

**PERSONAL, ACADEMIC AND DEPARTMENTAL CORRELATES OF
RESEARCH PRODUCTIVITY : A REVIEW OF LITERATURE**

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ABSTRACT:

Reviews published sources on research productivity under two broad categories, general measures of research productivity and correlates of publication productivity. The latter cover studies on three broad determinants comprising (1) personal, (2) academic, (3) and departmental correlates considered to be related to academic publication productivity.

Keywords: Research productivity; publication productivity; correlates of productivity, scientometrics.

RESEARCH PRODUCTIVITY

Research is an important academic activity and is expected of every faculty member. The assessment of research may take the form of an input-output process (Moracsik, 1985). The inputs constitute manpower (qualified lecturer and professors, percentage of time spent on research, number of research students, number of support staff); institutional resources (supportive administration, laboratories, libraries, electronic support facilities); and financial resources. The outputs of research are more complex comprising intangible outcomes such as new scientific knowledge and awareness of new methodologies, in the form of theories and empirical findings. The tangible output are research findings which are published (research report or publication in refereed journals which has attained national or international recognition) or communicated (presentation at conferences); and finished products (patented inventions or trained and qualified researchers). The

outcome of research comes in varying forms of recognition conferred to the researcher on the basis of his contribution to his field of research which comprises; citations, positive ratings and rankings by peers, award of honors and prizes. Published research findings are the most common tool used to assess the output of research. As aptly described by Ramsden (1994):

“The most critical indicator of research productivity is publication. Widely regarded as the main source of esteem, as a requirement for individual promotion, as evidence of institutional excellence, as a sine qua non for obtaining competitive research funds, publication is central to scholarly activity and recognition. Indeed, it can be argued that research work only becomes ‘a work’ in the academic world when it takes the conventional, physical form of a published paper or its equivalent, and that the most fundamental social process of science are the communication and exchange of research findings and results... In the culture of the university, it seems, academic distinction and publications go together”.

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Bibliometric analysis is the term used when handling quantitative analysis of published bibliographic data. The bibliographic data of published research are extracted from scientific indexes, abstracts, bibliographies and databases such as the *Science Citation Index* produced by the American Institute for Scientific Information. Creswell (1985) reported that early studies examining faculty research performance began in the 1940s and 1960s as exemplified by Wilson (1942), Westbrook, (1960), as well as Pelz and Andrews (1966). Example of studies which saw the potential of using bibliometric data as a tool to assess the productivity of individual scientists, departments or institutions are Wade (1975), Martin and Irvin, (1983) Irvin and Martin (1985), Moed, et al. (1983) and DeBruin et al. (1993).

Quantity of publications refer to the number of publications produced by an individual or group of scientists, departments or institutions. A number of studies have used the quantity of publication to assess publication productivity (Blackburn, Behymer and Hal, 1978; Braun, Glanzel and Schubert, 1990; Budd, 1995). A widely used instrument to gather publication data is the questionnaire. Allison and Stewart (1974) found that self-reported response from chemists was correlated with publication counts obtained from *Chemical Abstracts* ($r = .94$).

Although publication counts have been widely used as a partial indicator of productivity, there are problems associated with its use. These include: co-authors are given the same amount of credit as a solo author; a short paper is counted the same as a long one; no distinction is made be-

tween a poor and an excellent paper or between an original or repetitive work (Knorr, 1979). Martin and Irvin (1983) pointed out that the relationship between total publication and scientific progress was not straightforward as some 'mass producer' of publications, made very little scientific progress, while other 'perfectionists' achieved few publications which may be a significant scientific contributions. A simple count therefore, may provide a measure of scientific production but not scientific progress. Martin and Irvin further suggested that publication counts could be used to compare individual or small group performances provided the subjects are carefully matched. Previous studies have indicated a correlation between the quantity, quality of publications and ratings by peers (Pelz and Andrews, 1966; Cole and Cole, 1967). Lawani (1986) assessed 279 papers from the 1975/76 volumes of the *Yearbook of Cancer* published in serials covered by the *SCI* and found positive correlation between the quantity and quality of research productivity. Lawani suggested that the more research a person does the better researcher he becomes and the more familiar he gets with the demands of the literature in his field. This led to the situation where the producer of quality also becomes a producer of quantity. Cole and Cole (1967) also suggested that where citation counts are not readily available especially for countries which are not adequately or not at all represented in the *SCI* – publication counts are roughly adequate as indicators of the significance of a scientist's work.

Currently more studies are using multiple indicators in the assessment of basic research. Martin (1996) surveyed the me-

thods used by articles submitted to 12 issues of *Scientometrics* (volumes 31-34) published between 1994-1995 compared with 12 issues published between 1988-1989 (volumes 14-15). The survey indicated that in the earlier studies, 38 out of 54 (70%) of papers used one or two indicators and only 2 used five indicators. In the later years 43 out of 67 (64%) used one to two indicators and only 1 study used eight distinct methods. The proportion of papers using three or more indicators was not significantly greater than that in 1988-1989. The most common indicator used was publication (72 out of 121 papers, 70%), followed by citation counts (38, 32%). Academics' views were also sought about the indicators used. Not surprising, 86% supported the peer review process, 41% favoured the inclusion of international peers in the review process, 64% preferred the use of publication counts, 70% rated positively on weighting publications according to the status of the journals in which articles appear. Overall, the majority favoured a combined approach. Martin suggested that publication and citation counts continue to be popular because it was comparatively cheaper to carry out than the peer review process.

The studies related above indicated that a large number of measures have been used to assess scientific quality. However the two most used quality indicators are publication and citation counts. Most of the studies take the form of raw counts or averages while some have devised weighting schemes to improve both raw publication and citation counts. Since publication is the standard way of communicating research findings, it is widely considered an appropriate measurable instrument of a scientist's performance (Sonnert, 1995).

THE DETERMINANTS OF RESEARCH PRODUCTIVITY

Generally, a number of determinants have been used to explain research productivity. This review article focuses on three types of determinant used in previous studies which comprises the (1) personal; (2) academic; (3) and departmental correlates.

(1) Personal Correlates

Personal correlates are considered important by academics (Behymer, 1974). Woods (1990) interviewed 53 academic staff from Australian universities and sought their opinion on the determinants of research performance and the importance of individual autonomy. The study found that academic research activity is highly influenced by a number of personal variables, such as research styles and the freedom of inquiry (the choice of research topics). The personal correlates considered in studies are gender, age family background and personality traits.

(a) Gender

Three issues are recurrently indicated in studies investigating gender and publication productivity and these are: (a) men publishes more than women; (b) there are differences in publication productivity between married and unmarried women and (c) the gap in the publication performance between the genders is narrowing.

Men publish more than women - Early studies reported that men publish more than women. Babcock and Bates (1962) studied 262 sociologists and found that there were more women in the low publication group. Austin (1969) carried out a survey for the American Council on Edu-

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cation and indicated that 26% of the women and only 10% of the men never published in journals. Fulton (1974a; 1974b) analysed data from the 1969 survey and found that academic men in general have published 2.5 times as much as the academic women. The ratio differed among the seven disciplines (physical sciences, social sciences, new professions, education, humanities and others). In the same year, Blackburn, Behymer and Hall (1978) found that the men are three times more likely than women to have published 11 or more articles during their careers and 5 or more articles in a 2 year period, irrespective of academic discipline. Cole (1979) found that men published more or get more citations than women but cannot clearly ascertain why this was so. Six years later, Cole and Zuckerman (1984) studied 526 scientists and found the men were more prolific writers than the women. On average the men published 40% to 50% more papers than their female counterparts. An Indonesian study (Waworuntu, 1986a; 1986b) found that the male academics appeared to be more productive and gender was significantly related with total raw and weighted publication score. Kyvik (1990a; 1990b) reported a survey by Franklin (1988) who studied scientific research in the European Economic Community. The European study reported that women researchers published on average five articles in a three-year period in contrast to eight papers by the male scientists. Kyvik (1990a; 1990b) who sampled the assistant professors and professors found that on average men published 5.0 article equivalents in the three-year period (1979-1981) while the women published 3.5 (30%) fewer articles.

