CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

Publication productivity is not a new and novel subject of scientific research. Early studies examining faculty research performance began in the 1940s and 1960s, and bibliometrics was used as a tool to assess the research productivity of individual scientists, departments or institutions in the mid-seventies (Zainab, 1999). A large number of literature in this study were obtained from *LISA Plus (Library and Information Science Abstract)* CD-ROM version (1969-1999) and *Dissertation Abstracts Ondisc* by using keywords for retrieval such as research productivity, publication productivity, bibliometrics and authorship. A total of 265 related titles were finally selected and entered into a Microsoft Access database. These literature consist of 253 (95.5%) journal articles, 6 (2.3%) conference papers and 4 (1.5%) doctoral dissertations. In terms of chronological category, 193 (72.8%), 59 (22.3%) and 13 (4.9%) publications were dated 1990-1999, 1980-1989 and 1970-1979 respectively. This distribution reveals that the vast majority of studies were undertaken during the 90's. Figure 2.1 indicates in detail the distribution of publications during 1974 and 1999. The peak year in production was 1996.

A total of 63 journal titles published the 253 articles. The biggest contributor was *Scientometrics*, with an overwhelming 101 (39.9%) articles, followed by *Malaysian Journal of Library & Information Science* (ranked second) with 14 (5.5%) articles. *Journal of the American Society for Information Science* and *Revista Espanola de*

Documentacion Cientifica (in Spanish) (ranked third) with 9 (3.6%) articles each. *IASLIC Bulletin* and *Journal of Information Science* carried 8 (3.2%) scientific papers each. Seven (2.8%) academic works were from *Annals of Library Science and Documentation*. The five groups (sixteen titles) of moderately contributive journals accounted 6 (2.4%), 5 (2.0%), 4 (1.6%), 3 (1.2%) and 2 (0.8%) articles each. The rest thirty-nine journals contributed just one article each. Table 2.1 shows the distribution of journal articles and indicates that 24 (38.1%) main journals contributed 214 (84.6%) articles on the topic being studied. Table 2.2 indicates the most productive individual writers. They were: A. N. Zainab, A. Schubert, B. K. Sen, B. M. Gupta, T. Braun, V. L. Kalyane, B. S. Maheswarappa, C. R. Karisiddappa, I. Gomez and W. Glanzel.

Figure 2.1: Distribution of Publications Since 1974

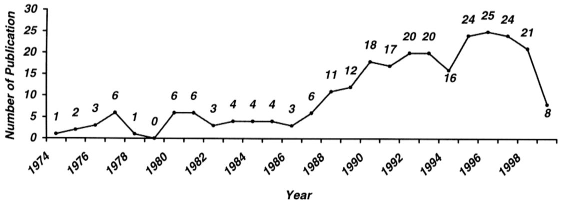

Table 2.1: Distribution and Percentage of Journal Articles on Research Productivity

Groups	Journal Titles	Number of Published Articles (%)
1	*Scientometrics*	101 (39.9)
2	*Malaysian Journal of Library & Information Science*	14 (5.5)
3	*Journal of the American Society for Information Science*	9 (3.6)
	Revista Espanola de Documentacion Cientifica	9 (3.6)
4	*IASLIC Bulletin*	8 (3.2)
	Journal of Information Science	8 (3.2)
5	*Annals of Library Science and Documentation*	7 (2.8)
6	*Library and Information Science Research*	6 (2.4)
	Nauchno-Tekhnicheskaya Informatsiya	6 (2.4)
7	*Information Processing & Management*	5 (2.0)
	Ciencia da Informacao	5 (2.0)
8	*Bulletin of the Medical Library Association*	4 (1.6)
	College & Research Libraries	4 (1.6)
	International Forum on Information and Documentation	4 (1.6)
9	*Australian Academic and Research Libraries*	3 (1.2)
	Journal of Documentation	3 (1.2)
	Journal of Education for Library and Information Science	3 (1.2)
	Kekal Abadi	3 (1.2)
10	*Behavioral and Social Sciences Librarian*	2 (0.8)
	International Information and Library Review	2 (0.8)
	International Library Review	2 (0.8)
	Library Research	2 (0.8)
	Probleme de Informare si Documentare	2 (0.8)
	Revista da Escola Biblioteconomia da UFMG	2 (0.8)
11	Others	39 (15.4)
12	Total	253 (100)

