for promotion.

4.3.4 Null hypothesis 4: ***Research publications of South Africa's "A" grade scientists do not have a significant impact on the research and publication of other scientists when compared to those of non - "A" grade scientists.***

According to the literature reviewed in this study, the most obvious way to measure the impact of a scientist's work on his/her peers is counting the total number of citations the author received. Lancaster (23) as discussed in section 2.4 of this thesis, explains that the preferred measure of a writer's influence is the extent to which his work is cited outside his own field. Another impact of the scientist's productivity is by counting the number of postgraduate students that he/she attracts to research under him or her. Alvarez Ossario and Associates (24) claimed in section 2.4 that "A" grade scientists tend to publish in foreign journals to reach a wider audience.

South African scientists are graded as A, B, C, P, Y or L according to the set criteria by FRD on their research and publication productivity and other criteria. Scientists who are well established in their research are considered to be of international standing.

One of the objectives of this study was to determine whether these scientists have a greater impact on other scientists through their works. That is, to assess whether their work influences other scientists more than the works of scientists who are not "A" graded.

One of the methods used to see if the "A" grade scientists received more citations than the non- "A" graded scientists was explained Lancaster and Associates. They stated that a preferred measure of a writer's influence is the extent to which his/her work is cited outside of his/her field of expertise.

In the research instrument, the researcher stated that the availability of an "A" rated scientist in an institution would motivate other scientists to actively work towards the achievement of "A" grade status. Out of 153 respondents, 81 scientists indicated that they agreed with this fact.

The "A" grade scientists were requested to indicate whether they attracted or supervised students over the period 1992 – 1996. One hundred and twenty eight said they had attracted and supervised students, while 25 showed that they never supervise post graduate students during the given period. Most of these were the young lecturers with less than ten years of research experience from departments with large numbers of senior scientists such as professors, associate professors and senior lecturers. Further, 98 scientists indicated that they supervised five students on the average, 28 scientists showed that they supervised 15 students and three of them said that they supervised about 25 students.

In order to gauge the impact these researchers have on other scientists, the researcher picked the names of scientists at random from the sample. To choose a sample from the study population, the researcher chose 25 subjects in the following manner; a list of all the scientists was made, classifying these scientists according to the number of publications they have. There were five groups of scientists. The first group was composed of those with publications between 150 and 200 publications; the second group was composed of those with 100 to 149 publications, the third group was composed of those with 50 to 99 publications; the fourth group was composed of those with less than

50 publications, and the fifth group was composed of those with less than 20 publications.
Random selection was employed in choosing five scientists from each of the groups. Included in this list were the scientists from all the institutions of the three provinces and covering all the subjects from the physical and natural sciences.

The total number of scientists in the study were 153 and out of which, 13 belonged to the University of Port Elizabeth; ten scientists from the University of Natal, Durban, 15 from Rhodes University; nine from University of Fort Hare; 21 from the University of Cape Town; 18 from University of Stellenbosch; 12 from the University of Durban Westville; 19 from University of Natal, Durban. Fourteen from the University of Western Cape; 19 from the University of Transkei and two from the University of Zululand. There were scientists who were FRD graded – both "A" graded and non- "A" graded as well as scientists who had not been graded at all by the FRD in this sample.

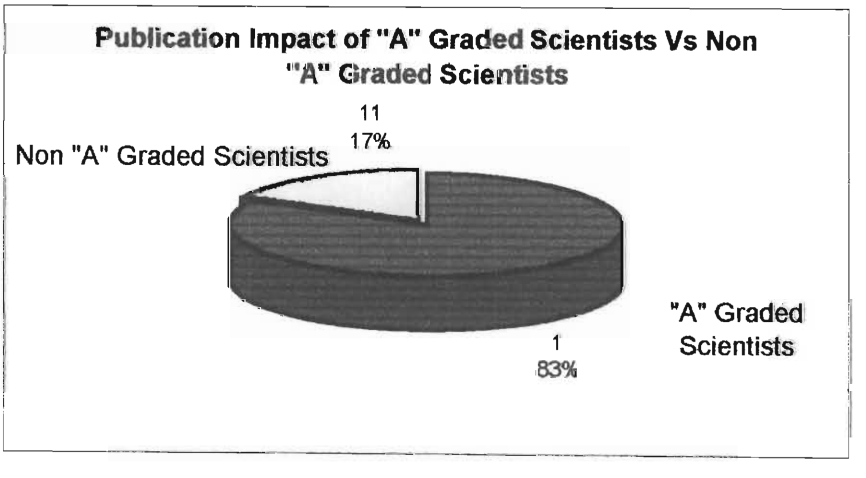
In order to discover whether or not there was a disparity in the citations received by these scientists, their publications for the years 1992 - 1996 were examined using the Science Citation Index (on-line) from the University of Orange Free State.

An intriguing discovery in the citation of publications was that some of the citations, which the SCI did not show as being cited, were found in journals, cited by other scientists. This gave a clear indication that SCI could be used as the main guide in checking publication citations, but it does not cite all the publications of any particular scientists.

The scientists in the group had publications for those five years. Publications, which the scientists had published as first authors, were used to make sure that the citations that they received were works that were attributed to themselves personally and shared authorship. This prevented the senior scientists getting citations from the work of their post graduate students' work or those of the colleagues. It was considered logical to use this method, since most of the junior scientists only had their own research to publish, taking the citations on the basis of first author would remove any kind of disparity. However, the researcher recognised that scientists often do collaborative work and therefore share authorship. This may have been a slight pitfall in the method used, but to a large extent personal authorship appeared a better and more reliable indicator of exactly what each person has published

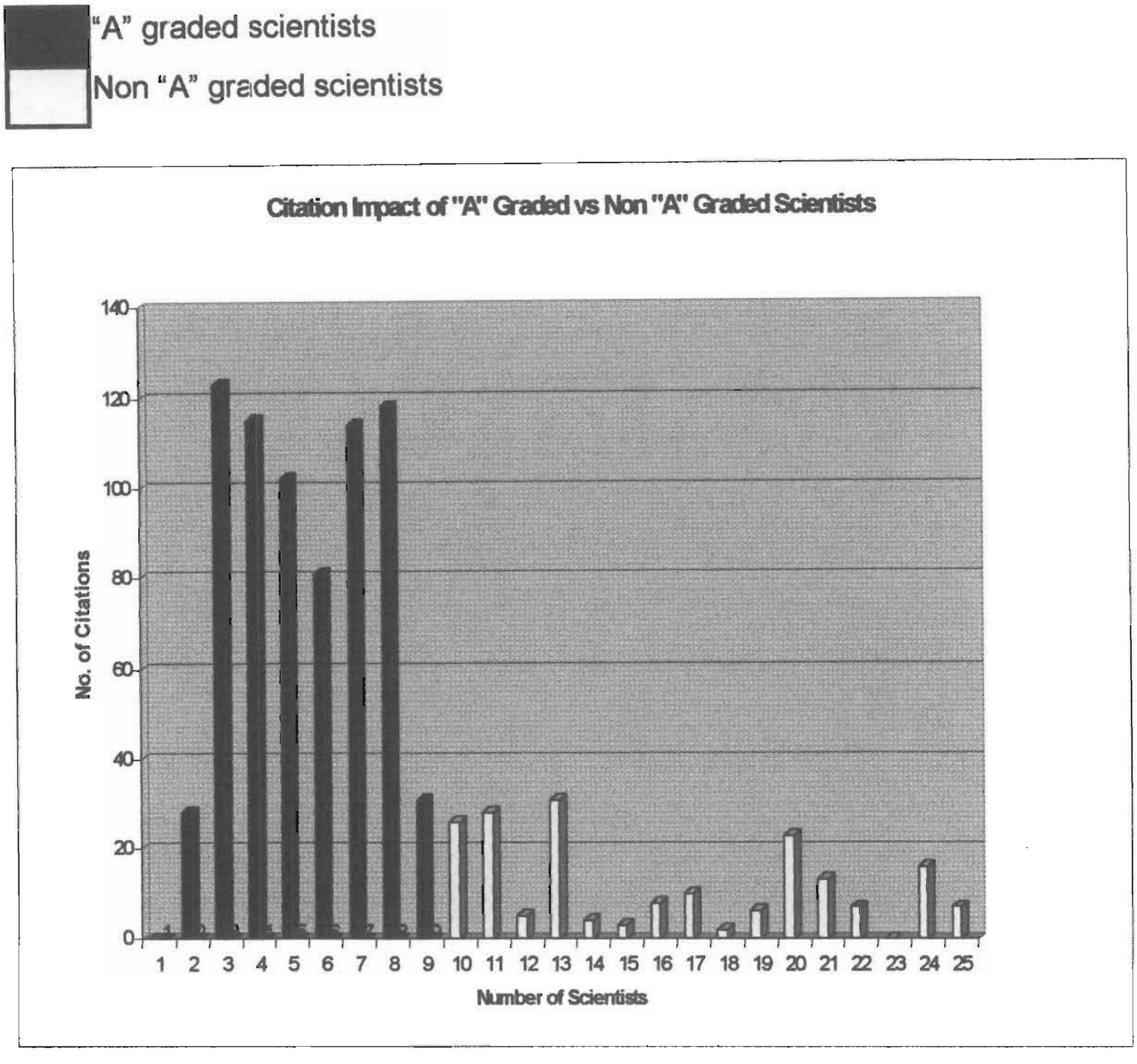
The method employed in choosing the scientists is described on page 130 above. Of the 25 scientists, eight of them were "A" graded scientists and 17 were non- "A" graded scientists. The total number of citations on their publications that these scientists had received for the years 1992 to 1996 were 894, out of which 738 citations were received by the "A" graded scientists and only 156 citations were received by the non "A" graded scientists. Figures 11 and 12 represent two charts that show in detail the distribution of these scientists and the citations they received.