Married and unmarried women academics - A number of studies indicated that married women are likely to be more productive than unmarried women. Simon, Clark and Galway (1967) reported that married women with Ph.D., holding full-time positions published more on average than either single women or men. Cole and Zuckerman (1987) carried out a longitudinal study of American natural and social scientists and showed that married female researchers with children published more per year during the course of their career than the unmarried female researchers. Married Finish female academics are also more productive than their single counterparts (Luukkonen-Gronow and Stolte-Heiskanen (1983). In contrast, Hamovitch and Morgenstern (1977) found that married American academics with children are not significantly more productive than those unmarried and found productivity differences are least in the natural sciences. In Norway, Kyvik (1990b) found that (a) married and divorced persons are more productive than single persons (applies to both men and women); (b) women with children are more productive than those without children; (c) women with more than two children are less productive than those with only one and (d) women who have children under 10 years old produce 47% less publications than their male colleagues in the same position or those with older children. The study gave possible explanations for this situation: (a) married women may have more energy and stamina than women without children; (b) get support from their husbands; (c) experience a more stable social life; (d) family life increases their self-respect; (e) and being married neutralized the effect of sex

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since married women cooperate more with their male colleagues than unmarried women.

Why women academics are less productive - Several reasons have been put forward to explain why women appear to be less productive than their male colleagues. Guyer and Fidell (1973) proposed that male academics engaged in theoretical research rather than applied research, which needed considerably more time to publish. Reskin (1978a;1978b) indicated that women responded differently to the citations they receive. They needed more encouragement than men, to set their publication targets. Cole and Zuckerman (1984) gave the following possible reasons: women published less than men because they were more isolated and do not have “the old boys” network. They agreed with Reskin that women were easily discouraged by the varying degree of citations to their work. Furthermore family obligations prevented women from spending as much time on research as men. The correlates that work for men and women academics are not the same as women have less opportunity than men, to utilise more time to their research. Other reasons put forward were; (Garland and Rike, 1987) women were less interested in research, generally graduate from less prestigious institutions, held lower rank posts, taught undergraduate courses and were found more in the humanities and less in the natural sciences. Even though studies in general indicated that men out-publish women when comparisons were made between the genders, gender differences (academic rank and disciplines, differing ages, and types of academic institutions) were reduced when one or more variables were controlled.

Narrowing the gap - Evidence indicates that scholarly productivity between the genders is narrowing. Cole and Zuckerman (1984) compared the 1957-1958 cohort studied by Cole (1979) to a matched sample that received their doctorates in the natural and physical sciences in 1969-1970. They found an increased proportion of women among the most prolific scientists. Austin (1978, 1984) compared data from the surveys of 1969, 1972 and 1980 and found greater growth in productivity among the women than among men supporting the theory of “narrowing the gap” in the publication productivity of both the genders. Long (1992) studied the publication productivity of male and female biochemists and found that the differences in publication was slight during the first three years (26% difference) and widened between the 3rd and 4th year (66% difference). The percent difference steadily increase by the 9th year (91%) after which point productivity of males leveled off while the female continued to increase, narrowing the gap to 56% by the 17th year. The study found no significant difference in the percentage of males and female that collaborated with mentors or colleagues. The average paper of a female scientist was cited more frequently than the average paper of the more prolific male scientists.

Opposing Studies - There are opposing views to the effect of gender on productivity (Simon, Clark and Galway, 1967). Guyer and Fidell (1973) surveyed 122 female and 122 male psychologists with Ph.D. from the 1968 *Directory of the American Psychological Association*. Although the men on average published a higher number of papers per year than the wo-

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men, such differences in publication rates diminished when controlled for such variables as subject matter, training, length of career and academic position. When the sample was subdivided into several levels of academic appointment, the major difference occurred at the full professor and associate professor levels. Clemente (1973) studied the publication records of 2,205 Ph.D. holders in sociology and found gender a weak predictor of publication output. Fulton (1974a; 1974b) found that differences in productivity were reduced when comparisons were made by rank. Other studies similarly found gender to be a weak correlate of publication productivity (Blackburn, Behymer and Hall, 1978; Cole and Zuckerman, 1984; Blackburn, et al 1991) especially when the effects of other relevant variables are controlled.

(b) Age

Literature covering the relation of age and research productivity indicated results that are inconclusive. Various types of age correlates were used. Clemente, 1973, Cole, (1979), Pelz and Andrews (1966) used chronological age, while Creswell, Patterson and Barnes (1984a, 1984b) used years of professional experience; Allison and Stewart (1974) as well as Bayer and Dutton (1977) used years since receipt of the doctorate degree. The general findings indicated that age impaired performance, though performance improved with experience. Age may be a determinant at different stages of a professional career. A frequently cited work is by Lehman (1953) whose data consisted of discoveries listed in prominent histories of science. He suggested that young scientists made important discoveries and that age was

negatively correlated with scientific productivity or creativity. In the next year, Davies (1954) noted that age and publication productivity of a university faculty is significantly related.

Age peaks in research publications. Pelz and Andrews (1966) found that publication productivity peaked during the ages of 35 to 44 and 50 to 54. Bayer and Dutton (1977) also reported a similar pattern between age and publication productivity among their sample. Bayer and Dutton (1977) studied a cross-section of academic scientists in 7 fields. In 5 out of 7 cases they observed a spurt obsolescence function between age and articles published. This function presented a two-peak curve. The first peak was reached about the 10th year of career age followed by a second productivity peak as the scientists approached retirement age. Cole (1979) studied the research output of a sample of scientists working in Ph.D. granting institutions in 6 fields; chemistry, geology, mathematics, physics, psychology and sociology. The output were papers published between 1965 to 1969 and citations received for those publications. In general the study indicated that age was curvilinear in relation to productivity. Productivity peaked in the late thirties and forties and then dropped off. This result was similar to those obtained by Bayer and Dutton (1977). However the results did not explain why there were variance in productivity (that is, why there was a difference of only 3.06 papers between the most productive age group of 40-44 and the least productive (60+). Also, age had only a slight curvilinear effect on the quality of published work by scientists between the ages of 30 and 50. Hammel

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(1980) reported that the publication of chemists at the University of California correlated well with the other productivity dimension studied but found that scientific productivity increased with age with some evidence of a flattening rather than a continuous decline. In the same year, Reskin (1979) suggested other factors such as motivation, risk taking, social position, and scientific specialty, which may influence age and in turn affect research performance. Sodofsky (1984) found among his sample that their publication peaked at 0.8 per year for the 36-50 years old and declined to 0.55 for the 55 and above. He gave the reason for the declining rate as the relaxation of pressures to publish after the desired promotion was achieved. A more recent study of Norwegian academics by Kyvik (1990a) found that productivity was highest in the 45 to 49 age group which thereafter decreased and this pattern held true for both men and women academics. A curvilinear relationship between age and productivity was therefore indicated.

Early productivity and recognition - Studies have indicated that early productivity is a good predictor of later productivity. Meltzer (1949) studied the productivity of social scientists and found that an early age at first publication is associated with high productivity. Manis (1951) suggested that high producers started publishing early in their careers. Kidwai (1969) studied the recruitment and training of scientific research personnel and found that the most creative and productive period of a scientist was below 40 years. Lightfield (1971) associated early publications with the few years after they received their doctorate. Sociologists who published and were cited during the first 5 years

following their Ph.D. continued to be productive during the second five-year period.

Zuckerman and Merton (1971) studied the journal - *Physical Review* and found that manuscripts written by researchers over 50 were rejected more often than those by younger persons. This corroborated with Clemente's (1973) finding that among sociologists, early publication activity, early interest in research correlated strongly with later productivity. Those in highly prestigious department on average remained being productive at 60. In turn the academics who published little early in their career continued to publish little later on. Reskin (1977) observed that chemists who achieved high publications during the third to fifth year after receiving their doctorate were also highly productive after 10 years. This is especially true in situations where the academics worked in a high quality Ph.D. department, and access to resources was available. Blackburn, Behymer and Hall (1978) found that a two-year performance was an excellent predictor to total career articles, confirming that early high producer remained productive throughout their career.

Cole (1979) performed a longitudinal study of a sample of mathematicians and used data about the number published for a 25-year period and showed that those who received rewards for their work were more productive at a later stage of their career.

Effect of the discipline and the workplace - Several studies indicated that publication productivity peaks maybe discipline and workplace dependent. The individual publication productivity in academic and industrial research units was studied by Knorr (1979). Knorr's findings verified the earlier results that indicated a

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curvilinear relationship between the scientist's age and his productivity and saw a decline in productivity after achievement peaked in the 40s. The study also saw two peaks form the curve for chronological age, which verified the findings by Pelz and Andrews. Knorr found that in academic natural science the peak occur after 15 to 20 years which steadily rise and this is followed by a period of stagnation or very slow growth in the second part of a scientist's career. Scientists in the research technological science units also showed a decline in productivity towards the end of their careers with a very late peak after nearly 30 years of professional work. In the latter case the curve was remarkably flatter than in the academic setting. The explanation given were: scientists may be drawn off from research into teaching, administration and other work not productive for scientific output. This is supported by the data which showed that the scientists who were older tended to be the head of research units longer, allocated lesser time for research and spent more time on administration.