Table 2.2: The Top Ten Most Productive Authors in the Field of Publication Productivity

Name	Number of Publications	% n=265	Year of Publications
A. N. Zainab	10	3.8	1994, 1995, 1996, 1997, 1997, 1997, 1997, 1998, 1999, 1999
A. Schubert	7	2.6	1985, 1989, 1990, 1991, 1991, 1992, 1992
B. K. Sen	6	2.3	1992, 1995, 1996, 1996, 1996, 1998
B. M. Gupta	6	2.3	1997, 1997, 1998, 1998, 1998, 1999
T. Braun	6	2.3	1990, 1991, 1992, 1992, 1993, 1996
V. L. Kalyane	6	2.3	1994, 1995, 1995, 1995, 1996, 1998
B. S. Maheswarappa	5	1.9	1987, 1988, 1990, 1990, 1996
C. R. Karisiddappa	5	1.9	1990, 1997, 1997, 1998, 1998
I. Gomez	5	1.9	1986, 1992, 1996, 1997, 1999
W. Glanzel	5	1.9	1985, 1990, 1991, 1996, 1997

Methodology Used to Evaluate Research Productivity

Evaluation of scientific work is essential because the value of the results is never self-evident. There is, however, no single simple formula for carrying out evaluation. Appropriate indicators have to be selected to suit the particular requirements of each individual case. Moravcsik (1989) outlined some of the chief types of indicators that can be used, such as productivity and progress; quality and impact; micro and macro indicators; quantitative and qualitative indicators. Other widely used evaluation methods are citation analysis and peer review. Above all, evaluation must be carried out regularly and perceptively. The 'view from afar' based exclusively on information drawn from international databases does not accurately reflect the population of researchers or domestic productivity in less developed countries (Shrum, 1997). Makino (1998) suggested that widely used quantitative measures of productivity do not give a meaningful measure for the actual contribution of a research group to science.

Bibliometric measures of productivity

Bibliometric measures have been actively used to measure research productivity. Bibliometrics has been defined as a quantitative and analytical method for discovering and establishing functional relationships between biodata and bibliodata elements. Bibliometric indicators if applied properly may give useful information on the research performance and nature of research carried out in university departments (Zachos, 1991). Arenas (1992) combined the most widely used bibliometric indicators for research evaluation which includes publication count and citation analysis which are used to determine the degree of production, productivity, and impact.

publications as a measure of research productivity is to arrive at a valid definition of what constitutes a publication.

Schwarz, Schwarz and Tijssen (1998) studied the research output of the Danish Technical University as an aspect of the organization's research policy and visibility in its international context. They proposed that, by using citation analysis techniques, the dynamics of citation frequencies and a number of other features of the research system (for example self-citation, research collaborations and relative impact on the international literature) can be used to analyze institutional and national research efforts and to monitor effects of changing policies.

Citations as a measure of productivity in industrial research are not valid since much of industrial research is never reported in the primary or secondary literature. The ability to obtain widely differing results in a small citation study casts doubt on the value of citation analysis in providing data for science policy decisions (Pragier and Ronayne, 1975).

Rinia, Lange and Moed (1993) presented a study of Dutch publication output in physics in which methods of delimitating fields by journal categories in the *Science Citation Index* were tested compared with the classification of individual publications into subfields in the subject specific database *Physics Briefs*. In most fields in physics the method which delimits fields by journal categories yielded an incomplete picture of the output of a country. Integer counted world shares was highly influenced by the degree of internationalisation. First author counting gave a satisfactory approximation of fractional counting. Citation indicators based on first author counting might be distorted in fields with a large fraction of international co-authored publications.