Fig. 11



The results obtained show that although the number of "A" graded scientists were almost half the number of the non - "A" graded scientists, the citation obtained by the former group is approximately five (4.7 exact) times more than the latter group.

Fig. 12



Based on the findings related to hypothesis three, the following conclusions can be drawn:

(i) Research publications of South Africa's "A" grade scientists are more cited. Based on the definition of impact which says that the impact of a scientist is the frequency at which he/she is cited, one can therefore state that they have significant impact on the research and publications of other scientists as compared to the publications of non-"A" grade scientists.

(ii) "A"- grade scientists are cited equally by colleagues in the department as well as those who work in the same field or related to the field in which the scientists work.

(iii) Analysis of questions such as "Have any of your works (research and publications) in the last five years been influenced by other South African scientists?" or "how does the presence of an "A" grade scientist motivate other scientists to work harder to achieve "A" grade status?" and the query whether they have supervised students in the last five years, from the questionnaire showed that the "A" grade scientists produce a greater influence on other scientists than the non- "A" graded scientists.

4.3.5 Null hypothesis 5: *There are no significant differences in productivity between areas of science, which have more funding than those with less funding.*

In order to study null hypothesis five, the answers from the respondents to questions about their attendance at conferences and presentation of papers, publishing of scientific articles in the national and international journals, and invitation to conferences as guest speakers analysed, as these questions were directly related to the productivity of scientists in various departments. Another indicative variable used was the number of students that these scientists had supervised in the years 1992 – 1996.

Based on the number of research papers presented both at national and international conferences, number of popular science articles and scientific papers published in scientific journals and the number of postgraduate students supervised by these scientists, their productivity was calculated.

4.3.5.1 Funding by the FRD

The funding utilised by the scientists was gauged from information provided by FRD on Grants allowed to various departments and institutions for the period 1992 - 1996.

The charts below represent the funding received by various departments and the productivity of the respective departments.

Fig. 13

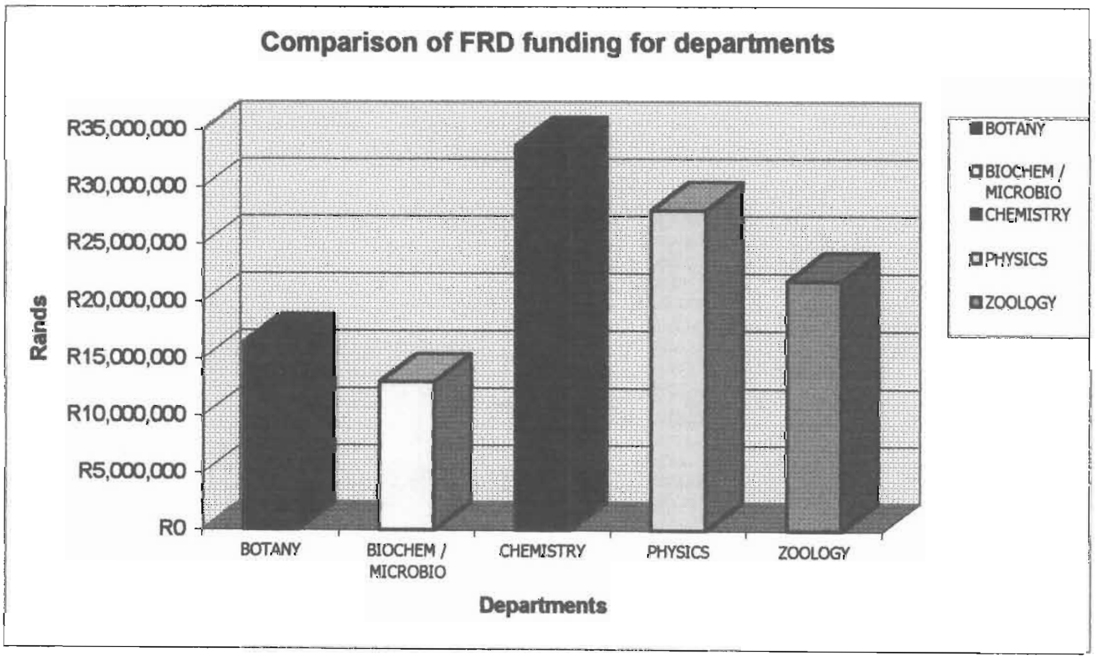
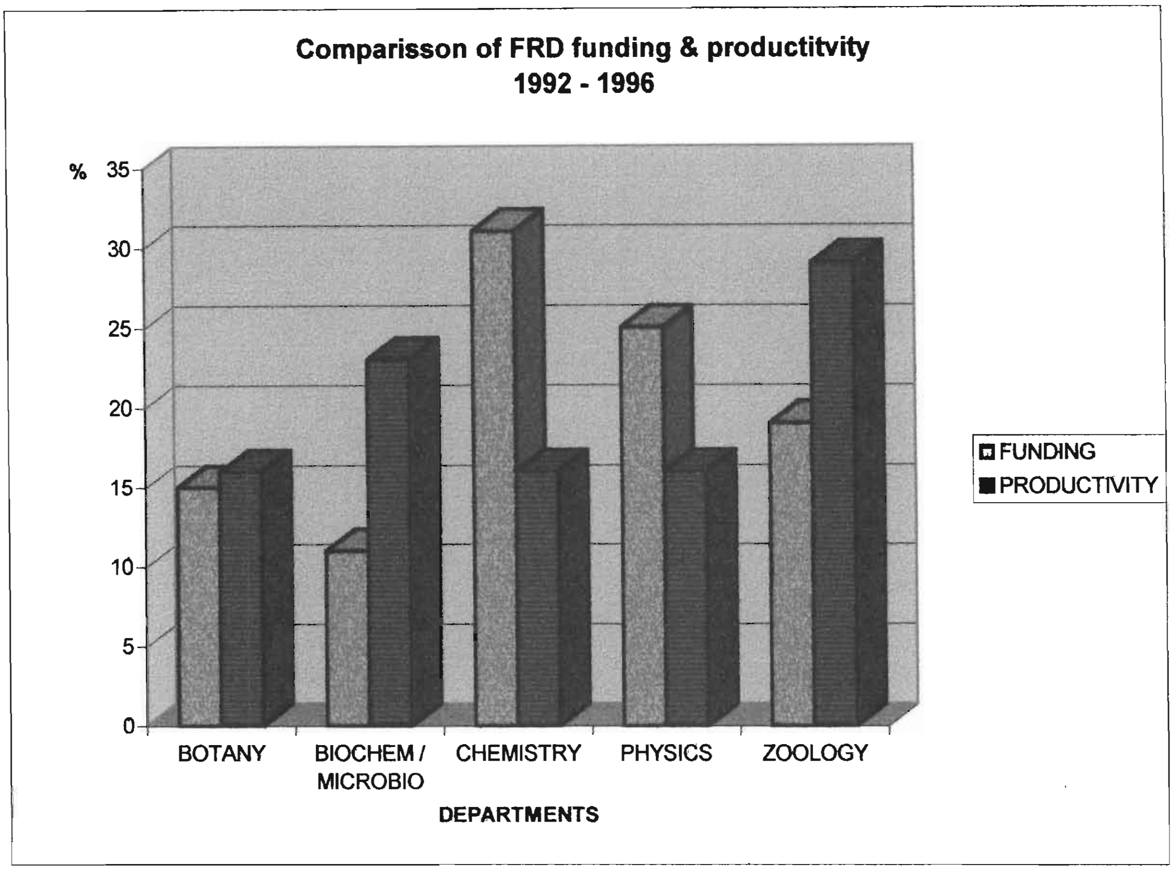


Fig. 14



The productivity of the scientists was estimated by their publication output, supervision of postgraduate students and the part played in staff development. Analysis of the collected data provided the results obtained. The scientists from the Department of Botany had 14.55% of the total funding while their productivity was 15.53%, whereas the Department of Physics, which obtained funding of 24.77% of the total, had a productivity of 16.11%. The Department of Biochemistry / Microbiology with 10.57% of the total funding had an output of 23.21% while the Department of Chemistry, which obtained 30.75% of the total funding, had a very low output of 15.83%. The Department of Zoology had a funding of 19.36% and produced 29.32%.