Kyvik (1990a) analysed the relationship between age and scientific productivity at four Norwegian universities. Cross-sectional data indicated that publishing activity reached a peak in the 45-49 age group and declined by 30% among researchers 60 years of age. There were large differences between fields of learning. In the social sciences, productivity remained more or less the same in all ages. In the humanities publishing activity declined in the 55-59 year old age group but reached a new peak at 60 years and over. In the natural sciences productivity continued to decrease with increasing age. The study

suggested that the differences affected by the various fields of learning arose from corresponding differences in the development of scientific disciplines. In fields where the production of new knowledge is fast and where new scientific methods and equipment are continuously introduced, researchers may have problems coping and hence can become easily obsolescent. In fields where knowledge production occur at a slower pace, the faculty may be productive throughout their careers. In the natural sciences therefore, older faculty members in physics are less productive than older researchers in mathematics.

Reasons for the decline in productivity with age - Studies has attributed psychological explanations for the decline in productivity with increasing age. Sociologists attributed it to a resocialization of the faculty's role where perhaps, changes in interest can mediate the influence of environmental factors on role performance. The decline is attributed to reduced motivation, and less time on research (Lawrene and Blackburn, 1988). Bayer and Dutton (1977) found a decline in the lifetime article productivity of faculty members in mid-career or at the latter part of their careers. This is attributed to changing market conditions, where the productive scientists were taken away from academia during the second half of their career and returned to it later in life. The study also found the situation was publication dependent, that is, lifetime publication of books increased linearly with career age for most fields. Kylik (1990a) puts forward these reasons for the curvilinear relationships: (a) those who published at a younger age and obtained their reward earlier were likely to be motivated to publish more;

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(b) the expectation of keeping productivity high for those who have achieved rank and tenure decreases; and (c) the older researchers most often found problems in coping with scientific development and subsequently become obsolete. Cole (1979) attributed the general decline to the scientific reward system. Those who published early and who obtained recognition continue to be productive, while those who initially publish but did not receive recognition are discouraged and their productivity decline.

At the same time, Kyvik (1990b) proposed the maximizing theory – where both competent and less competent researchers would choose to reduce their research effort over time because it would not really improve the high professional reputation they have already achieved.

Lawrence and Blackburn (1988) gave the following explanations for the age-publication decline situation: (a) scholar's self-examination during the transition period could lead to a decline in productivity in mid-life as professors began to realise they may never become the great disciplinary scholar that was their ideal early in their careers; (b) professors in their mid to late thirties may experience a sense of overload and forced to choose among multiple role demands; and (c) as they age professors tend to report a greater affinity for their institutions rather than to their disciplines.

The sociologist emphasized on the reward structure (Reskin, 1977). The reward system gives recognition and those who enjoy previous rewards would continue to be productive while others not rewarded became discouraged. The economists how-

ever argued that scientist produce research because of the financial reward both now and in the future associated with the activity. As scientists age and the future becomes shorter, the present value of the reward that research generates decline while costs do not. As such scientists has less incentive to be productive as they gets older (Diamond, 1984). Soldofsky (1984) asked his sample of 149 deans, 506 heads of departments and 258 professors nearing retirement to explain the reason for the decline in journal publication as academics gets older. The sample was divided into 2 groups; 41-55 years and 55 and over. The top three explanations given were: (a) the relaxation of publication pressure; (b) more time was allocated for consultation to increase income; and (c) more time was allocated to administrative activities. Other explanation included spending more time to write textbooks or scholarly monographs to supplement income.

Opposing studies - It is difficult to determine the precise relationship between age and research productivity. Blackburn; Behymer and Hall (1978) eliminated age as a predictor since they found it to be strongly correlated with rank and was a weaker predictor than rank. They proposed the importance of other factors such as interest in research, which may decrease with advancing age and this decrease is relative. Interests in research continue to be high in high producers and remain so throughout their career. Cole (1979) in his study of the research productivity of a sample of 497 mathematicians with Ph.D. in American universities between 1947 to 1950 found that their productivity did not differ significantly with age and when citations in 1975 was used as an indicator of quality,

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found no significant change in the quality of work produced by this cohort throughout the 25 years. Also, there was a gradual decrease in the average number of citations received to work published up until the late 1960s and a slight decline in the early 1970s. They concluded that the average members of the cohort produced more significant work in the later years than they did in the years immediately following the receipt of their PhD. Hammel (1980) and Creswell, Patterson and Barnes (1984a; 1984b) pointed out that the productivity curve gradually increased which confirmed that productivity increases with age and there was evidence of the flattening of the curve instead of a decline. Creswell (1985) therefore attributed that age itself has little predictive influence on performance but rather the variables highly related to age may help explain variations in productivity. Over (1982) found that even though British psychologists who were over 45 published less than those under the age of 45, there was considerable individual variability among both the older and younger psychologists. A person's previous research productivity was a far better predictor of subsequent performance than his age since those who were productive in 1978-1980 had been productive in 1968-70. Also, age becomes an insignificant correlate when productivity was regressed against gender, academic rank, prior publication and research standing of the university. Waworuntu (1986a; 1986b) found that age was not significantly related to productivity for his Indonesian academic sample. Levin and Stephan (1989) surveyed the age publishing profiles in four fields of science based on data from the 1977 survey of doctorate recipients. Age was found to be a weak

predictor of performance but in general the older scientists tended to publish less than their younger peers. This led to a situation described by them as, "...the graying of America's scientific community was accompanied with slowed rates of research in higher education".

Kylik (1990b) summarizes the findings from previous studies as follow: (a) the relationship between age and the number of publication is curvilinear where productivity expands with increasing age and reaches a peak when the scientists are in the late thirties and early fourties after which it declines; (b) those scientists who are more productive at a younger age will continue to be productive as they grow older; (c) in some cases two peaks are observed, the first and highest in their late thirties and early fourties and another around 60; (d) there are vast differences between various disciplines with regard to the relationship between age and scientific publishing.

(c) Family Background

Family problems and attitude toward jobs can influence scholarly publication (Horowitz, Blackburn and Edington, 1984). Some studies like that of Hargens; McCann and Reskin (1978a) found that children are an impediment to research productivity since researchers with children publish fewer articles and articles of slightly lower average quality than the childless group. Later studies however did not corroborate this finding. Cole and Zuckerman (1987) indicated that the American natural and social scientists who were married with children published more per year during the course of their career than the unmarried female researchers. The affect of children on

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scientific productivity might vary with the children's age. Younger children make greater demands on a researcher's time and energies. Kylik (1990a & b) in a Norwegian sample, found that women who have children under 10 years of age published less than their male colleagues (with similar aged children) and other female academics with older children.

(d) Personality Traits

Studies indicate that the productive scientists possess certain characteristics which may be absent from the non-productive. Some of these characteristics are; conducive early childhood experiences, positive attitude, high motivation, and creative work habits.

Conducive early childhood experiences - Roe (1953a, 1953b, 1952) studied 64 eminent male physical and social scientists. Their life histories indicated that their parents were also professionals, held intense private interests in their youth, relied on rational control and looked at problems in a question-answer way.

Attitude and motivation - The productive scientists engaged in research because they have a strong inner drive or compulsion to achieve. Eminent scientists have developed cognitive styles such as the ability to play with ideas, differentiate stimuli, recombine concepts, tolerate ambiguity and abstraction (Gordon and Morse, 1970). They are often highly motivated, self-reliant and confident with their ideas. These characteristics tend to make them devote more of their time to research (Merton, 1973). It is difficult to measure motivation because it varies at various stages of the research process. Pelz and

Andrews (1966) found that university research scientists who are productive are also highly motivated, and have a strong drive to explore ideas. The low publishers depended on their supervisors for their motivation. Merton (1973b) found that eminent scientists are strongly motivated as a group of researchers.

