Indian Journal of Science and Technology Vol. 5 No. 2 (Feb 2012) ISSN: 0974- 6846

Determinants of scientific productivity among Nigerian University academics

Olufemi B. Obembe
Department of Economics, Obafemi Awolowo University, Ile-Ife, Nigeria.
f_obembe@yahoo.com

Abstract

In light of the static or declining contribution of scientists from the sub-Saharan Africa, especially Nigeria, to the global production of scientific knowledge, this study collected and analyzed cross-sectional data on the scientific productivity of 77 researchers from the faculty of science in two Nigerian universities. Negative binomial and probit econometric methods were utilized for the analysis. Our findings show that academic ranks, conference attendance, membership in the earliest cohort group were significant factors predicting scientific productivity of scientists in the two universities.

Keywords: Academic productivity, research, University, Nigeria.

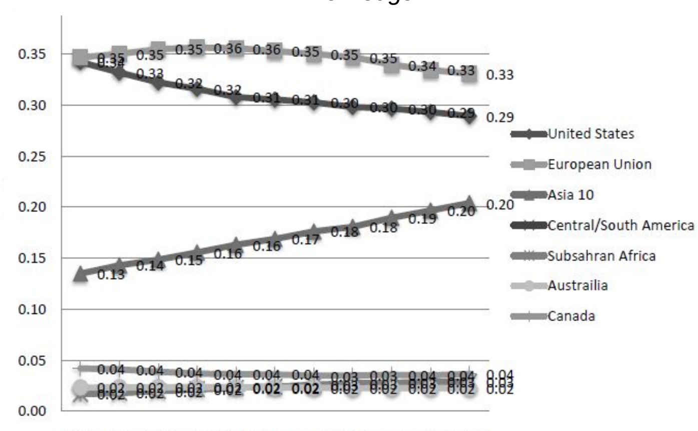
Introduction

The study of the determinants of scientific productivity has attracted the attention of economists around the world for several decades now. According to Stephan (2010), three reasons have elevated the study of economics of science to the frontier of discourse. First, science has been identified as a source of growth which has been corroborated by recent advances in information technology that has contributed significantly to the growth in service sectors in recent years. More so, advancement in the medical research has led to tremendous extension of work and life expectancy. The second reason is the appropriability issue i.e., a feature of knowledge production. Once it is produced and made public, others cannot be excluded from its consumption. Hence, the failure of economies in producing an optimal quantity of knowledge as a public good is of a major concern to economists. Finally, the public nature of research and the spillover inherent in such a system have become fundamental to the concept of endogenous growth theory developed by Paul Romer and others. Despite the wide attention from developed and developing countries on the role of science and technology in development, the topic has received scanty attention from the sub-Saharan African region and in particular Nigeria.

The 1998/99 World Development Report highlighted the role of knowledge in development. Countries that experienced economic growth in the recent decades were found to be those that applied knowledge in their production processes rather than those that accumulated physical capital. Scientific knowledge was found to expand the limits of other factors of production thereby enabling a long run sustainable growth in output. Indeed, most of the economically advanced countries were found to have invested a greater proportion of their annual income on scientific research which eventually paid off in their sustained output growth and consequently improved standard of living. The South/East Asian countries including China were also found to have increased their expenditure on R&D which has also brought economic prosperity to them.

In the game of world knowledge production, the sub-Saharan African countries, of which Nigeria is one have, however, remained dormant. Fig.1 provides a vivid picture of the world distribution of scientific production between 1995 and 2005 among the regions of the world. The picture clearly shows that the European Union countries put together and the United States of America continue to dominate knowledge production. The proportion of scientific production attributed to the sub-Saharan African countries did not exceed 3 percent throughout the review period. Incidentally, sub-Saharan African countries remain virtually the only region of the world where incidence of poverty is still at a very high level.