Referring to the reviewed literature of this study, (section 2.3), productivity has been linked to various factors such as age, subject specialisation, and economic indicators such as government expenditure on civil research and development.

This study agrees with the above finding of Budd and Seavey (25). Further, Narin's (26) 1976 study explained that "scientific talent is highly concentrated in a limited number of individuals" and as far as the analysis of this data is considered, it can be said that most of the talent in publication productivity is concentrated around the departments of botany, biochemistry / microbiology and zoology.

The logical conclusion that can be drawn, as one of FRD reports stated (as in 1.2), in the past most of the funding went to a few historically white tertiary institutions with little prospect of support for black and coloured scientists. These scientists were given very few opportunities to excel. So, until 1996, no efforts were made to rectify this imbalance. Hence, it can be seen that a substantial funding was provided for the departments of physics and chemistry, but the personnel for these departments have not been developed. It was also the lack of development in all areas that forced the changing of FRD in to the National Research Foundation (NRF).

The above results demonstrate that there are significant differences between productivity in different areas of science. Although the productivity is not directly proportional to the funding in all the cases, there are reasons to believe that funding plays a major role in the overall productivity of the scientists, especially in the case of junior scientists such as lecturers. The graph indicates that in the case of the Departments of Chemistry and Physics, there are low levels of productivity in spite of the high funding. The reason for this may be the need for expensive equipment in these departments, which may reduce the funds available for research. On the other hand, disciplines like zoology, botany and biochemistry with little funding have high productivity. Therefore, the null hypothesis five is rejected and inconclusive.

4.3.5.2 Summary

After having analysed the collected data, the researcher came up with the following findings:

- Research question one: Is there any relationship between academic rank and productivity of South African scientists?

Of the sixteen questions from the questionnaire used to prove hypothesis one, nine of them produced results which indicated marked significance in the productivity of these scientists in relation to the rank. The results showed that professors published profusely while associate professors and senior lecturers published much less. The conclusion drawn was that those who do not expect any promotion in the immediate future do less publications and presentation of papers at conferences. **In most cases, such as attendance at national conference, presentation of papers at national conferences and publication of articles in south African journals, it was found that the productivity of lecturers was remarkably high in relation to associate professors and senior lecturers. On examining the productivity of scientists as far as publication of papers in the last five years, attendance and presentation of papers in international conferences, publication in international journals are concerned, it was found that the productivity of scientists increased with the rank, that is to say, professors were higher in the productivity ladder, with associate professors following and senior lecturers and lecturers below them.

With regard to first research question from the results of the study, it was found that there is a direct relationship between rank and productivity.

- With regard to the second research question:" Does a scientist's prestige (personal, departmental and or institutional) have any influence on the productivity of South African scientists?"

The one way ANOVA and the Pearson Chi-Square tests provided the following results :

(i) There is a direct relationship between prestige and productivity of South African scientists.

(ii) There is more research and publication among scientists from the historically well developed universities than among those scientists from the historically disadvantaged universities, even though the responses from the latter were poor. Looking at it another way, all those scientists who work hard at their own research are those who would support others with their research, hence all those who responded are also the hard working scientists who are more productive.

(iii) There is more attendance and presentation of papers at conferences both national and international, in and out of South Africa, by scientists from prestigious institutions.

(iv) Scientists who publish in overseas journals were predominantly senior scientists.

(v) Professors have published more papers during the period 1992 – 1996 as compared with other scientists within the same time period. Lecturers are also seen to have published significant amounts as compared to senior lecturers and associate professors in national journals.

(vi) FRD grading was seen to be closely linked to prestige of both institutions and individuals.

(vii) The works of "A" graded scientists were seen to have a significant impact on the works of other scientists as compared to those of non-"A" grade scientists.

(viii) It was found that "A" graded scientists mostly worked in institutions which are historically well developed and have a high level of prestige.

- Based on the findings related to answering the fourth research question, which stated," Do "A" grade scientists' research and publication influence other scientists more than that of non-"A" grade scientists?"

The publications of the "A" grade scientists together with the non- "A" grade scientists were processed to discern the citations received by each scientist. The results obtained showed that:

(i) Research publications of South Africa's "A" grade scientists have a significant impact on the research and publications of other scientists as compared to the publications of non-"A" grade scientists.

(ii) "A grade" scientists are cited equally by colleagues in the department as well as those who work in the same field or related to the field in which the scientists work.

(iii) Analysis of questions from the questionnaire showed that the "A" grade scientists produce a greater influence on other scientists than the non- "A" graded scientists.

- The research questions four, five and six were as follows, "Are there any differences in productivity among the different areas of science?" "Does the level of funding affect the level of productivity in all areas of science?" "Are there any differences in productivity among the different areas of science?"

To answer these questions, their publication output, and supervision of postgraduate students estimated the productivity of the scientists. The analysis of the collected data provided the results obtained. The scientists from the department of botany had 14.55 % of the total funding for the scientists while their productivity was 15.53%, whereas the department of physics, which obtained funding of 24.77% of the total, had a productivity of 16.11%. The department of biochemistry / microbiology with 10.57% of the total funding had an output of 23.21% mismatched chemistry, which obtained a high 30.75% of funding, had a very low output of 15.83%. Zoology had a funding of 19.36% and produced 29.32%. The above results demonstrate that there are significant differences in productivity between areas of science.

While departments of botany, biochemistry / microbiology, and zoology published according to or even more than the research funding provided, departments of chemistry and physics published less than half of the required research in relation to the funds provided. Hence, null hypothesis five was rejected and inconclusive.

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Chapter 5
Research Findings, Recommendations and Conclusions

5.1 Introduction

This chapter summarises the findings of the study and draws conclusions in the light of the discussions in the previous chapters. It also makes recommendations in relation to the stated problem, based on the findings of the study. The present study was aimed at investigating the quantity of research done and the patterns of publication by academics in different universities of the three provinces of Western Cape, Eastern Cape and KwaZulu-Natal. The universities of the three provinces appeared to be fairly representative of scientists from all other universities of South Africa, as they included the various types of universities, namely, scientists from the historically advantaged institutions as well as historically disadvantaged institutions. Although University of Durban Westville was considered by the researcher as a bridging institution, the responses received from them for both lists of publications and questionnaires as well as for the citations they received placed it closer to the less developed institutions. Another important point in considering UDW in the group of historically disadvantaged institutions is the fact that FRD grouped it together with the other disadvantaged institutions that needed university development fund (refer page 119). Thus, it was considered fit to separate all the universities in the country into these two groups. Universities such as UCT, Natal, Stellenbosch, Port Elizabeth and Rhodes can be compared to Universities such as Witwatersrand, UNISA, Orange Free State, Pretoria, and Rand Afrikaans University. Universities of Zululand, Transkei, Fort Hare, Durban Westville and Western Cape can be compared to those of Boputhswana, Venda, North, MEDUNSA respectively. Refer to page 19.

Four research objectives were formulated and set in order to establish the prevailing publication patterns of scientists in South Africa, to identify the most productive category of scientists and presenters of papers at conferences, and to establish the various types of works produced by these scientists who are known to be productive in their academic work and research.. South Africa, just as any other third world country, is plagued by new problems and depends on its' scientists to discover new evidence and solutions to existing problems.

The research objectives were:

(i) To determine whether or not academic rank, status and prestige (personal, departmental, and /or institutional) have any impact on the level of productivity of South African scientists.

(ii) To determine whether or not "A" grade scientists in South Africa have a higher impact in their individual fields than other scientists.

(iii) To determine the levels of productivity within different areas of science in South Africa.

(iv) To determine whether or not the level of funding and /or the prospects of being funded have any influence on the level of productivity in each area of science in South Africa.

To achieve the intended purpose of the study, seven research questions were posed.

(i) Is there a relationship between academic rank and productivity of South African Scientists?

(ii) Does the scientist's prestige (personal, departmental, and/or institutional) have any influence on productivity of South African scientists?

(iii) Is there any relationship between academic status and productivity of South African scientists?

(iv) Do “A” grade scientists’ research and publications influence other scientists more than those of non- “A” grade scientists?

(v) Are there any differences in productivity among the different areas of science?

(vi) Do prospects for funding affect the level of productivity in all areas of science?

(vii) Does the level of funding affect the level of productivity in all areas of science?

Additionally, five null hypotheses have been stated and tested in order to accomplish the above objectives. These null hypotheses were as follows:

(i) There is no direct relationship between academic rank and productivity of South African Scientists.

(ii) There is no direct relationship between the attainment and sustenance of prestige (Personal, departmental, and/or institutional) and productivity among South African scientists.

(iii) There is no direct relationship between academic status and productivity of South African scientists.

(iv) Research publications of South Africa’s “A” grade scientists have a higher impact on the research and publication of other scientists than those of non- “A” grade scientists.