Work habits - The characteristics of eminent psychologists indicated an intense devotion to their work (Roe, 1953a & b). Mills (1959) maintained that the productive scientists have intellectual craftsmanship, the ability to organise time, space and materials. Krebs (1967) observed the emphasis given by productive scientists to their mentors and a supportive team. They dedicated longer time to work and put less importance to material condition. Simon (1974) focused on the work habits of the eminent scientists and found that they spent vast amount of time on their research, worked at several problems at the same time, and devoted early mornings to their work. Pelz and Andrews (1976) attributed the high productivity of scientists to what they called the sacred spark, comprising an inner compulsion which drove them through in the absence of external reward. The productive engineers were absorbed in their work, involved and identified strongly with their work. They also have the stamina and energy to work hard and persisted on long range goals (Zuckerman, 1970). Taylor and Ellison (1967) studied 2,000 scientists of the National Aeronautics and Space Administration and found the productive scientists to be independent, intellectually oriented, and have high self-confidence.

Cole and Cole (1973) indicated that the productive scientists have an innate scien-

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tific ability, talent, intelligence, strong compulsions and were highly motivated. The productive scientists were also more confident of their ideas, and were able to tolerate ambiguity, abstraction and have high ego strength (Fox, 1983; Merton, 1973a, Roe; 1953a and 1953b; Roe, 1982).

The breadth of interests among researchers also helped to increase research productivity (Eastman, 1989; Subramaniam, 1984). Wowuruntu (1986a, 1986b) found that those Indonesian academics, who improved themselves by undertaking research methodology class were more likely to be productive. Close inter-personal communication is related to scientific productivity (Singh and Laharia, 1986).

Woods (1990) found the following factors to be related to research performance of university academic staff in higher education in Australia. There are differences across disciplines, in ability, energy, creativity, motivation, ambition and self-discipline and these were considered important factors in distinguishing between the productive and the unproductive researchers. Academics distinguished the productive types as those who could cope with extraordinary work load, intellectually curious, liked writing and always put time away for research. Less flattering description saw the productive researcher as one who was adept at academic gamesmanship, hard-nosed about the time allocated to research and pursued this even though other responsibilities such as teaching may suffer. They are strategists in relation to publications. The university's promotion requirements are the main reason why academics employ such gamesmanship tactics. Some attributed productivity to focus (some

focus on research while others on teaching). A disillusionment with the university reward system, and the lack of confidence in getting work judged by peers are contributory to a decrease in productivity.

A recent study by Fonseca et al. (1997) of 50 eminent Brazilian scientists in the field of biochemistry and cell biology, indicated that they are highly motivated, found pleasure in their work and able to face challenges effectively. High publication productivity reflects excellence. The eminent scientists have a common trait in that they were all highly productive. The scientists were also interviewed and their CV examined to identify periods of greater and lesser productivity. The peaks and falls were used as a reference point in the interviews. For each scientist two productivity scores were computed (a) total number of published papers and (b) sum impact factors (IF) of the journals in which the articles are published. The IF of a journal is the average number of citations received in one year by the articles published in that journal in the two previous years. These two scores were plotted along the years of each scientist's career. The interviews revealed five groups of factors influencing productivity: (a) human factors – related to human relations in the laboratory, the quality of the working team, the relationship of the leaders to the students, the ability to exchange ideas, interact with other scientists, and the rapport among team members; (b) subjective emotional factors – related to the ability to face challenges, motivation and pleasure at work.; (c) active material conditions - related to facilities, equipment and money to buy chemicals ; (d) types of research – related to having the freedom

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to make individual focus to new areas, and (e) time dedicated to work – related to time allocated to too many bureaucratic tasks. In this study the highly productive group have singled out human relationships as the most important factor for scientific productivity. The majority of respondents also indicated that problems in their personal life interfered with their productivity.

Creativity – A number of studies found the eminent scientists as creative, exact, precise, reliable, intelligent and introverted (Andrews, 1976; Cattell and Drevdahl, 1955; Chambers, 1964; Knapp, 1963; Roe, 1953, 1964; Collins, 1971). Taylor and Barron (1963) indicated that the psychological traits of the productive scientists were different from those less productive, such as they tended to be more creative. Gordon and Morse (1970) found that the underlying personality factors defined the effective researchers as leaders. They tended to have an independent trait, high level of ambition and endurance, intelligence and orderliness. Rushton, Murray and Paunonen (1987) also found these traits in their sample of productive academics. Connor (1974) described the creative ability of the productive researcher as characterised by independence of thought, initiative, imagination, intuitiveness and these factors contributed to research competence and helped explain variations in research productivity. He pointed out that although creativity is critical to research competence, organizational environment affects the manifestation of that ability into research competence. Successful employment of creative ability in research is strongly affected by psychological, social and organizational variables. As Creswell (1985) pointed out, personality traits are

important factors but those factors too can be affected by other social factors.

In another study where personality was considered important, was that of Babu and Singh (1998) who identified 200 variables influencing research productivity collected through relevant literature. Out of these, 80 were selected for the Q-sort technique. On the basis of the Q-sort data 26 variables were selected and subjected to principal component factor analysis. The results indicated 11 factors affecting research productivity out of which 4 are related to personal variables. The first is persistence, characterised by the scientists who are observant, has the capability to work under constraints, and those who recognised good work. The second trait is termed initiative, characterised by self-reliance and persistence. The third trait is termed as intelligence characterised by sharp memory, creativity which led to work satisfaction and the freedom to plan and organize their own work. The fourth trait is learning capability, characterised by the ability to exploit new scientific developments, and the ability to self-examine their own performance.

(2) Academic Correlates

(a) Rank and Tenure

Rank - A number of studies found academic rank and tenure related to research productivity. Academic staff who are in the higher professorial rank have larger publication records than those lower in the ranks (Blackburn, Behymer and Hall, 1978; Creswell, Patterson and Barnes, 1984a). Blackburn, Behymer and Hall (1978) proposed that rank and not tenure was the best predictor of productivity. Over 28.6% (28) of full professors in their

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sample, published 5 or more articles over a two-year period compared to associate professors and lecturers. They suggested that an increase in rank did not subsequently increase the rate of productivity. It may be that full professors have more opportunities to do research and publish their findings because of fewer teaching, better professional contacts and access to more research funds. Subsequently, productivity increased steadily with rank, and a saddle shaped age and productivity curve emerged. Warner, Lewis and Gregorio (1981) found that academic rank strongly affected article count among the natural scientists and social scientists but not among the humanities. For the humanities, rank was related to higher book count than in the sciences. Studying the determinants of publication rates among faculty members from Canadian universities, Dickson (1983) found those higher in academic ranks were more productive. In a recent study, Bentley (1990) found rank to be a significant predictor of faculty research productivity. Whether academic rank caused high productivity or vice versa is an open question (Wanner, Lewis and Gregorio, 1981). Kyvik (1990a) studied the productivity of academic Norwegians and found that academic rank was related to productivity. Professors are more productive than the associate professors. Prpic (1996b) indicated that among her 385 eminent Croatian scientists one of the key productivity indicator, was early rise in academic rank. Tien and Blackburn (1996) looked closely at the relationship between academic rank and productivity and concluded that the results obtained are inconclusive. Tien and Blackburn also indicated that there was no difference in publication productivity between assistant professors

and associate professors although full professor published significantly more. Overall the study failed to support the hypothesis that those higher in rank is more productive. The variance of the productivity of full professors is significantly greater than the other two ranks, indicating that some professors remained being productive after they reached the highest career ladder while others do not. The study also failed to support the hypothesis that variation of productivity decreased as rank advances. An interesting finding from the study is that, low productivity occurred in the early years before the next promotion (1-2 years after assistant professorship). Those who remained as assistant professors longer than the average 6 years have fewer publications than their colleagues within the same rank. – the fewer publications one produced, the longer one stays in the rank. Productivity from the 2-5 years gradually increases as the time for the next promotion approaches. The productivity declined after the promotion to associate professorship, which picked up again just before the promotion exercise for professorship. The productivity of faculty with more than 20 years as full professors were even higher than faculty who have just become full professorship. For this group intrinsic motivation on productivity prevailed, the critical role of resources acquisition, external rewards, salary increase, peer recognition provided a suitable environment for continued dedication to research (Allison and Stewart, 1974). The findings therefore support the behavioural theory (Cooper, Heron and Heward, 1987; Skinner, 1969) that suggested promotion has a motivation effect on faculty research performance.

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Tenure - Tenure however exercises little influence on performance. Holley (1977) studied sociologists and found that research output declined after obtaining tenure. Blackburn, Behymer and Hall (1978) revealed that tenure was a poor predictor of productivity. Neumann (1979) who studied four departments; physics, chemistry, sociology and political science found little difference in the publication rates between tenure and untenured staff. Long, Allison and McGinnes (1993), studied biochemists, who obtained their PhD. between 1956 to 1963 (for men) to 1967 (for women). Time in rank and the number of publication in rank were important factors determining rates of promotion. Rates of promotion were lower for women than men for promotion to associate professor and full professor. The study concluded that the sheer number of publication dominated the effect of citations to papers. The number of articles in rank dominated the number of citations in rank in determining promotion to full professor.