Fig. 1. Distribution of production of world scientific knowledge



Source: Thompson Scientific, May 2007

This picture is consistent with the idea that the long-run sustainable growth and development of the sub-Saharan African countries lies in the application of science and technology in their production process. While the role of Foreign Direct Investment (FDI) has often been emphasized, the development of local capability to complement the FDI is critical. Hence, universities and research institutes remain a prominent option in ensuring that this region of the world is lifted from poverty. The universities possess great physical and human assets required for production of Research and Development (R&D) which can be used to enhance the growth and

Indian Journal of Science and Technology Vol. 5 No. 2 (Feb 2012) ISSN: 0974- 6846

efficiency of Small and Medium scale Enterprises (SMEs). Moreover, given the uncertain nature of R&D, large scale firms can afford themselves the opportunity of forging collaborations with the universities in developing new products and technology. The effective cultivation of the innovative potentials inherent in the university system will go a long way in promoting growth with poverty reduction in developing countries.

This study is thus motivated by an interest in studying the determinants of scientific productivity among Nigerian academics with a view to making necessary policy recommendations for long term sustainable growth and development.

The remaining part of this study is divided into four parts. Part two reviews the literature, while section three described the methodology; section four presents the analysis of data and results while the final section presents the summary, conclusions and recommendations

Literature Review

Scientific productivity

Two major outcomes are typically used to measure scientific productivity; patents and publications. Because patents are not common among Nigerian academics, we focus on publications. Levin and Stephan (1989) observed that when publications are used as a measure of productivity, five major indices are normally constructed. These includes; (1) the counts of journal-publications made in the preceding two-year period (2) counts adjusted for co-authorship in the two-year period (3) counts adjusted for the impact factor of the journal in which publications appeared (4) scientists author-and quality-adjusted count of journal publications and (5) a dichotomous variable of 1 if the author publishes at least one paper in the two year period and equal to zero otherwise. In our study, we have adopted the first approach to measuring productivity. However, instead of using the counts of publications in the immediate 2-year period, we extend it to 5-year period because of infrastructural problems encountered by researchers in publishing in Nigeria such as, epileptic electricity supplies, poor internet connectivity and poor general operating environment which are not usually experienced by developed countries. Hence, we assumed that five-year period would be a better time frame for examining the count of productivity of researchers. Furthermore, we feel that the role of co-authorship may assign the same weight both for the real author and the collaborating author. In Nigeria, it is not that uncommon for a scientist to write a paper and include as a co-author of someone who did not participate in the production of the paper. Hence, we created a second dichotomous variable that captures actual participation in research by measuring whether or not the individual submitted a proposal for external funding. We tried to find out from the questionnaire whether a researcher came up with one or more research proposals to attract external funding in the immediate five-year year period. This we assume will provide a clarification on the first count variable used to measure our productivity.

Age and scientific productivity

The economic explanation of the relationship between age and scientific productivity is rooted in the human capital model, where human capital investment is presumed to decline over time due to the finiteness of life which results in an inverted-U shaped pattern of scientific productivity (Stephan, 1996). Empirical support has been found for this relationship through some cross-sectional studies in which productivity of older scientists was compared with those of younger scientists. Bernier et al (1975) found that productivity in terms of publications and citations peaked at age 40-44 in a sample of American chemical engineers. Cole (1979), also, analyzing a cross section of American scientists from six different fields, found a curvilinear relationship with both quantity and quality of scientific productivity. Moreover, Levin and Stephan (1989) found that older scientists published less than their youngest peers. In physiology and biochemistry, older scientists publish less than their middle-aged colleagues.

Gender and scientific productivity

The common finding on the relationship between gender and scientific productivity is that women publish less than men. Rebne (1990), in a study based on 1980 survey data of faculty from UCLA HERI, confirmed that women tend to produce less research than men across disciplines in accordance with previous research work (Astin, 1978; Long, 1978; Cole, 1979; Vasil, 1996).

Experience and scientific productivity

Experience is usually measured by career age, this is strongly correlated with the chronological age of the researchers. Rank is also sometimes used as a measure of experience. Career age refers to the number of years a researcher has accumulated in the career. A study by Rebne (1990) suggested that publishing increases sharply within the first ten years of work, while a decline to below average performance tends to set in after 25-30 years of activity. This was confirmed by Goodwin and Sauer (1995) in a study of 140 tenured professors of economics.