(v) There are no significant differences in productivity between areas of science, which have more funding than those with less funding.

Two sets of data were collected. Firstly, the scientists were requested to supply the researcher with lists of their publications. Secondly, another set of data was collected by means of a seven-page questionnaire.

The questionnaire of the study was pretested using a sample of thirty five members of the science faculty in different departments at the University of Transkei. Eighteen respondents or 51% of the subjects, returned the questionnaire. The comments of the respondents enabled the investigator to make the necessary revisions in the subsequent questionnaire.

The instrument used in this study comprised three parts. The first part (Questions 1 - 14) was designed to collect information on research, teaching activities and some demographic data of the respondents. The second part (questions 15 to 27) provided information on research and publication productivity, while the third section (28 to 37) sought information on institutional prestige, funding and factors that motivated publication. Thus, the data provided by the second and third sections of the questionnaire and the publications' list obtained from the scientists made the testing of the four null hypotheses possible.

The questionnaire was then sent to the same 350 full-time academic scientists in the departments of physics, chemistry, botany, zoology and biochemistry / microbiology in the universities within the three provinces of Eastern Cape, Western Cape and KwaZulu-Natal. Out of the 350 subjects, 135 scientists answered and returned the questionnaire, a further reminder brought another 39 more, thus making the total return 174 or 50%. Among the 174 returns, only 153 were used in the data analysis. Twenty one returns were discarded, as they did not include complete answers.

The subjects were asked to rate the time spent on research, teaching, administration, their opinion on the influence of an "A" graded scientist in an institution as well as their opinion on the influence of funding on research and publication on a Likert-type of scale of 5 to 1, where 5 is for "strongly agree" and 1 for "strongly disagree".

The information required to study the null hypotheses three and four were collected from the FRD and Science Citation Index respectively, together with the data collected by means of the questionnaire. The data provided by the second and third parts of the questionnaire made possible the testing of the four hypotheses stated in this study.

Data were analysed using descriptive and inferential statistics as described in the update edition of the Statistical Package for the Social Sciences (SPSS update 7-9).

Descriptive statistics (Means, standards of deviation, and proportions) were used in determining the characteristics of the population of the study, inferential statistics (one-way ANOVA) was performed in studying the differences.

Pearson Chi-Square tests were used in addition to one-way ANOVA tests. Further analysis of results were done using Bonferroni multiple comparison tests to confirm the significant differences between the groups.

5.2 Summary of the findings

This section of chapter 5 presents the review of the findings related to the characteristics of the respondents and the testing of the null hypotheses that were stated earlier. According to Wilkinson and Bhandarkar (1), if the end product of analysis is the setting up of certain general conclusions, what these conclusions mean is the bare minimum of what is expected to be known. It therefore helps in understanding the reasons for certain findings. Thus, interpretation provides an understanding of the general factors which explain what has been observed as well as providing a theoretical conception which can serve in turn as a guide for further studies.

5.3 Characteristics of respondents:

The 153 respondents who took part in this study were distributed among the departments of botany, biochemistry/microbiology, chemistry, physics and zoology. Out of these scientists, 24 or 16% were botanists, 26 or 17% were biochemists/microbiologists, 39 or 25% were chemists, 29 or 19% were physicists and 35 or 23% were zoologists.

On analysing the academic rank of respondents, there were 47 or 30.7% professors, 27 or 17% associate professors, 30 or 19.6% senior lecturers, 46 or 30.1% lecturers, and three or two percent senior research associates. Although these scientists belonged to five departments, their fields of specialisation extended to 36 areas.

On further analysis of the data collected, it was found out that the scientists who took part in the study were distributed as follows: -

Ten from the University of Natal; 13 from the University of Port Elizabeth; 16 from Rhodes University; nine belonged to the University of Fort Hare; 21 from University of Cape Town; 18 from University of Stellenbosch and 12 from the University of Durban-Westville; 19 from the University of Natal, Durban; 13 from the University of the Western Cape; two from the University of Zululand and 19 from the University of Transkei.

With regard to variable experience in teaching and research as expressed in years, 25 scientists said that they had been teaching for over 30 years; 15 had been teaching for over 27 years; 25 had been teaching for more than 22 years; 20 had the teaching experience of 17 years and 17 said that they had been teaching for the last 12 years. Twenty five of them had been teaching for less than 9 years; 23 of them had been teaching for less than four years and two respondents had been teaching for less than a year.

On the question of administration and management, five percent of them indicated that they spent about 75 to 100% of their time on administrative work and 11% spent 50 to 75% on management. Twenty eight percent indicated that they spent 25 to 50% on administration, while 58% of the respondents indicated that they spent very little or no time on administrative work. About 52% of the respondents said that they had held the post of HOD some time or other during the last five years.

An interesting aspect of the information gathered about the respondents was that 27% of them belonged to the age group of between 40 and 60 years. This period of one's life was also considered by many of the scientists as the most productive years academically. Another useful fact that was noticed was that 75% of the scientists were White, eight percent were Indian, five percent were Coloured and 12% Black. This showed that most of the research output shown was by white scientists who were predominantly from the well established South African universities.

5.4 Summary of the findings related to the testing of the hypotheses

The major findings in testing the first hypothesis and the related research question were: **Research question one**: "Is there a relationship between Academic rank and Productivity of South African scientists?"

Of the 16 questions from the questionnaire used to test the hypothesis, nine produced results which indicated marked significance in the productivity of the scientists in relation to rank, that is, the higher the rank, the greater is the productivity of these scientists, that is in spite of the very poor response from the historically disadvantaged institutions. Those scientists who work hard at their own research and publication, also supports the research of others in any possible way they can. All those responded to this study are the willing and hard working scientists, who sent their lists of publications and filled and returned the questionnaires. Hence it is felt that those who belong to the study are representative of the researchers and other scientists.

- It was found that professors published far greater numbers of scientific papers as compared to scientists of lower rank. A special finding of this study was that Lecturers presented more papers in national conferences in South Africa, as compared to associate professors and senior lecturers.

- Although the associate professors and senior lecturers were at a higher rank than the lecturers, they did not appear to publish as much as the lecturers in the national journals.

- The productivity of scientists decreased with the decrease in rank, for example, in the attendance of international conferences and publication in international journals.

- It was found that there is more research and publication among scientists from the historically well developed universities than among those from the historically disadvantaged universities. See section 4.2.7.

On the whole, it was found that professors attended and presented more papers at conferences and published more articles in journals, especially in overseas journals. Associate professors and senior lecturers also presented and published more papers at the international conferences and journals compared to lecturers. On the other hand, there was an increased productivity among the lecturers, perhaps because these scientists are thought to be aspiring towards a higher rank. Therefore, it may be said that rank plays a key role in the productivity of the scientists.

Based on these findings, **null hypothesis one** which stated "there is no direct relationship between academic rank and productivity of South African scientists", was not accepted, and the **alternative hypothesis** which stated that there is a direct relationship between academic rank and productivity of South African scientists was accepted.

Answers to the **second research question**: "Does prestige (personal, departmental, and/or institutional) have any influence on productivity of South African Scientists?" showed that out of 20 questions that were analysed using one-way ANOVA, in order to establish significance of items, with regard to prestige and productivity, 11 of them showed a significant relationship between prestige and productivity.

The results of the one-way ANOVA and Pearson Chi-square tests showed that:

- There is more research and publication among scientists from the historically well developed universities than those scientists from the historically disadvantaged universities.

- There is more attendance and presentation of papers at conferences both national and international, in and out of South Africa by scientists from the well established universities in South Africa. This finding may have been different if the response rate from the historically black universities were better where there are more black lecturers in the science faculty than professors.

- Scientists who publish in overseas journals were predominantly senior scientists (professors). Professors have published more papers during the period 1992 - 1996 as compared with other scientists within the same period. Lecturers also seen to have published significant amounts as compared to senior lecturers.

- FRD grading was seen to be closely linked to prestige - both institutional and individual. Out of the 46 "A" graded scientists, 45 of them hail from the prestigious institutions indicating that all these higher graded scientists worked in institutions which have a high level of prestige.

As a result, **null hypothesis two** which stated "there is no direct relationship between the attainment and sustenance of prestige (personal, departmental, and/or institutional) and productivity among South African scientists" was not accepted. The **alternative hypothesis** which stated that there is a direct relationship between the attainment and sustenance of prestige (personal, departmental, and/or institutional) and productivity among South African scientists was accepted.

The **research question three** : "Is there any relationship between academic status and productivity of South African scientists?"
The answer to question three was obtained by analysis of the data, which showed that :

- Professors with Ph.D attended more overseas conferences and presented more papers than those scientists with a lower status

- Scientists with higher status (with regards to his qualification) published more papers in both international and national journals.

- Scientists regard FRD evaluation as an influential factor regarding their status as it affects both their prestige and funding.

Therefore, **null hypothesis three** which stated that "there is no direct relationship between academic status and productivity of South African scientists" was not accepted and the **alternative hypothesis** which stated that there is a direct relationship between academic status and productivity of South African scientists was accepted.