Opposing Views - The inability to attain promotion and a low rate of productivity are positively correlated. Gunne and Stout (1980) found that rank did not affect total output of most academicians. Publication efforts are spread rather evenly among all ranks and positions. Other studies however reported that rank have no influence on faculty research productivity when relevant variables are taken into consideration (Guyer and Fidell; 1973; Over, 1982; and Wanner, Lewis and Gregorio, 1981).

(b) Qualifications and Experience

Qualification - Long, Allison and McGinnis (1979) reported that while prestige of

doctoral departments and mentor's eminence were positive in their effect upon productivity, the strength of the association was small. However, pre-doctoral publication was directly related to future productivity. Chubin, Porter and Boeckman (1981) supported Long's finding that early publication predicts later publication. Therefore, the prestige of the doctoral programme and pre-doctoral publications are important predictor of productivity. Nederhof and van Raan (1987) found that Ph.D. students being awarded with cum laude doctorate were cited more frequently than students who did not obtain this predicate. PrPic (1996b) in a study of eminent Croatian scientists indicated that the most relevant productivity factor is an early acquisition of a Ph.D. Creamer and McGuire (1998) found that the majority of the productive academics interviewed (15 out of 24), earned their doctorate from highly rated research university. Half of the female academics felt that their doctorate programme did not develop their skill to be a successful writer. This may be due to the fact that only one third of the women compared to three quarters of the men reported publishing with their supervisors.

Experience - Rushton, Murray and Paunonen (1987) indicated that publication output vary with age and experience. The average publication of researchers increased with the number of years of professional experience, which then flattened off. Babu and Singh (1998) indicated that responses from their Indian academics stressed on the importance of career advancement and the productive researchers were characterised by their vast research experience and acquaintance with varied research practice.

(3) Departmental Correlates

Departmental correlates comprise the following factors: (a) cumulative advantage; (b) reinforcement; (c) the graduate programme; (d) institutional prestige; (e) time allocated for research and department size; (f) discipline differences; (h) colleagues; (i) leadership and departmental /faculty management.

(a) Cumulative advantage

Cumulative advantage describes a situation where an academic staff acquires the opportunity, which helps him advance in his work. The idea is based on Merton's (1973a) *Mathew effect* in science – where, once scientists receive recognition from their colleagues they accumulate additional advantages as they progress through their career. Creamer and McGuire (1998) applied the cumulative advantage perspective to scholarly writers in higher education and found that a number of studies have related this factor with publication productivity (Bentley and Blackburn, 1990; Clark and Corcoran, 1993; Creswell, 1985; Fox, 1983, 1985). Allison and Stewart (1974) and Allison, Long and Krauze (1982) developed mathematical models to test the evidence for cumulative advantage on cross-sectional survey data for chemists, physicists and mathematicians (1974) and biochemists and chemists (1982). The studies found that the data supported the hypothesis of cumulative advantage and an association was indicated between productivity, resources, and esteem, which increased as career age increases. Academics who achieved high publication output were characterized by those who have been advantaged in terms of resources, being trained at prestigious institutions

and had published early in their career. Creamer and McGuire (1998) described the prolific writer as those who (a) earned a doctorate at a prestigious, research oriented institution; (b) developed an interest in research early in their career, (d) were mentored by a prominent, senior scholar, (d) published early in their career, (e) accepted faculty appointments in research institutions and (f) developed extensive collegial network. Ramsden (1994) proposed the following key elements of cumulative advantage: (a) opportunities gained through training (being mentored in a prestigious department which lead to subsequent appointment in prestigious research institutions); and (b) the recognition received – formal (awards and citations) (Cole and Zuckerman, 1984), and informal (feed backs from colleagues). Two situations were indicated: firstly, a strong correlation is indicated between prestige of institution and scholarly productivity (Bentley and Blackburn, 1990; Blackburn, Behymer and Hall, 1978), and secondly, the gap between the high and low publishers widened over time, while productivity generally decreases with age (Creamer and McGuire, 1998). Creamer and McGuire (1998) interviewed 31 productive academic staff (7 men and 19 women). The study used a broader measure of productivity (articles, books, book chapters). Each participant was asked to discuss (a) the doctoral preparation program; (b) departmental or institutional factors; (c) professional associations; and (d) personal characteristics. The study found that, (a) the majority (15 out of 24) earned their doctorate from prestigious university; (b) did not show an early interest in a faculty career since most had intended to continue their career as an

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administrator; (c) there was only moderate support for mentoring as an element of the cumulative advantage perspective; (e) most achieved early publishing success (strong support for this factor- the majority (20) published at least 1 refereed publication during the doctorate or within 2 years of completing it); (f) initial faculty appointment was a weak predictor (fewer than half were hired as full time faculty immediately after completing their doctoral programme); and (g) there was moderate collegial support (16 indicate getting feed backs from colleagues regarding their publications which included getting references, reading drafts, informal interaction, and comments at conference presentation). The results indicated that only one of the factors indicated above, support the cumulative advantage perspective, that is the importance of an early publishing success.

(b) Reinforcement / Reward

This is based fundamentally on the behaviorist theory that activity which is rewarded continues to be emitted, while activity which is not rewarded tends to be distinguished (Skinner, 1953). This concept is closely related to the cumulative advantage but both are basically different. Fox (1983) pointed out that positive reinforcement can exist without cumulative advantage but reinforcement will not account for much productivity unless accompanied by the accumulation of resources for research. On the other hand cumulative advantage do not exist without prior positive reinforcement. Hence the process of reinforcement almost certainly accompanies enabling advantages. Meltzer (1949) studied social scientists and found that early publishing, early age at first publication

and frequent early publication were associated with high productivity. Lightfield (1971) pointed out that the academics who has the ability to produce a quality piece of work is reinforced enough. The study traced the publication records of 83 sociologists, who had received their doctorates between 1954-1958 and found that among those who published and received citations to their work in the 5 years immediately after receiving the doctorate – the majority (73%) continued to be active. The reverse was the case for those who published, but did not receive citation during the 5 years, where only a small number continue to receive citations during their second 5 year. The study concluded that unless a person achieved a quality piece of work during his first 5 years, it would seem unlikely that he will do so during the next 5 years of his career. This situation is also verified by Cole and Cole (1973) who indicated that later productivity is influenced by recognition of early work, so that persons who received heavy citation continued to be highly productive while those who are not cited will decrease their productivity. The scientists who experienced early success are able to command or obtain the increased time, facilities and support for research (Guston, 1973). These resources and rewards then enrich the scientists at an accelerating rate. Early performance brings reward and once these rewards are received they have an independent effect on the acquisition of further resources (Long, Allison and McGinnis, 1979; Cole and Cole, 1973).

Reskin (1977) studied productivity and the reward structure of science, stressed on collegial support. This study suggested that in research oriented universities the

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immediate and informal collegial recognition which follow publication may be more important in maintaining productivity than the formal delayed reinforcement of citation. Cole (1979) indicated that reinforcement in the form of recognition received for contributions, helps stimulate further publications. Colleagues and disciplinary environment therefore helped shape academic research performance.

Other studies have investigated the relationship between tenure or financial rewards and research performance. Associations were found between faculty work in research and institutionally dispensed rewards such as salary and promotion (Katz, 1973; Fulton and Trow, 1974a & b). Hoyt (1970) found that publications were related to salary increment. Kasten (1984) also found that faculty work in research is tightly coupled to faculty rewards.

(c) Graduate Programme

Graduate and postgraduate programmes socialise students to the values and norms of a profession. A department is critical in developing knowledge, skills and competence, cultivate values and attitudes, shapes the conception of the scientific role standards of performances and styles of work among its students. Hence, if the academic is trained in a department, which stressed on publication productivity, it is assumed that this would influence his publication behaviour. Crane (1965) contended that the best graduate schools, usually attract the best students and in turn the best of these are selected for training by the top scientists. She analysed data from interviews with 150 scientists (biologists, political scientists, psychologists) located at three

universities of varying prestige levels. From these analyses, Crane reported that the department in which scientists received their graduate training has more effect on later publication. Scientists from major universities are likely to be productive regardless of their current work environment while scientists trained at minor universities would unlikely be productive unless currently located at a major university. Working with eminent scientists affects the productivity of the students in the pre-doctoral years and early years upon receiving the doctorate. The impact of the department declines over time and is replaced by the influence of the first academic job (Hargens and Hagstrom, 1967). Studies have explored the relationship between the prestige of the doctoral department and research performance. Long (1978) and Reskin (1979) studied performance after the completion of the doctorate programme and suggested that the effect is short lived, that is, through the first six years of the academic's career. Doctoral department's influence comes in the form of high quality training, the resources available, and the eminence of the faculty. Long, Allison and McGinnis (1979) reported that while prestige of doctoral department, mentor's eminence and selectivity of undergraduate institution are all positive in their effect upon productivity, the magnitude of the association is small and statistically insignificant. The study found that pre-doctoral productivity is directly related to future productivity. Chubin, Porter and Boeckman (1981), support Long's finding that early publication predicts later publication. The prestige of the doctoral programme and pre-doctoral publications are important predictors of productivity.