Nagpaul (1995) examined the contribution of Indian universities to the mainstream scientific literature during 1987 to 1989 along 2 distinct, but interrelated dimensions of quantity and quality of research output. The quantity of output is assessed through the number of articles published in journals covered by *Science Citation Index*, while the quality of output is assessed through the impact factors of journals in which the articles are published.

Taylor (1980) investigated a comprehensive file of bibliographies published during the period 1974 and 1978 in terms of subject scope, authorship patterns, type of publisher, format, contents and price in order to provide some statistical indicators of U.K. publishing activities.

Sudhier (1997) reported results of a quantitative study of the characteristics and behavior of scientific research output in Kerala, India, during the period 1979 and 1994, in order to determine the growth rate of literature, ascertain subject wise distribution of publications, authorship pattern, relative contribution of institutions, and compare research works of universities and scientific productivity of different districts in the state.

Gupta and Karisiddappa (1997) analysed the frequency distribution of the scientific productivity of authors active for the same length of time in the speciality of theoretical population genetics, focusing on 2 aspects: the duration of the authors' participation in the total research output and the speed at which they are able to produce their research publications.

Quantitative measures of productivity has indicated that scientific productivity is constant as a scientist's age. An economic model of the life-cycle productivity of scientists was presented which implies that the number of citations made to a scientist's previous work would decline with age. The implication could be consistent with the finding of constant quality output which declines with age (as measured by number of citations per article) (Diamond, 1984).

A postulated model of scientific productivity asserts that 1/2 of all scientific papers in a field are contributed by a few highly productive authors numbering approximately the square root of the total of scientific authors. Additional data drawn from other studies suggest that the most productive authors produces an average of 25% of the total papers (Coile, 1977). An early research which involved 38 Asian rice breeders indicated that the distribution of publication productivity was the same as that found among scientists in the highly developed nations. Fifty percent of the scientific papers published in the 2 years were authored by only 6 breeders, roughly the square root of the sample of 38 breeders (Hargrove, 1980).

Collaboration and productivity

Scientific research is becoming an increasingly collaborative endeavor. The nature and magnitude of collaboration vary from one discipline to another. Earlier studies have shown a high degree of correlation between collaboration and research productivity, and between collaboration and financial support for research. Bibliometrics offers a convenient and non-reactive tool for studying collaboration in research (Subramanyam, 1983).

The collaborative activities have been investigated from a broad international macro level to the individual micro level. The significance for modern scientific practice is mainly based on networking just as much as it is a collection of data or writing of texts. Research is generally co-authored and the average number of authors of a scientific article is now close to four. The sole researcher is no longer the relevant producer of ideas and discoveries, it is instead the team or possibly an individual operating within a network (Melin, 1997). The scientific and technical potential of an organization is reflected in its production of research reports (Arutyunov, 1997). Pao (1980), refining and applying the entropy measure for information for determining the contribution made by authors in a communication system, found highly collaborative authors to be highly prolific.

Narvaez-Berthelemot (1995) used an index developed to measure international collaboration by taking into account individual institutional participation and which showed a positive increase in the productivity of research for the countries covered. Results indicated variations in the degree of institutional participation between fields and countries. By giving weight to individual institutional participation, scientists could be motivated to enhance their role in international science in the region. The index discussed could be developed as a `quality indicator' of national institutional performance.

Bordons, Gomez, Fernandez, Zulueta and Mendez (1996) used bibliometric indicators to analyze international, domestic and local collaboration in publications of Spanish authors in 3 biomedical subfields: neurosciences, gastroenterology and cardiovascular system as covered by the Science Citation Index database. Team size, visibility and basic applied level of research were analyzed according to collaboration scope. International collaboration was linked to higher visibility documents. Cluster analysis of the most productive authors and center provided a description of collaboration habits in the 3 subfields. A positive correlation was found between productivity and international and domestic collaboration at the author level.