The **fourth research question** stated:"Do "A" grade scientists' research and publication influence other scientists more than those of non-"A" grade scientists?"
The publications of the "A" grade scientists together with the non- "A" grade scientists were processed to discern the citations received by each scientist. The results obtained showed that:

- Research publications of South Africa's "A" grade scientists have a significant impact on the research and publications of other scientists as compared to the publications of non-"A" grade scientists.

- "A" grade scientists are cited equally by colleagues in the department as well as those who work in the same field or fields related to the scientists' work

- Analysis of the questions related to the influence of "A" grade scientists from the questionnaire showed that the "A" grade scientists produce a greater influence on other scientists and motivated them to forge ahead to achieve the "A" grade status for themselves.

- Another factor assessed was the attraction and supervision of students, and it was found that many of the "A" grade scientists had as many as 25-29 post graduate students each under them during the last five years.

Based on these findings, **null hypothesis four** which stated "research publications of South Africa's "A" grade scientists do not have higher impact on the research and publications of other scientists as compared to those of non - "A" grade scientists" was not accepted. The **alternative hypothesis** which stated that research publications of South Africa's "A" grade scientists have a higher impact on the research and publications of other scientists as compared to those of non - "A" grade scientists was accepted.

The **research questions five and six** were as follows: - "Does the level of funding affect the level of productivity in all areas of science?", and, "Are there any differences in productivity among the different areas of science ?"

To answer these questions, the productivity of the scientists was estimated by their publication output, attendance at conferences and presentation of papers as well as supervision of postgraduate students. The analysis of the data collected provided the results, which demonstrated that there were significant differences in productivity between areas of science.

While the departments of botany, biochemistry/microbiology and zoology published according to or even more than the research funding provided, the departments of chemistry and physics published less than half of the required research in relation to the funds provided. Hence, **null hypothesis five** which stated "there are no significant differences in productivity between areas of science, which have more funding than those with less funding" was not accepted. The **alternative hypothesis** which stated that there are significant differences in productivity between areas of science, which have more funding than those with less funding was accepted.

5.5 Conclusion of findings

The results obtained from the statistical analysis of the data provides insight towards the productivity of scientists from the various universities who responded to the questionnaire which correlates with their rank, status and prestige - both individual and institutional. This study found that most of the publications both in and out of the country were done by professors and there was a marked publication productivity of lecturers. Lecturers appeared to publish more than senior lecturers and associate professors, and the possible reason for this pattern of productivity was believed to be due to the fact that they do publish more in an attempt to attain a higher rank .

A study by Dalymple and Varlejs (2) found that in a department, only a few professors are significantly engaged in research. Another study by the same authors estimated that 80% of the research is being done by 19 % of the staff at 20% of the universities in the United States of America. Another study by Jalogo (3), indicated that 42% of the staff spent four hours or less weekly on research, and only 32% do research for more than 10 hours per week. Fifty-five percent have never published or edited a book, and 22 % have never published in a professional journal. This present study is quite similar to their research results in that most of the research and publication activities are done by few "A" and "B" graded scientists, while most of the associate professors and senior lecturers produced much less compared to the professors.

A remarkable result obtained by analysis of citations was the publication impact of "A" grade scientists as compared to non- "A" grade scientists. The names of "A" graded scientists were shown by other scientists as those who have influenced them in their research and publication. This clearly indicated that, despite most of their work being published in the international journals, they also published in national journals. It is evident, therefore, that their achievement in the field is noted and appreciated by their colleagues in the department as well as scientists from the same field and from other institutions in South Africa.

Another important finding in this study is related to the presentation of papers by lecturers at national conferences in South Africa. The data showed that lecturers equalled the professors in the number of papers that they have presented. The explanation for this is that the lecturers get opportunities to attend the national conferences. This is an indication that if opportunities are made available to these young scientists, they will most certainly make use of the facilities to improve in their research and publication activities.

Professors are found to attend more international conferences and present papers. This can be attributed to the fact that professors have more opportunities to go abroad to present papers than the academics at a lower rank. It was quite evident as a whole that associate professors presented fewer papers. The main reason could be attributed to their either being promoted just before this study was undertaken, or because these scientists may not be expecting a promotion in the near future. It could also be that they feel quite content with their position.

Many of the professors who responded to the questionnaire expressed their attitude towards government funding and external grants. Most of them felt that funding did not affect them directly and that they did the research and publication merely for academic satisfaction, while lecturers felt that funding was an incentive towards research and publication as they needed to establish themselves.

Another important finding of this study is the productivity of the scientists from the various departments. It was interesting to see that while the scientists in the departments of botany, biochemistry/microbiology, and zoology were very productive according to the funding they received, the scientists from the departments of chemistry and physics, although received more financial aid compared to some of the other departments, their research results were rather poor and they were also less productive than others.

Another interesting finding of this study was the indication by scientists that the most productive years of their research career was between the ages of forty and sixty.

Another important aspect that came out of this research was that one of the main attractions for postgraduate students to a particular researcher or institution depended on the prestige of the researcher and that of the institution.

Funding was another major issue that attracted postgraduate students to a particular scientist or an institution. Many of the scientists stressed the need for commitment on the part of the researcher as well as a sincere and attractive personality, that is, some one who is willing to share his/her expertise with his/her students and is flexible about their shortcomings.

5.6 Implications of the findings and recommendations

The findings of this study point towards the role played by rank, prestige, status and funding in the productivity of the scientists. On further scrutiny, it is found that the causes and effects of these variables are neither directly proportional to the publication output nor do they show considerable variance, as in some cases of the lecturers and senior lecturers. For example, on a detailed analysis of the data collected showed that while professors published much more than the other scientists, a comparison of professors from the prestigious universities with those of the less prestigious (historically disadvantaged) universities. It

was found that the former published in greater numbers compared to the latter even after 1994. Since this was not one of the research questions asked, was not worked out in detail. In order to compare the well established universities with the historically disadvantaged universities, it was necessary to have obtained more responses from them .

It is extremely crucial that the libraries and information centres support research activities of scientists, and ensure that these individuals receive the documents and information that they require as expeditiously as possible and in the form they require. Unless, there is an active invisible college in the institution in which they work, the scientists may not be aware of the research and publication their colleagues carry out. A reason for scarcity of citation may be lack of physical accessibility to information sources as discussed in 2.4.1 of this thesis, (Liu 101). Another possible reason is lack of relevant information concerning existing publications. Its also worth noting the concern of some of the younger researchers who felt that they were not receiving sufficient co-operation and support from the senior established scientists from their own institutions. It would be considered valuable if there was networking between institutions to provide information about who is doing what.

It is felt that information about the latest research and publication from other scientists would encourage the less motivated scientists to work harder and compete with the others to produce better research for the improvement of himself / herself and the community.

The FRD report collected for this study showed that UCT has 19 "A" grade scientists, while the University of Stellenbosch has just one. In spite of this difference, Stellenbosch still attracts many post-graduate students. According to the answer to question 34, the main reasons for this attraction of students to well established universities were stability and academic environment and prestige.

It was also clearly noticeable that the publication output as well as attendance at international conferences were highly favoured by the professors while there was a downward trend among the scientists in the lower rank. This calls for increased commitment by the policy makers to provide adequate incentives to the scientists who seem to lag behind, so that they may engage in more consistent research endeavours and strive to produce higher quality research outputs that would bring about a positive impact on the quality of the living standard of the South African populace. Research alone is not sufficient, as these results need to be published (as discussed in 1.3 of this thesis).

There was a marked difference in research and publication productivity between scientists from prestigious institutions (formally advantaged) as compared to those from disadvantaged institutions. In an attempt to balance disparity in research between the institutions, collaborative research between and among scientists from previously advantaged and disadvantaged institutions needs to be established. Although, the advantaged institutions will not stand to gain very much, it will assist the disadvantaged institutions in terms of expertise and develop quality research.. This in fact is what the NRF is emphasising, and it is strongly supported by the findings of this study.

It is also considered worthwhile for universities to assess themselves to discover their position in the real academic world of research and publication. After the demographic transition in 1994, much has been done to uplift the previously disadvantaged institutions. It is now up to the individual institutions to see why their academics still have a very low productivity in research and publication compared to academics at other well established institutions.

One of the findings of this study is that the high calibre scientists are found predominantly in a few prestigious institutions. This attracts students – both black and white – to these institutions with good reputation and few disruptions. It is imperative, therefore, for policy makers in the government and funding agencies to work together to change the poor reputation by introducing incentives to attract scientists of good repute to these universities.

An important finding of this study is the high impact of the publications of "A" grade scientists on other scientists in the field. These scientists have proven themselves worthy of the reputation they have. This study therefore supports the idea of grading by the FRD and suggests that the NRF continues this. However, it may be necessary for the NRF to alter its' evaluation criteria to ensure that all scientists – from both previously advantaged as well as disadvantaged institutions – feel that they are treated fairly and equally.