(d) Institutional Prestige

Evidence indicates that individual accomplishments are as important as academic background when securing appointment (Hargens and Hagstrom, 1967; Cole and Cole, 1973). Blackburn, Behymer and Hall (1978) found a relatively strong relationship between productivity and school type and institutional prestige. University faculty published significantly more than their 4 year college counterparts. Faculties employed at high prestige institutions published more than those at lower prestige institutions. This finding is similar with those of Lazarsfeld and Thielen (1958); Crane (1965), Parsons and Platt (1968), Eckert and Williams (1972), Cole and Cole (1973). Crane (1965) studied the career of 150 scientists at three universities of varying prestige. She found that scientists trained and later hired by minor universities have difficulty continuing their research activities and are differently motivated than scientists trained and hired by major universities. Folger, Austin and Bayer (1970) count citations to 467 Ph.D. students in biochemistry. Subsequently they asked the 152 biochemists to give a qualitative assessment of the institutes where the Ph.D. students were working. The study obtained a high correlation between citation measures and the assessment of the institutes concerned. Comparison between citation counts and department rank was also correlated. Cartter (1966) who carried out a study for the American Council on Education found correlation in the range of 0.6 to 0.8 between Cartter (1966) and Roose-Anderson (1970) ranks and bibliometric measures. Hagstrom (1965) studied the fields of biology, mathematics, physics and chemistry, found similar correlation between prestige of the university

departments and publication output measures. Small (1974) compared citation to individual articles in the field of chemistry and departmental prestige and found a significant and positive relationship.

Employment in a prestigious institution also shapes and stimulates research performance. Once a graduate is employed in a prestigious institution, the correlation between the prestige of the institution and productivity grow larger over time. Long (1978) studied the productivity and academic position in the scientific career and found that the effect of productivity upon departmental prestige was weak. However, the effect of prestigious department upon productivity was strong and this is especially true for scientists moving into first academic position. In general, publication levels are not immediately affected by the prestige of the new department but rather productivity is affected by early (pre-doctoral) publication. However, after the third year in appointment scientist's productivity rates are more strongly affected by the prestige of their present location than by their pre-doctoral publications. Those in a prestigious department will increase their publication while those in less prestigious department begin to publish less. Hence in any change of jobs, the department will start to affect the faculty within 5 years of appointment. When the academic staff moves, the effect of the previous institution diminishes and the influence of the new department, grow steadily within subsequent 5 years. Three years later Long and McGinnis (1981) extended the line of inquiry beyond the academic department's prestige to the effect of larger organizational context, to find out whether the research university or non-research university, 4 year college and

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nonacademic sectors have an effect on productivity. They reported that the chances of obtaining employment are not related to productivity (number of publications). However, once employed the individual's levels of productivity soon conform to the characteristics of his work place. Location in four-year colleges or non-academic sectors depresses publication while appointment in research universities foster publication. When changing jobs, the work place will only influence the individual after 3 years. Hence productivity is largely determined by the context of the new position. Prestigious department may enhance productivity because of the visibility and contacts that accrue to faculty in major institutions and papers submitted by faculty in prestigious departments may appear superior and more readily accepted for publication.

Reskin (1979) used data from a random sample of chemists who received their doctoral degrees from US universities between 1955 and 1961. The study analysed the effect upon post-doctoral publication and citation on the calibre of the total programme, training with productive sponsor and collaborative publication with a sponsor. Training with a productive sponsor and collaboration with a sponsor are associated with high productivity during the pre-doctoral period while the calibre of the doctoral programme has no impact on publication during this period. The findings for the post doctoral productivity is reverse, that is the calibre of the doctoral programme is important to productivity at the middle and end of the first post doctoral decade, while sponsorship is not important for productivity during this period. The findings show that sponsorship may be important in launching a

scientist's early publication while the quality of the graduate programme is more important for continued productivity.

Allison and Long (1990) studied 179 job changes by academic chemists, biologists, physicists and mathematicians found that publication and citation rates increased after faculty members are relocated to more prestigious departments. In contrast, publication and citation rates declined for scientists who made downward move to less prestigious units. Similar to other studies they suggested that prestigious departments enhance scholarly work because of the rich source of colleagues that value and engage in scholarship. The results suggested that the effect of departmental affiliations on productivity was more important than the effect of productivity on departmental affiliation. In a recent study Debackere and Rappa (1995) monitored the career progress of 373 scientists working in the field of neural networks graduating from US universities. The study found that the prestige of a scientist's graduate school is a significant indicator of prestige of an academic staff's academic appointment in the initial 5 years after graduation. After five years the effect of graduate school prestige becomes non-significant. Whether they entered the field before or after it gained widespread recognition in the scientific community, did not affect subsequent career progress in terms of institutional prestige.

(e) **Time for Research and Teaching; Department Size**

Research and teaching - Most studies did not indicate a very significant relationship between research and teaching (Voeks, 1962; Harry and Goldner, 1972 and Dent and Lewis, 1976, Neumann, 1992). Webster

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(1985) looked at nine studies and all of which indicated little or no positive correlation between research productivity and teaching effectiveness. Ramsden and Moses (1992) studied the relationship for Australian academics and found negative or near zero correlation both at individual or departmental level. However in 1951, Manis found an association between time spent on research with productivity and reputation among social scientists, while time on teaching and administration was negatively associated with productivity. This was also indicated by Andrews (1964) in his sample of scientists with Ph.D. and the maximum performance was obtained from those who spent three quarters of their time on non-teaching, non-administrative work. Work variety seems to contribute to better performance. Pelz and Andrews (1966) found that scientists with several areas of specialization, and undertaking several research and development functions, tended to perform at higher levels than those with just a single function. This finding concurred with Andrews (1964) who reported that scientists who spent part of their time on other than their own technical work achieved above average performance. Michalak and Friedrich (1981) studied academic staff at Franklin and Marshall College in Lancaster, Pennsylvania and found that faculty members who were active researchers tended to be somewhat better teachers than those who are not, though the relationship is not a strong one. The relationship is strongest in the lowest rank of the faculty and weakest in the highest rank. Centra (1983) and Neumann (1992) believed that there is a link than evidently shown in current study.

Clark and Corcoran (1993) studied individual and organizational contributions to

faculty vitality and indicated that the highly active ideal type of research university academic staff allocated a smaller percentage of their time to teaching and has a stronger research orientation. These academic staff also viewed their departmental and institutional service activities as a significant drain on their research time. In the health sciences, Calligro et al (1991), Harrington and Levine (1986) indicated that their more productive faculty also spent greater amount of their time in research than the less productive faculty. Working on the random sample of social science faculties, Fox (1992) found that those whose publication productivity was high were not strongly invested in both research and teaching. The productive researchers have less classroom contact with students, spent fewer hours preparing for courses and consider teaching much less important than research. In a survey of studies on research productivity, Johnston (1994) indicated that both Australian and UK studies provided no evidence that research productivity impairs normal teaching commitments.

Department size - The study which relates research productivity and department's or research group size indicates no clear tendencies. Wallmark et al (1966, 1973) and Blume and Sinclair (1973) reported a positive correlation between size and productivity. Wallmark et al. collected data from 60 teams in three specialized areas in applied physics and the study concluded that: (a) there was no positive effect of increasing group size on performance; (b) there was no evidence of either an optimum or minimum size effect; (c) the improvement in performance was exponential (a single team of 50 scientists) would be as great as that of 138 scientists

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working individually; and (4) other factors contributing to research effectiveness included material resources, selection of productive group members, and the effectiveness of the leaders.