Gupta and Karisiddappa (1998) analyzed the growth of funded and collaborative research publications and authors as reflected in selected theoretical population genetics literature from 1956-60 to 1976-80. The analysis indicated that the number of funded and collaborated publications had not proportionally increased along with the growth of total research publications and authors with time, but however, there was a strong correlation between the two. Results displayed the extent of multi authored research publications in different countries.

Budd (1995) employed rank order correlation to examine relationships between the variables and goodness of fit tests are used to test hypotheses regarding the relationship between the publishing data and the other variables. Although results indicated some relationship between publishing activity and other variables, he recommended that care be taken not to impart too much significance to these relationships since their dynamic interactions are still not fully understood.

Nederhof and Wijk (1997) introduced a method to identify and map the internationally most visible research topics occurring in the social and behavioral sciences, as well as the topics that changed most over a decade. Keywords used by authors in scientific or scholarly publications provided a window on scientific developments and changes in scientific research. It was shown that the maps, enriched with scientometric indicators of strengths and weaknesses of national research efforts, could be important tools for science policy. The findings indicated that the research front on many topics in both social and behavioral sciences was international in the late 1980s.

Authorship patterns and productivity

Sen and Gan (1990) argued that the science and technology situation of a country, organization or subject field is best understood through the study of more important personalities engaged in research and development. Studying the functional relationships between the biodata elements and the bibliodata elements may reveal the activity of scientists (and technologists) and their social correlations.

Harsanyi (1993) considered the methodological impact of various ways of allotting `credit' for multi authored works and the relationships between multiple authorship and other publication variables, such as quality and impact in the field of library and information science. Given the complex relationship between collaboration and productivity, the concomitant use of non-bibliometric methods of studying collaboration, as well as the application of meta-analysis, was suggested.

A large number of studies have been conducted to analyse and interpret the trends in authorship in different disciplines. The study of authorship clearly relates to collaborative research activities which has resulted in a corresponding increase in multiauthored papers and a decrease in single authored papers. The increase in multiauthorship and collaboration between researchers is an indication of growing professionalism in different fields of science. Arora and Pawan (1995) analysed the authorship pattern in articles on immunology and the correlation between the number of authors associated with the publication of an article and its citedness. They inferred initially that the citedness of an article was presumed to increase with the increase in the number of collaborating authors associated with it, but stated that results of an analysis dictated otherwise.

Vimala and Reddy (1996) investigated the trends in the pattern of authorship and collaborative research in Zoology. Specific aims of the study were: to examine the nature of authorship patterns in the zoology literature, to determine the proportion of single versus multi-authored papers, and to determine the degree of collaboration and average number of authors per paper. Although multiple authorship was found to be dominant, solo research also exists. The proportion of single authored papers showed a declining trend during the period 1901-1995. They predicted that the proportion of single authorship was likely to be insignificant after 2030. Multi-authored papers accounted for 75 per cent of the total cited papers and the degree of collaboration had increased from 0.0 during 1901-1905 to 0.95 during 1991-1995.

However, O'Neill (1998) examined authorship patterns in 2 theory-based journals, *Educational Theory* from 1955 to 1994 and *Journal of Educational Thought* from 1970 to 1994. Results revealed that the majority of authorships were single in both journals regardless of the date of publication. These findings challenged predictions that co and multiple authorships would eventually outnumber single authorships.

Factors Influencing Publication Productivity

Koenig (1990) compared the 4 most highly productive US based pharmaceutical companies with the 4 least productive of comparable size (in terms of R & D budgets). The more productive companies were found to be characterized by: greater openness to outside information; less concern with protecting proprietary information; greater information systems development effort; greater end user use of information systems; greater technical and subject sophistication of the information services staff; relatively unobtrusive managerial structure and status indicators in the R & D environment.