5.7 Conclusions of the study

This study endeavoured to establish the fields within which scientists publish more and the correlation between departmental productivity and rank, status, prestige and funding. The final result is that all the null hypotheses were not accepted and the alternate hypotheses were accepted.

The findings obtained in this study pointed to the marked difference in productivity of professors, associate professors and senior lecturers with regard to publications.

Analysis of the data clearly indicated that professors published profusely, the other two categories did very little research and publication. Lecturers on the other hand, endeavoured to publish articles and present papers nationally. An interpretation for this behaviour of the lecturers may be the motivation for promotion. This finding therefore agrees with Cooper (4) who explained that promotion was the driving force behind faculty research publication. Ruseic (5) also agreed with Cooper when he said that most of what he reads shows that the main reason for research and publication is for promotion.

A study by Bottle (6) found that professors are prolific producers of papers and that there is no difference in productivity between Britain and France. They also discovered that there was a difference in productivity of the middle ranks, i.e., associate professors and senior lecturers in British Universities. Their results are very similar to the findings of the present study, which showed that associate professors and senior lecturers produced fewer publications as compared to professors.

Ninety percent of the professors in this study revealed that the reason behind their research and publication was purely for academic satisfaction, thus exhibiting intrinsic motivation. This study, therefore agrees with Cooper (7) and Finkelstein (8) who explained that intrinsic motivation (research interest) rather than extrinsic motivation (promotion) plays a more important role in faculty research productivity. On the other hand, the present research disagrees with Tien and Blackburn (9) who thought that intrinsic claims are open to doubt.
Studies conducted by Bently (10) and Blackburn, Beheyman and Hale (11) came up with the idea that academic rank is a predictor of faculty research productivity. On the other hand, studies conducted by Guyen and Fidell (12),

Oven (13) came up with the conclusion that academic rank had no influence on departmental research productivity. But, the present study proved that academic rank and productivity are highly correlated i.e., out of 21 ANOVA tests done, 11 were highly significant, thus indicating that academic rank is well related to publication productivity.

Finkelstein (14), conducted a study on rank and research. His finding was that institutions promote productive scientists. Consequently, higher rank faculty members were academic "winners". Finkelstein's data showed that scientists are promoted because of their publications, which was in line with the present study which showed that the academics who are higher in rank produce more publications than those who are lower in rank.

Another important research result obtained in this study is the relationship between the "A" graded scientists and their publication impact compared with the publication impacts of non- "A" graded scientists. The "A" graded scientists' publications had higher impact than those of the non- "A" graded scientists. The data were analysed and the results showed that the publications of the former received far greater number of citations than those of the latter. The results are depicted graphically (both bar graphs and pie charts).

While eight "A" grade scientists received more than 75% of the citations for the same length of time, 15 non - "A" graded scientists received only 25% of the citations. This proved positively that the publications of South Africa's "A" graded scientists' publications have higher impact than those of the non- "A" graded scientists.

The results of the present research agree with the studies of Bently and Blackburn, Beheyman and Hale completely and disagree with the findings of Guyen and Fidell and Oven. The results further revealed that professors had 50 - 150 publications, senior lecturers had less that 20 publications, lecturers had less than five.

The differences between the lecturers and the professors may be attributed to the former group's years of work in the department and experience, which the latter group is lacking. But the difference between the professors and the associate professors is quite distinct. In this case, there cannot be much difference in their working years.

One finding this study points to is the personal, departmental and institutional prestige related to the productivity of the scientists. A study by Budd and Seavey (15) found that prestige and productivity were linked. The present study supports this finding.

Both the ANOVA and the Chi - Square tests showed that there was a significant relationship between prestige and productivity. The scientists with the large numbers of publications were from the previously well established institutions, while the scientists with the least number of publications were from "previously disadvantaged" institutions. This finding can be interpreted as those who feel privileged to work in a prestigious institution try to excel themselves, hence the research and large numbers of publication papers, whereas those in historically disadvantaged universities have little or no motivation to do research. Besides publications, many of the scientists indicated that students join the scientists who have a reputation in their respective field for study and postgraduate research. Hence, prestige of scientists and institutions go together with their productivity.

5.8 Suggestions for further studies.

- There was disparity in the publication productivity of the scientists from the departments of chemistry and physics in spite of being heavily funded. It would be wise to investigate the reason for this apparent failure on their part to produce more as well as any other factors that may aggravate this situation.

- Another aspect for further study is to evaluate the staff situation in all the universities of South Africa. Some departments in certain universities seem to have many professors with very few numbers of lecturers, while the situation in other universities is reversed. This irregularity may affect the research and publication patterns of scientists within these institutions. It is therefore of importance to determine productivity of individual departments in all universities in South Africa.

- Another aspect of this study that should be studied further is examination of the publication patterns of scientists over three different years to see if scientific research and publication are improving or deteriorating.

- This would help policy makers and funding agencies to continue with their methods in the first case or change their tactics in the second case.

- It would be interesting to study the publication patterns of academics from other fields such as the social sciences and the humanities, in order to make comparisons and, if possible, draw parallels.

- A further interesting field would be medical sciences. This is a field which requires a study of this nature to observe whether or not medical scientists are on a par with the rest of the world with regards to their research and publications in order to keep up-to-date with the current trends in medicine. A rapidly developing country like South Africa requires medical professionals who are committed and are well versed in current research findings and recommendations.

- This study investigated the publication patterns of South African Scientists in three provinces and ten universities. It would be worthwhile to investigate the topic using a larger population, which is, using a countrywide survey, to include all the universities in the country. Although a nation-wide survey would be a great challenge, it would be of immense value in noting the popular areas for research and thus the major areas of funding for research.

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Appendix A

FRD
SNO

FORM FRD 1
VORM SNO 1

FRD Evaluation Secretariat
SNO-Evalueringsekretariaat
P O Box 395/Posbus 395
PRETORIA 0001

APPLICATION FOR FRD EVALUATION OF INDIVIDUALS
AANSOEK OM SNO-EVALUERING VAN INDIVIDUE

Complete in typescript/Voltooi in tikskrif
Where applicable, mark with X/Waar toepaslik, merk met X

BIOGRAPHICAL SKETCH / BIOGRAFIESE SKETS

Surname Van		Maiden name Nooiensvan	
First names Voorname			
Citizenship Burgerskap		Prof Dr Mr Mrs Miss Prof Dr Mnr Mev Mej	
Date of Birth Geboortedatum		Place of birth Geboorteplek	
Name of present employer Naam van huidige werkgewer			
Department Departement			
Faculty Fakulteit			
Academic speciality Akademiese spesialiteit			

Degrees Grade	Field of study Studieveld	University Universiteit	Year Jaar	Distinctions Onderskeidings

I wish to receive correspondence in English Ek ontvang graag korrespondensie in Engels		Afrikaans Afrikaans	

EXPERIENCE TO DATE / ONDERVINDING TOT DATUM

Name of employer Naam van werkgewer	Capacity and/or type of work Hoedanigheid en/of soort werk	Period Termyn

PARTICULARS OF THREE NOMINATED REFEREES
BESONDERHEDE VAN DRIE GENOMINEERDE BEOORDELAARS

1. Name Naam	
Full address Volledige adres	
2. Name Naam	
Full address Volledige adres	
3. Name Naam	
Full address Volledige adres	

TO BE COMPLETED BY THE APPROPRIATE AUTHORITY — **MOET DEUR DIE TOEPASLIKE OWERHEID VOLTOOI WORD**

Universities/museums/organisations are asked to make their input into the evaluation by rating the applicant on the following scale:		Universiteite/museums/organisasies word versoek om hulle inset in die evaluering te maak deur die aansoeker op die volgende skaal te plaas :
Researchers who are accepted by the international community as being amongst the leaders in their field.	A	Navorsers wat deur die internasionale gemeenskap as leiers op hulle gebied aanvaar word.
Researchers not in category A, but who nonetheless enjoy considerable international recognition as independent researchers.	B	Navorsers wat nie in die A-kategorie is nie maar wat nogtans besondere internasionale aansien as onafhanklike navorsers geniet.
Proven researchers who have maintained a constant level of research productivity and whose work is regularly made known internationally.	C	Beproefde navorsers wat 'n konstante vlak van navorsingsproduktiwiteit handhaaf en wie se werk gereeld internasionaal bekend gestel word.
Researchers younger than 35 who have already obtained PhD degrees, and who have shown that they possess exceptional potential as researchers.	P	Navorsers jonger as 35 jaar, wat oor doktorsgrade beskik en wat reeds bewys het dat hulle oor uitsonderlike potensiaal as navorsers beskik.
Normally researchers who are less than 35 years of age, who are highly likely to achieve C status by the end of the support period.	Y	Normaalweg jong navorsers wat jonger as 35 jaar is en wat hoogs waarskynlik C-status teen verstryking van die ondersteuningstermyn sal bereik.