Some other studies have tried to examine the relationship between professional rank and productivity. Holley (1977) found a significant difference between the productivity of pre-tenured output and post-tenured output. Pre-tenured researchers were found to produce more than post-tenured researchers in most instances. In Nigeria, academic positions are not classified as tenured. Rather, they are classified in terms of Professors, Associate Professors, Senior Lecturer, lecturer 1, lecturer 2, Assistant lecturer and graduate Assistant. Researchers from the rank of Graduate assistants to lecturer 2 are usually designated as training positions. In our study, therefore, we have tried to compare research productivity of other status to that of professors. Some studies have documented a correlation between academic rank and research productivity. Blackburn *et al.* (1978) in a study of American scientists showed that professors were more proficient in publishing than Associate Professors, while Disckson (1983) and Kyvik (1990) confirmed the same results for a sample of Canadian scientists.

Educational quality

Jones and Preusz (1993) in a survey of 833 researchers found a significant correlation between perceived proficiencies in research methodology and techniques attained at training stages with scientific productivity. In our own study, we have tried to capture educational quality of the researchers by class of degree obtained at first degree level. We categorized those with first class and second class upper division degrees in one group and those below second class upper division degree into another group.

Cohort effects and productivity

The different cohorts in which researchers belong are presumed to exercise some effect on scientific productivity. Stephan (2008) identified two types of cohort effects that may affect productivity. One, changes in the knowledge base is presumed to affect productivity. Those who are educated at a latter period were assumed to be better educated than those educated at a much earlier period due to a secular progression of knowledge. Two, fluctuations in the job market could also exert some influence on productivity. Certain graduates employed at a particular time may have easier access to resources than those employed when job openings in the research sector are few. The study by Levin and Stephan (1991) did not find empirical support for the hypothesis that those in the latest cohort with updated knowledge were more productive than those in the much earlier cohort. In terms of fluctuations in the labour market, Oyer (2006) found that initial career placement which was related to job market conditions was an important determinant of careers of economists which supported the cohort effect hypothesis.

In our study, we have grouped our researchers into 4 different cohorts. Our groupings were influenced by the fluctuations experienced by the Nigerian economy between 1970s and current time. The 1970s was a very good period for Nigerian academics up till the late '70s when there was a crash in the price of Nigeria's crude oil that caused a serious economic crisis. The 1980s was not so good for the educational sector, even up till mid-1990s. The academics were able to engage in negotiations in the late 1990s which led to some relief for the sector. In consideration of these fluctuations, four cohort groups can be identified in Nigeria, these include; 1970-1980, 1981-1990, 1991-2000, 2001-2009. From the classifications, the first and final cohorts represents periods of economic prosperity for the academics, while the second and third cohorts were periods of poor economic environments for the academics.

Scientific disciplines and productivity

Scientometrics provides some insights on the differentials existing between academic disciplines and productivity. The peak in scientific productivity has been found to occur at different ages depending on the disciplines (Weiss & Lillard, 1982; Levin & Stephan, 1991). The average number of publications of a productive researcher also varies consecutively by field. In our study, we have thus categorized scientific disciplines into three areas; the first category comprises physics, mathematics and electronics; the second comprises microbiology, botany, plant and animal science; while the third includes chemistry, biochemistry and pharmacy.

Funding

Funding for research is usually advocated for on the grounds of appropriability. Given the fact that knowledge is a public good which may be acquired at no cost by third parties, it is argued that without adequate support for the knowledge producers, the society may in the long run be short-changed of a socially desirable level of knowledge production. Empirical evidence has shown that research grants exert a positive impact on scientific productivity (Stephan, 1996; Lee & Bozeman, 2005).