Blume and Sinclair (1973) used a large sample of British university chemists and reported a modest positive association between individual productivity and group size. Blackburn, Behymer and Hall (1978) studied a large sample of academics in American colleges and universities and found that department size was a relatively poor predictor of scientific productivity. However they reported a critical minimum size of between 11-15 departmental members. Beyond this size productivity remained relatively stable. Although generally, department size is not a good predictor of productivity, a minimum size seems to be necessary (Gallant and Prothero, 1972). It appears that a department does need to have sufficient faculty (average between 11-15) to facilitate communication, and stimulation between colleagues. Beyond this size, productivity per professor remained relatively stable. Stankiewicz (1979a) studied 173 Swedish academic groups and found that group size was significantly related to the output of published papers. The relationship of group size to performance was curvilinear especially when group age was controlled. The bigger the group the larger the output till a certain size was reached when it began to decline. The optimum group size in this case is about 5 to 7 scientists. Fritschi et al (1980) in their Swiss sample found a relationship between productivity and department size but observed that for chemistry, physics and mathematics a significant productivity peak was indicated

when the department size was between 9 to 22 researchers and assistants.

The reverse results, was reported by Wispe (1969) and Elton and Rose (1972). Wispe measured a department's age by its turnover and found that the department productivity and turnover are unrelated. Stankiewicz (1979) measured the size, the age and the output of 172 randomly selected Swedish academic research groups from the fields of natural science and technology. The age of the group was defined as the number of years since it was formed. The study found that size and age separately or in combination indicated little relation to the output per scientist (p.203). Cohen (1991) proposed that no reliable evidence indicated the existence of a size or a range of sizes for a research group that maximizes output per unit of size. Similar report of results on group age and output indicated that the only consistent evidence is that age, measured as years since the founding or first functioning of the group is uncorrelated with output per capita. There is no evidence of an age or range of ages for a research group that is optimal. Jordan, Meador and Walters (1988, 1989) used ranked economics departments by their output of published research to assess whether department size or organization (public or private) was related to the average research productivity. Their findings indicated that private institutions were associated with greater average productivity. They also found that research productivity is positively affected by department size, that is, increased department size was associated with greater average research output, but this effect diminishes as department size increases. In a later study Meador, Walker and Jordan

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(1992) added other factors to be considered with department size and this includes: fraction of staff receiving grant support, the ration of student per lecturer and the quality of the research library. Instead of the raw publication score, the study considered the scholarly competence and achievement rating of each department's faculty, based on faculty's opinion about the scholarly achievements of their peers. They found that the rating was positively correlated with publication performance for all 22 disciplines studied. The findings from this study received criticisms from Golden and Carstensen (1992). Qurashi (1993) investigated the dependence of per capita research output of an interacting group of research workers, on the size of the group. The comparison of various research groups and institutions in the USA, UK, Pakistan and Bangladesh showed an initial linear rise, followed by one or more maximum, the first being at group size of 6 to 8 persons. The group of 8-9 is taken as a basic unit in these research groups.

Johnston (1994) surveyed the literature in this field and proposed that the critical size vary in the natural sciences Below a certain size (estimated 3-5), academic researchers, post-doctoral fellows, post-graduate students is reduced. Kyvik (1995) examined whether large university departments create better opportunities for research than small ones. The sample comprised assistant professor or higher at four universities in Norway. The study found no significant relationship between department size and productivity in scientific publishing. They found that faculty members in the smaller departments were more content with their research environment than their colleagues in larger depart-

ments. This is consistent with the findings of a study undertaken 10 years earlier (Kyvik, 1991). The size however, have variant effects on disciplines. For instance, Kyvik found that in the humanities, the smaller the department the better the performance, while the opposite was indicated in the medical sciences. This may be due to the nature of study in each discipline. There is more team work in the medical sciences than in the social science department. A more recent study by Hemlin and Gustafsson (1996) found that the size of the department in the arts and humanities has no effect on individual productivity.

Johnston (1994) summarizes suggestion by various studies on the optimum size of a research group as follows: (a) about six fully qualified scientists working in the same problem area with a dozen support staff, graduate students and post-doctoral fellows (suggested by Ziman, 1989); (b) as few as three persons, up to more than twenty; (c) a middle range of four at the lower level and six or eight at the upper limit (suggested by Etzkowitz, 1992); and (d) typical size of five (suggested by Franklin, 1988).

The results of previous studies indicate that increasing the size of the department will not necessarily result in better units and better research productivity.

(f) Age of the Research Group

A number of studies have related the age of the research group and productivity. Group age is defined as the average number of years the members belonged to the group. A group with high turnover is regarded as young even though it has existed

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for a long time. Shepard (1956) found that creativity of research teams in industrial laboratories is highest during the first 16 months of its existence and declined thereafter. Wells (1962) and Wells and Pelz (1966) studied 83 research groups (49 in industry and 34 in government) and found that the general scientific contribution of their groups tended to decline with increasing age. Wells and Pelz attributed this situation to the decreasing cohesion and competitiveness in the aging groups. Stankiewicz (1979a) proposed that the size and age of research groups was affected by both the nature of the groups themselves and by the institutional/organizational setting they operate. The study consisted of 172 randomly selected Swedish academic research groups from the fields of natural science and technology. The study found that group age was significantly related to research output. Output per scientist seemed to increase during the first 10 years of a group's existence, after which output either stabilized or declined. Both the leader and non-leaders indicated a decline in output when groups were 11 or more years old.

(g)Discipline Differences

Faculty research differs among disciplines. Blackburn, Behymer and Hall (1978) found that US faculty in the natural sciences tended to publish more articles than faculties in the humanities. Wanner, Lewis and Gregorio (1981) compared the productivity among academics in the natural sciences, social sciences and humanities and found that the natural scientists produced the most journal articles and the social scientists wrote most books. Biglan (1973) distinguished between those in the hard discipline (e.g. chemistry) and the soft discipline (accounting) and found that the soft

discipline produced more books. Similarly, Creswell and Bean (1981) categorised their sample as those belonging to the hard, soft, pure, applied and life sciences. Kyvik (1990a) pointed out that the average publication is higher in some disciplines. A number of studies found that the publication rate was higher in chemistry than in physics (Hagstrom, 1965; Cole, 1979; Thagaard, 1986). In a British study by Rushton, Murray and Paunonen (1987), of university departments and individual researchers in the field of psychology, indicated that 2 of the 51 departments accounted for the majority of total journal publications and 1/3 of total citations. The study showed that in the field of psychology, few individuals were the key researchers in the discipline and these superstars accounted for most of the scientific impact in their field.

Woods (1990) studied the factors influencing research performance of university academic staff in Australian universities. She found that disciplines could influence the degree of productivity, where the type of processes and techniques of research within and between disciplines brought different potentials for productivity. Variations in research productivity between academics can be explained by differences in the fields of research and the varying definitions of what constitute acceptable research output in these fields. Productivity vary in accordance to the type of research; pure or applied; high or low risk; field-work or laboratory or desk; established or developing; local or national; short term or long term and experimental or ecological. The time needed to carry out the research and the time lag between completion and publications were related factors. This finding is consistent with that of Pelz and

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Andrews (1976) who indicated that the stage of entering into the research area is also a determinant of productivity. It was suggested that academics have better chances of making significant contribution if they enter the field at an early stage. Martin and Irvin (1983) also verify this situation. Prpic (1996) studied 385 eminent Croatian scientists in four different scientific fields (natural sciences, technical sciences, biosciences, and social sciences and the humanities and found that the total (career) publications and average five-year productivity was significantly different across the examined scientific fields. The differences was most obvious in two contextual situations; (a) the ratio of solo-authored and co-authored publications, and (b) the share of the works published abroad. Co-authored works are more common in the natural sciences, biosciences and technical sciences, while the solo-authored publications are predominant in the social sciences and humanities. Also, although the eminent scientists from every discipline have several times more foreign publications than the average in their field, the differences among them are immense. The studies above indicate that the field of study may be imperative in explaining differences or relatedness of publication productivity.