Rating by authority ☐ **Beoordeling deur owerheid**

Where applicable, mark with X : — *Waar toepaslik, merk met X :*

This candidate holds a full-time permanent appointment ☐ Hierdie kandidaat beklee 'n voltyds- permanente aanstelling

This candidate holds a full-time temporary appointment ☐ Hierdie kandidaat beklee 'n voltyds- tydelike aanstelling

This candidate is under consideration for appointment to the following post : .... — Hierdie kandidaat word oorweeg vir 'n aanstelling in die volgende pos : ....

Date .... Datum ....

Name .... Naam ....

Designation .... Ampstitel ....

Signature .... Handtekening

UNIVERSITY OF TRANSKEI
PROGRESS THROUGH LEARNING

University of Transkei

Ms D Jacobs
Department of Chemistry P.Bag X1 UNITRA Umtata 5117
E -Cape , South Africa
Tel (0471) 3022601(O) / 312864 (H) Fax : (0471)3022725/ 3022655
EMail : djacobs@getafix.utr.ac.za

Dear Prof.

REQUEST FOR YOUR LIST OF PUBLICATIONS

I have registered for a Ph.D. programme at the department of Information studies, University of Natal, Pietermaritzburg. The topic of my dissertation is PUBLICATION PATTERNS OF SOUTH AFRICAN SCIENTISTS: A BIBLIOMETRIC STUDY.

You are one of the scientists chosen for my study. I shall be grateful if you kindly send me a copy of your list of publications as they appear in your Curriculum Vitae. Data from the list will be used for my study.

I will be pleased to send you the summary of the results if you so wish.

Thanking you for your co-operation,

Yours sincerely

DJacobs

Daisy Jacobs

Appendix C

2 April 1997

UNIVERSITY OF NATAL
Pietermaritzburg

Information Studies

Private Bag X01 Scottsville
Pietermaritzburg 3209 South Africa
Telephone (0331) 2605007 Fax (0331) 2605092
Telegrams University Telex 643719
E-Mail Holtz @ infs.unp.ac.za

TO WHOM IT MAY CONCERN

I would like to introduce Mrs. Daisy Jacobs, a doctoral candidate in Information Studies, at the University of Natal (Pietermaritzburg) under my supervision. As part of her doctoral requirements she is conducting research in the area of bibliometrics on the productivity (research and publication patterns) of scientists in South Africa. Some of the data she needs for this research, namely, research and publication patterns, can only be collected from scientists like yourself. It is both Mrs. Jacob's and my belief that this will provide better insights in the areas of strength and weakness, reasons for theses and possible interventions towards balanced scientific productivity in this country.

I would therefore be most grateful if you would be kind enough to extend to Mrs. Jacobs the help she may need in collecting the necessary data for this research. Thanking you in anticipation.

Yours sincerely,

Professor Andrew M. Kaniki
HOD, Information Studies Dept.

Appendix D

A BIBLIOMETRIC STUDY OF THE PUBLICATION PATTERNS OF SOUTH AFRICAN SCIENTISTS

A Questionnaire for scientists

This questionnaire is intended to collect additional data to that which has been available from a number of curriculum vitae and resumes supplied by a number South African scientists to the researcher. The data to be collected through this questionnaire is expected to assist the researcher in the study of research productivity and impact of various science disciplines and specialisations in South Africa

No Name(s) should be written on this questionnaire. All the information provided will be treated confidentially.

Please provide as complete information to each item in this questionnaire as possible.

SECTION 1 - PERSONAL DATA

Instruction: ***In answer to the following questions, CIRCLE the letter(s) which best apply(ies) to you or best answer(s) the question. Where no choice(s) are given use the space provided for your answer. If more space is needed, please use the back of the page, indicating the appropriate question number.***

1. What is your broad field of specialisation?
   (a) Botany
   (b) Chemistry
   (c) Biochemistry
   (d) Physics
   (e) Other (Please specify)--

2. Please indicate below, your specific area(s) of specialisation.

   ----

3. Please indicate your department and faculty.

   ----

4. Please state your current academic rank, i.e., Professor ; Associate Professor, Senior Lecturer, Lecturer etc.

----

5. Give the highest academic or professional qualification you have attained?

----

6. How long have you been teaching (College Level and/or above)?
   (a) Over 30 years (b) 25 - 29 years
   (c) 20 - 24 years (d) 15 - 19 years
   (e) 10 - 14 years (f) 5 - 9 years
   (g) 1 - 4 years (h) Less than ONE(1) year

7. How long have you been involved in and/or conducting research associated with your broad field and/or specialisation as in 1 and 2 above?
   (a) Over 30 years (b) 25 - 29 years
   (c) 20 - 24 years (d) 15 - 19 years
   (e) 10 - 14 years (f) 5 - 9 years
   (g) 1 - 4 years (h) Less than ONE (1) year

8. What proportion of your work time has been and is devoted to the planning and execution of research in the last five 5 years ?
   (a) 75 - 100%
   (b) 50 - 75 %
   (c) 25 - 50 %
   (d) 1 - 25 %
   (e) None

9. What proportion of your work time has been and is devoted to preparation and teaching over the last five 5 years?
   (a) 75 - 100 %
   (b) 50 - 75 %
   (c) 25 - 50 %
   (d) 1 - 25 %
   (e) None

10. What proportion of your time do you currently (1998) devote to administration and management ?

(a) 75 - 100 %
(b) 50 - 75 %
(c) 25 - 50 %
(d) 1 - 25 %
(e) None

11. Have you in the last five(5) years, held an administrative post within your institution/ Division/department?

(a) No
(b) Yes

Please specify the position and period (e.g. Head of Department)

----

12. What is your age group?

(a) 20 - 30 years
(b) 31 - 40 years
(c) 41 - 50 years
(d) 51 - 60 years
(e) 61 years and above

13. What is your gender?

(a) male
(b) Female

14. Please indicate your race (This information is needed to simply assist in the analysis of the current trends)

(a) Black
(b) Coloured
(c) Indian
(d) White
(e) Other. Please specify--

SECTION II - PROFESSIONAL WORK

15. Indicate the number of **National** and **International** conferences, seminars held in South Africa which you have attended in the last five(5) years.

National Conferences attended --

International Conferences attended ---

16. Please indicate the number of papers you have personally or in collaboration with other(s) authored and presented at National and International conferences held in South Africa in the last five(5) years?

Papers at National Conferences--

Papers at International Conferences---

17. How many conferences held abroad (outside South Africa) have you attended in the last five(5) years?

----

18. How many scientific papers have you presented in conferences outside of South Africa in the last five(5) years?

----

19. How many scientific papers/articles have you published in the past five(5) years?

----

20. Have you ever been invited as a special guest or resource person to present paper(s) in a particular area in the last five(5) years?
(a) No
(b) Yes
Please give some details ---

21. How many papers have you published as author or co-author in South African journals?

22. How many papers have you published as author or co-author in overseas journals?

23. How many popular science articles have you published in South African journals/magazines ?

24. How many popular science articles have you published in overseas journals?

25. Have you been evaluated by FRD?
(a) No
(b) Yes
Please indicate the grade

____

____

26. Do you have "A" rated scientists in your institution ?
(a) No
(b) Yes
(c) Don't know

27. Have any of your works (research/publications) in the last five(5) years been influenced by another/ other South African scientist(s)?

(a) No------Why not? (Please explain briefly)

(b) Yes----- Please indicate not more than 5 scientists and/or works that have influenced you.

Instruction

In the following series of questions, please indicate your opinion to the following statements, choosing one of the options given below.

28. The availability of an A-rated scientist in an institution will motivate other scientists within the same institution to actively work towards the achievement of A grade status.
    (a) strongly agree
    (b) agree
    (c) neutral
    (d) disagree
    (e) strongly disagree

29. Sustained publication by a scientist in refereed journals is important for maintaining a departmental or institutional prestige.
    (a) strongly agree
    (b) agree
    (c) neutral
    (d) disagree
    (e) strongly disagree

30. Prospects for promotion to a higher rank has play(ed) a big part in the number of paper you have present(ed) at conferences or submit(ed) for publication/published in the last 5 years.
    (a) strongly agree
    (b) agree
    (c) neutral
    (d) disagree
    (e) strongly disagree

31. Prospects of obtaining (more) subsidies from Government/or your Institution play a big part in the number of papers you publish.
    (a) strongly agree
    (b) agree
    (c) neutral
    (d) disagree
    (e) strongly disagree

32. Prospects of attaining research funds both nationally and internationally play a big part in quality and quantity of my research and publication.
(a) strongly agree
(b) agree
(c) neutral
(d) disagree
(e) strongly disagree

33. The number of research students attracted to a programme is an important factor in maintaining a departmental or institutional prestige.
(a) strongly agree
(b) agree
(c) neutral
(d) disagree
(e) strongly disagree

34. Have you over the last 5 year(s) (1993-1998) attracted/supervised research students?
(a) No
(b) Yes

Please indicate the number supervised during the last five(5) years.