Gupta, Kumar, Khanna and Amla (1999) reported results of a study of the two types of research output, research papers and patents, of scientists working in the Council of

Scientific and Industrial Research (CSIR) varying in chronological age and professional age in India. In all the cases when the entire range of age is considered, a non-linear relationship between lifetime productivity and professional and chronological age emerges. In the case of patents, lifetime productivity and achievement increases with age but in the case of research papers it eventually falls. The productivity of the scientists in the beginning of their career is slow in the case of patents compared to the research papers. Productivity of scientists in research papers reaches its peak between 26 and 30 years of experience then falls of after their late 50s. In the case of patents, lifetime productivity continues to increase with professional age.

Studies of stratification in science have increasingly accepted the idea that science is a highly stratified and elitist system with skewed distributions of productivity and rewards. Knorr and Mittermeir (1980) attempted to explain the higher productivity of higher status scientists by pointing to their greater ease of publication as far as acceptance of their work by journals. Position within a research organisation does confer greater ease of author or co-authorship; this is the major explanatory variable accounting for productivity differences within research laboratories.

Empirical studies showed that the output of a scientific or technical research group maybe directly proportional to its size. However, theoretical explanations for the proportionality between size and output were largely inadequate or untested. Similarly, among reported results on group age and output, the only consistency was that age is uncorrelated with output per capita. Again, there was no evidence for the existence of an age or a range of ages for a research group that was optimal (Cohen, 1991). There was no correlation between scientific productivity and numbers of scientists in a center but there was a significant positive correlation between scientific productivity and budget, indicating higher efficiency in the larger centers (Maclean and Janagap, 1993). The number of all publications of a research group in a year and the number of primary research publications of a group in a year were approximately proportional to the number of individuals in that group during the year (Cohen, 1980).

Qurashi (1993) presented studies investigating the dependence of per-capita research output of a group of research workers and on the size of the group. The per capita research output of various research groups and institutes in the USA, UK, Pakistan and Bangladesh showed an initial linear rise, followed by one or more maxima, the first one being a group size of 6 to 8 people.

Crewe (1988) found that: departmental per capita publication rates vary enormously; a department's relative productivity is strongly correlated across all types of publication; a few departments are substantially more productive than the rest. Among highly productive departments, one can usefully distinguish between those with 'collective' and those with 'individual' strength and a department's productivity was not related to its size. Wilson (1996) reviewed the different elements of research that needed to be monitored by research funding agencies and organizations, including: project management; methodological effectiveness; financial management; staffing; modes of delivery of results; research evaluation; research productivity (targeting, variety, volume). He examined the problems and possibilities of research into the impact of research with particular reference to a BLRD (British Library Research and Development Department) research project which used a variety of techniques to explore the impact of 3 research projects undertaken at Sheffield University. He concluded that the knowledge diffusion process should involve multiple channels of diffusion and publication must not be restricted to the scholarly literature of the field.

Matzinger-Tchakerian (1996), in her Ph.D. dissertation, evaluated higher education sectors of 23 members states of the Organization of Economic Cooperation and Development (OECD) in terms of their human and financial resources, the extent of their administrative and financial decentralization, the extent of their system-wide, institutional, and programmatic diversity, and the extent of their communication networks. Three measures of scientific research productivity in higher education between 1985 and 1994 were examined. The first two measures drew on *Science Citation Index* data and counted the number of publications per scientist in leading journals that emanate from each country's higher education sector. The third measure is a count of the number of Nobel laureates per scientist who emanate from each country's higher education sector. R&D expenditure per scientist – one indicator of a sector's financial resources – was found to be the most important determinant of research productivity. Decentralisation of higher education was also found to be a critical influence on research productivity. The lack of administrative decentralisation is particularly important in explaining the performance of countries that fall below expected levels relative to their R&D expenditure. The overall level of decentralisation in higher education – combining both administrative and financial decentralisation – was found to be conducive to pathbreaking research, as reflected in winning the Nobel prize.

Research productivity of scientists is affected by 11 factors, i.e., persistence, resource adequacy, access to literature, initiative, intelligence, creativity, learning capability, stimulative leadership, concern for advancement, external orientation, and professional commitment (Babu and Singh, 1998). Prpic (1996) pointed that the most important predictors of the `elite's' productivity are variables such as academic qualification and a conducive environment.