(h) Colleagues

Studies suggest that the productivity of scientists is influenced not only by their own behaviour and attitude but also the activities of their co-workers (Hargen and Hagstrom, 1967). Parker, Lingwood and Paisley (1968) indicated that colleagues are important source of information for the productive scholars. Colleagues were used

to obtain preprints or unpublished papers. Blau (1973) indicated that collegial discussion about discoveries and problems help stimulate and activate research involvement and interests. Pelz and Andrews (1976) described the factors involved in team motivation and the question of research diversity which characterised the successful teams. Motivation level was highest amongst team leaders or heads of units who voluntarily spent over-time on research and this was reported more by those in academic settings. Diversity in the professional activities helped enhance levels of performance. Scientists who split their time among several R & D functions, basic research, applied research, invention, consultation tended to be rated as making larger scientific contributions, produced more papers, patents and reports. Koenig (1982a, 1982b) compared the results of bibliometric indicators with expert opinion in assessing research performance of 19 pharmaceutical companies and concluded that general bibliometric indicators was not superior to expert judgements. The role of colleagues and its relation to research productivity was also addressed by Braxton (1983) who found that departmental colleague career publications substantially influence an individual's research productivity. Hence the departmental colleagues can either repressed or stimulate a faculty member's level of productivity. Rushton, Murray and Paunonen (1987) proposed an optimum size for a research laboratory to be conducive for productivity. Wallmark et al. (1984) studied the relationship between efficiency with size of research team and maintains that productivity of research laboratories increased without limit as size increases. On the other hand, other study indicated reverse findings

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(Knorr, et al. 1979), and found a negative effect in the natural science units.

(i). Leadership and Departmental /Institutional Management

Departmental environment and faculty leadership – These factors have recently been considered seriously as important predictors of research productivity. Friedrich (1985) recommended that heads of department can help create a healthy climate for scholarship by setting realistic expectations, making scholarly initiatives a departmental ones, beginning with areas where chances of success are high and adopting an individualized approach when dealing with academic staff. Boice (1988) indicated that heads of departments could promote discussion groups, model ideal writing habits, foster communication between staff, and hold writing workshops. The role of the departmental head in encouraging faculty research was also highlighted by Creswell and Brown (1992) who advocated that heads should help provide resources, allocate time for scholarly work, promote, publicise faculty who improved their scholarship, actively engage in interpersonal roles of mentoring, and promote collaboration among academic staff. Barnhill and Linton (1992) provided some insight on how to promote research from the head's perspective, which included: promoting a balance between teaching and research; identifying the best undergraduate students for the staff recruitment programme; encouraging under-represented groups such as females and minorities; establish clear departmental plan and relate how the plan support the department's research role; encourage team research groups; identify what is needed further by the successful team or

beef up the less successful group; and pay attention to current and future needs for expertise. The head is also responsible for creating the right research climate, informing staff of available grants; sharing copies of successful proposals and setting up periodic research seminar. The head's role in mentoring is also high-lighted which goes beyond directing research but includes learning about the interests of faculty members, set occasions to talk to them about their work; and read drafts of their articles. Finally, Barnhill and Linton's (1992) advice for research leadership are as follows: (a) lead by example; (b) lead proactively; (c) lead nationally; (d) search for local resources; (e) encourage interdisciplinary research; (f) encourage industrial collaboration; and (g) advertise departmental research. Jungnickel and Creswell (1994) highlighted the variables that may be related to scholarly performance such as the percent time spent on research, departmental respect and support and the departmental's support for research. In this study the role of the departmental head remains less a force in enhancing scholarly work. Snyder, McLaughlin and Montgomery (1991) identified factors, which contributed to research excellence and focused on institutional correlates such as, the culture and management environment of academic research. The study used telephone survey of 37 outstanding research universities, ranked as the top 100 universities by the 1987 National Science Foundation and aimed to identify management practices currently being used at outstanding research universities and determine whether the management style used were more successful than others. The typical characteristics of the successful department are as follows: insti-

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tutional support of faculties by locating and communicating funding opportunities, help in proposal preparation, provide seed money for new faculty member, provide statistical data on research activity; institutional “cheer leading” role for research, increased resources (increase funding and solicit gifts); and the ability to attract outstanding faculty and graduate students. The research division acted more as a clearing house than as a support or control function; research productivity was increased by setting specific goals and supporting those goals with the necessary resources; recruit and retain outstanding research faculty, monitor progress towards objectives.

Fonseca et al. (1997) identified human factors (human relations in the laboratory, interaction and exchange of ideas with other scientists, the relationships between team members and leaders) as influencing publication productivity. Babu and Singh (1998) found that Indian scientists were of the opinion that leadership behaviour can stimulate research productivity.

Departmental management - The amount of freedom conferred to researchers have also been related to research productivity (Box, Steven and Cotsgrove, 1968). The study investigated the productivity of scientists in modern industrial research laboratories and found a higher level of publication among scientists who were free to select, initiate and terminate their research projects. Scientists who are committed to their laboratory were also important. Commitment here refers to those who considers publication important and the scientific community as their reference group. This high level of commitment to the organisation is a necessary condition

for high level publication. Vollmer (1970) evaluated two aspects of quality in the effectiveness of research programmes. The study reported positive relationship between productivity and organizational freedom. Scientists with the highest level of productivity are more likely to be located at departments where they have freedom to select their own research project and suggested that productivity can thrive under working conditions that is similar to those in research universities or non-profit laboratories. The study by Pelz and Andrews (1976) stressed the importance of organizational freedom as a factor of supporting productivity among scientists. Bland and Ruffin (1992) reviewed the characteristics of research conducive environments and proposed these conditions: research emphasis; a distinctive scholarly culture, a positive group climate; assertive participatory governance; a decentralized organizational structure; frequent communication, accessible resources (particularly manpower) leaders who had expertise as researchers and who used participatory management practices.

(j) Supervision of Graduate Students

Studies have indicated that student supervision helps to increase publication productivity. Berelson (1960) found that the more productive scientists were more likely to have groups of three or more students undertaking research under their supervision than the less productive. Hagstrom (1965) also reported a significant correlation between the number of graduate students and post-doctoral fellows in a professor’s group and his productivity. Other studies have indicated disciplinary variations. Hargens (1975) found differen-

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ces between the disciplines of mathematics, chemistry and political science. About 12% of the mathematicians said that most of their research involved graduate students compared to 28% in political science and 93% in chemistry. Lodahl and Gordon (1972) indicated that physicists and chemists were more willing to work with graduate students than faculty in sociology and political science. Blackburn, Behymer and Hall (1978) reported that those academics who taught graduate students were approximately 6 times as likely to publish 5 or more articles over a 2 year period than those teaching undergraduates.

Woods (1990) explored factors influencing research performance of university academic staff and found that the number of quality postgraduate students was important especially for the scientists. These students helped enrich the research environment through their enthusiasm and new ideas. Other studies that make similar claims are Bean (1982) and Corcoran and Clark (1984).

Kyvik and Smeby (1994) examined the relationship between the supervision of graduate students and university faculty research performance and found that the supervision of Ph.D students who have projects related to their supervisor's research has an independent effect on faculty member's scientific productivity. This is especially so in the natural, medical sciences and technology but not in the humanities and social science. The results generally support data collected on faculty attitude towards the supervision of graduate students. Those who supervise Ph.D. students are considerably more favourable in their assessment of the importance of supervision for their own research than

those who only supervise final year student projects. The proportion of faculty members who indicated that supervising Ph.D. students is part of their own research is much higher in the natural and medical sciences and technology than in the humanities and social sciences. This may be due to the research tradition of the latter fields at the Ph.D level which favour individual research. On the contrary, in the humanities and social sciences, the number of major subject students influences the productivity of their supervisors more than the number of Ph.D. students. When interviewing 51 scientists to identify factors that influence their productivity, Fonseca et al (1997) found the majority of respondents felt that students did influence their productivity.

Problems - There are studies which did not support departmental effect on productivity. Clemente and Sturgis (1974) who studied the quality of the department providing doctoral training and its relationship to research productivity observed only a weak relation. Guston (1973) who investigated the reward system in British science also found no relationship. Fox (1983) pointed out that clear causal relationship was not indicated. It was not clear whether the more productive scientists gravitated toward settings, which provided freedom to select and initiated project or those settings promoted productivity among the scientists located in those places. In her literature review, Fox found that the studies failed to explain how department can influence productivity through the provision of research assistantship, or favourable reward system or a vibrant exchange and communication of ideas between colleagues and associates.

CONCLUSION

It is evident from the amount of literature reported in this section that studies on publication productivity assessment and its correlates have been undertaken since the early 1940's (especially in the European countries and the United States) and continue into the 1990s. The studies also indicate the complex situations, which are associated with publication productivity. The previous studies have not conclusively explained the complex situation of why some academics are publishing more than the others given similar situations and conditions or why some departments are so successful in nurturing its academic members to publish. The studies does however, identify possible correlates which may be related to publication productivity. Publication productivity is affected by a number of determinants, which are interwoven. This review have merely focused on the personal, academic and departmental variables used in previous studies. It is realised that factors such as institutional and communicational correlates are equally important and will be the subject of a future review.

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