35. Please indicate in Rank order one (1) being most important, 5 reasons research students are attracted to individual academics/researchers as supervisors/promoters
(1) --
(2) --
(3)---
(4) --
(5) --

36. At what stage of your academic/research career do you think you will be/have been most productive?
----

37. If you have any general commends please write.

Thank you very much for taking your time in completing the questionnaire. Please return the questionnaire to the address using the self addressed and stamped envelope.

Appendix E

University of Transkei

Ms D Jacobs

Department of Chemistry P.Bag X1 UNITRA Umtata 5117

E -Cape , South Africa

Tel (0471) 3022601(O) / 312864 (H) Fax : (0471)3022725/ 3022655

EMail : djacobs@getafix.utr.ac.za

Dear Sir / Madame

Subject : A Bibliometric Study of the Publication Patterns of south African Scientists

Under the auspices of the department of Information Studies, University of Natal, I am conducting a study on the Publication Patterns of the South African scientists, which is my dissertation topic. This study is required by the University for the degree of Doctor of Library and Information Science.

Many scientists, perhaps including yourself sent me their CVs which have been most helpful for the preliminary work. I am now at a stage of my research when I need additional data. May I ask you to assist me with this additional data.

I will be most grateful if you will complete the enclosed questionnaire and return to me at your earliest convenience, but before the 25th July, 1998. Enclosed please find the stamped envelope.

Your responses will be held in the strictest confidence. I will be pleased to send you the summary of the results if you so wish.

Thanking you for your co-operation,

Yours sincerely,

D Jacobs

Daisy Jacobs

Appendix F

PEARSON CHI-SQUARE TEST FOR PRODUCTIVITY

Item	value	df	prob	
National conferences attended	19.8	12	0.07	
International conferences attended	11.5	12	0.49	
Papers presented at national conferences	22.5	16	0.13	
Papers presented at International conferences	19.8	12	0.07	*
Overseas conferences attended	13.7	12	0.32	
Scientific papers presented in last 5 years	16.7	12	0.16	
Scientific papers published in last 5 years	38.6	16	0.01	**
Invited as a special guest to present?	17.5	6	0.01	**
Papers published in S.A journal	15.7	16	0.47	
Papers published in overseas journal	38.3	16	0.01	**
Number of popular science articles in S.A journals	13	14	0.52	
Number of popular science articles in overseas journals	15.6	10	0.11	
Evaluated by FRD?	10	2	0.01	**
FRD Grade	23.6	12	0.02	*
A rated Scientists in your Institution?	43.9	4	0.01	**
Your work in last 5 years influenced by S.A scientists?	8.7	8	0.37	
Motivation to be A grade by having one in institution	16.4	8	0.04	*
Institute prestige affected by number of postgraduates?	8.3	8	0.4	
Supervised students in last 5 years?	2.9	4	0.58	

Appendix G

Multiple Comparisons

Bonferroni

Dependent Variable	(I) VAR00003	(J) VAR00003	Mean Difference (I-J)	Std. Error	Sig.
V15A	1.00	2.00	.2446	.263	1.000
		3.00	5.095E-02	.322	1.000
	2.00	1.00	-.2446	.263	1.000
		3.00	-.1936	.354	1.000
	3.00	1.00	-5.0952E-02	.322	1.000
		2.00	.1936	.354	1.000
V15B	1.00	2.00	.4989	.210	.056
		3.00	.2662	.257	.904
	2.00	1.00	-.4989	.210	.056
		3.00	-.2327	.282	1.000
	3.00	1.00	-.2662	.257	.904
		2.00	.2327	.282	1.000
V16A	1.00	2.00	1.0422*	.425	.046
		3.00	-.1914	.520	1.000
	2.00	1.00	-1.0422*	.425	.046
		3.00	-1.2336	.571	.097
	3.00	1.00	.1914	.520	1.000
		2.00	1.2336	.571	.097
V16B	1.00	2.00	1.0000*	.286	.002
		3.00	.4300	.351	.666
	2.00	1.00	-1.0000*	.286	.002
		3.00	-.5700	.386	.424
	3.00	1.00	-.4300	.351	.666
		2.00	.5700	.386	.424
V17	1.00	2.00	.7457*	.253	.011
		3.00	.2548	.309	1.000
	2.00	1.00	-.7457*	.253	.011
		3.00	-.4909	.340	.453
	3.00	1.00	-.2548	.309	1.000
		2.00	.4909	.340	.453
V18	1.00	2.00	1.1093*	.299	.001
		3.00	.6348	.366	.255
	2.00	1.00	-1.1093*	.299	.001
		3.00	-.4745	.402	.720
	3.00	1.00	-.6348	.366	.255
		2.00	.4745	.402	.720
V19	1.00	2.00	2.1504*	.424	.000
		3.00	.4195	.519	1.000
	2.00	1.00	-2.1504*	.424	.000
		3.00	-1.7309*	.570	.009
	3.00	1.00	-.4195	.519	1.000
		2.00	1.7309*	.570	.009
V20	1.00	2.00	.2175	.108	.138
		3.00	1.571E-02	.132	1.000

Multiple Comparisons

Bonferroni

Dependent Variable	(I) VAR00003	(J) VAR00003	Mean Difference (I-J)	Std. Error	Sig.
V20	2.00	1.00	-.2175	.108	.138
		3.00	-.2018	.146	.503
	3.00	1.00	-1.5714E-02	.132	1.000
		2.00	.2018	.146	.503
V21	1.00	2.00	.6028	.371	.318
		3.00	.2419	.454	1.000
	2.00	1.00	-.6028	.371	.318
		3.00	-.3609	.499	1.000
	3.00	1.00	-.2419	.454	1.000
		2.00	.3609	.499	1.000
V22	1.00	2.00	2.2208*	.447	.000
		3.00	1.9271*	.547	.002
	2.00	1.00	-2.2208*	.447	.000
		3.00	-.2936	.601	1.000
	3.00	1.00	-1.9271*	.547	.002
		2.00	.2936	.601	1.000
V23	1.00	2.00	.2749	.282	.992
		3.00	4.762E-02	.345	1.000
	2.00	1.00	-.2749	.282	.992
		3.00	-.2273	.379	1.000
	3.00	1.00	-4.7619E-02	.345	1.000
		2.00	.2273	.379	1.000
V24	1.00	2.00	-.2392	.144	.299
		3.00	.2381	.177	.539
	2.00	1.00	.2392	.144	.299
		3.00	.4773*	.194	.045
	3.00	1.00	-.2381	.177	.539
		2.00	-.4773*	.194	.045
V25A	1.00	2.00	.2911*	.090	.005
		3.00	.1348	.111	.676
	2.00	1.00	-.2911*	.090	.005
		3.00	-.1564	.122	.602
	3.00	1.00	-.1348	.111	.676
		2.00	.1564	.122	.602
V25B	1.00	2.00	1.0725*	.335	.005
		3.00	.8152	.410	.145
	2.00	1.00	-1.0725*	.335	.005
		3.00	-.2573	.450	1.000
	3.00	1.00	-.8152	.410	.145
		2.00	.2573	.450	1.000
V26	1.00	2.00	.6894*	.115	.000
		3.00	.6667*	.141	.000
	2.00	1.00	-.6894*	.115	.000
		3.00	-2.2727E-02	.155	1.000

Multiple Comparisons

Bonferroni

Dependent Variable	(I) VAR00003	(J) VAR00003	Mean Difference (I-J)	Std. Error	Sig.
V26	3.00	1.00	-.6667*	.141	.000
		2.00	2.273E-02	.155	1.000
V27	1.00	2.00	1.948E-02	.270	1.000
		3.00	.3286	.330	.964
	2.00	1.00	-1.9481E-02	.270	1.000
		3.00	.3091	.363	1.000
	3.00	1.00	-.3286	.330	.964
		2.00	-.3091	.363	1.000
V34	1.00	2.00	.1234	.106	.741
		3.00	.1643	.130	.624
	2.00	1.00	-.1234	.106	.741
		3.00	4.091E-02	.143	1.000
	3.00	1.00	-.1643	.130	.624
		2.00	-4.0909E-02	.143	1.000
V34B	1.00	2.00	-.1721	.540	1.000
		3.00	-1.5714E-02	.661	1.000
	2.00	1.00	.1721	.540	1.000
		3.00	.1564	.726	1.000
	3.00	1.00	1.571E-02	.661	1.000
		2.00	-.1564	.726	1.000
V29	1.00	2.00	.5779*	.151	.001
		3.00	.2343	.185	.620
	2.00	1.00	-.5779*	.151	.001
		3.00	-.3436	.203	.278
	3.00	1.00	-.2343	.185	.620
		2.00	.3436	.203	.278
V33	1.00	2.00	.1461	.196	1.000
		3.00	.3343	.239	.494
	2.00	1.00	-.1461	.196	1.000
		3.00	.1882	.263	1.000
	3.00	1.00	-.3343	.239	.494
		2.00	-.1882	.263	1.000

*. The mean difference is significant at the .05 level.

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