Research Productivity in the Fields of Computer Science and Information Technology

A moderately strong positive correlation between the number of papers published by each author and the number of subfields of computer science in which these papers were published was found. Subramanyam (1984) investigated 419 authors drawn from a 4-year cumulative author index of *Computer and Control Abstracts* and found that research productivity and breadth of research interest of computer scientists appear to be directly related. It also appeared that computer scientists have a more diversified research interest within their own field than environmental scientists who tended to work consistently in a well-defined subfield of their discipline. However, a follow-up to the above study (Eastman, 1989) found no relationship between research productivity and breadth of interest.

Nath and Jackson (1991) examined 899 management information system research articles published in 10 periodicals between 1975 and 1987 and found that while Lotka's Law relating to the number of authors of papers written by each author does not apply, a generalized version of Lotka's Law, referred to as the inverse-power law fits remarkably well.

Rodriguez (1994) presented a discussion based on statistical data concerning information technology and research and of the barriers which inhibit the development of information technology (defined as the use of computers and telecommunications to organize, store, manipulate, and disseminate information) in Latin America and the Caribbean at the national and regional levels. He described some of the options open to developing countries such as: development and enforcement of national or regional policies on information technology; development of national policies on research priorities for information technology; design of educational programs to enhance and supplement manpower resources and increase efficiency and productivity at all levels; and promote linkages between users and researchers in both the private and public sectors, both regionally and nationally.

Cunningham and Dillon (1997) examined the patterns of multiple authorship in 5 information systems journals. Specifically, they determined the distribution of the number of authors per paper in this field, the proportion of male and female authors, gender composition of research teams, and the incidence of collaborative relationships spanning institutional affiliations and across different geographic regions.

Research Productivity in Southeast Asian (ASEAN) Countries

Davis and Eisemon (1989) described the mainstream scientific output of the scientific communities of 4 newly industrializing Asian countries (Malaysia, Singapore, South Korea, and Taiwan) and considered its adequacy for describing local scientific activities in biochemistry, biology, physics, electrical engineering, and computer science. They also examined non-mainstream scientific literature in these specialities. It was shown that a high proportion of non-mainstream authors also published in mainstream literature.

At two research institutes of Indonesia: Central Research Institute for Food Crops (CRIFC) and Central Research Institute for Estate Crops (CRIEC), Handayani (1995) used quantitative and qualitative research techniques to describe how 152 scientists choose research problems, how organizational structure influences the process of knowledge production, how organizational structure creates feelings of alienation, and how socio-demographic characteristics and organisational structure influence publication productivity.

A scientometric analysis of papers published over a 2-year period from the 5 ASEAN Countries, Indonesia, Malaysia, Philippines, Singapore and Thailand, and covered in *Science Citation Index* 1979 and 1980, and citations to them in the international literature of science as seen from SCI 1979-1983 revealed that despite the relative economic affluence, science in these countries is still on the periphery. Except in the Philippines, the thrust in these countries seems to be in medical research as is evident from the large number of papers published in medical journals. In the Philippines, medicine comes a close second to agriculture (Arunachalam and Garg, 1986).

Abdullah (1995) reported results of a bibliometric analysis of scientific publications from Southeast Asian (ASEAN) countries which indicated a high degree of knowledge dependence upon English language publications from the UK and USA. Technology information through patents registered in Malaysia also indicates only a small number of Malaysian patents, with a high citation rate to US patents. She concluded that the provision of bibliographic access to current, local, scholarly information needs to be upgraded and there is an urgent future need for ASEAN nations to focus on the production of scientific and technical knowledge in order to be on a par with other industrialised countries.

Summary

The literature retrieved indicates that studies on publication productivity of Malaysian scientists in the fields of computer science and information technology is lacking. This situation points clearly the significance and urgency of such a study to fill in the gaps in the above-mentioned field of study. The current study attempts to offer a few commonplace remarks by way of introduction so that others may come up with valuable opinions.