Collaboration (conference attendance)

The sharing of ideas and complementary relationships among researchers has long been recognized as major contributors to synergies resulting in collaborative projects (Avital & Collopy, 2001). Collaboration of researchers is presumed to enhance scientific productivity. Sources of collaboration include, number and extent of one's ongoing contacts with peers, joint research initiatives, conference participation and consulting. Avital and Collopy (2001) explained that participation in conferences indicates a level of exposure to the field's community and current research. It provides one with the opportunity to attain a direct impression of current research, to meet with active members in the field and to identify new partners for collaborations. A significant correlation between research productivity and interactions with colleagues was reported by Jones and Preusz (1993).

Data and methodology

This study makes use of a cross-sectional approach in estimating the determinants of scientific productivity. A well structured questionnaire was administered to scientists in the field of science at two universities in Nigeria–Obafemi Awolowo University and University of Ibadan. These two universities were part of the first

Indian Journal of Science and Technology Vol. 5 No. 2 (Feb 2012) ISSN: 0974- 6846

generation universities in Nigeria, more so, they both have an age-long culture of scientific research in Nigeria. In a sense, results emanating from these two universities could reasonably represent what goes on in other universities in Nigeria. Out of the 200 questionnaires administered, 77 (38.5%) of them were completed and returned; about 70 per cent of the respondents were from Obafemi Awolowo University, Ile-Ife while the remaining 30 per cent were from University of Ibadan.

Model Specification

Based on our literature review, our model is specified as follows:

$$FYRP/FRP = b_0 + b_1 Age + b_2 Agesq + b_3 Ability + b_4 Gender + b_5 Rank + b_6 Cohort + b_7 Conference\ attendance + b_8 Field + b_9 Grant + b_{10} Promotion + b_{11} Prestige\ of\ Institution + b_{12} Number\ of\ Children \quad \text{------(1)}$$

$$SRPF = b_0 + b_1 Age + b_2 Agesq + b_3 Ability + b_4 Gender + b_5 Rank + b_6 Cohort + b_7 Conference\ attendance + b_8 Field + b_9 Grant + b_{10} Promotion + b_{11} Prestige\ of\ Institution + b_{12} Number\ of\ Children \text{-- (2)}$$

Independent variables (Chart 1)

Productivity, the dependent variable is measured by three variables: i) the count of publications in the previous five years (FYRP), ii) the count of foreign publications presented for promotion to current academic status, iii) a dichotomous variable added for scientists that produced a research proposal for external funding in the recent years (SRPF). SRPF = 1, if research proposal was produced and 0 otherwise.

We adopted the Negative binomial regression and probit models for our analysis. We ran three regressions for equation 1. The first one was as specified above; in the second, we replaced age and agesq with age brackets and in the third, we replaced the age brackets with the cohort variable. Similarly we did the same thing in the second model, which has a dichotomous dependent. Scientists with research proposals submitted for external funding were categorized in one group labeled 1, while others were labeled 0. We also ran different regressions to examine the impact of age and cohort effects on productivity of the scientists.

Chart 1. Independent variables

Variables	Definitions
Productivity	FYRP = counts of publication in the last five years
	FRP = counts of foreign publication presented for promotion to current status.
	SRPF = Submit Research Proposal for Funding
Age	Chronological age of researchers in years
Age 1	Less than 36 years = 1, others = 0
Age 2	Between 36 and 39 years = 1, others = 0
Age 3	Between 40 and 44 years = 1, others = 0
Age 4	Between 45 and 49 years = 1, others = 0
Age 5	Between 50 and 54 years = 1, others = 0
Age 6	Between 55 and 59 years = 1, others = 0
Age 7	Greater than 59 years = 1; others 0
Gender	1 = male; 0 = female
Ability	1 = First Class/Second class Upper; 0 = below second class upper
Experience	Number of years since employed in academics
Children	Count of number of children of the researchers
Professional Status	1 = Prof; 0 = others 1 = Associate Prof; 0 = others 1 = Senior lecturer; 0 = others 1 = lecturer 1; 0 = others 1 = less than lecturer 1; 0 = others
Collaboration	1 = attended conference; 0 = did not attend conference
Foreign grant	1 = received grant; 0 = did not receive grant
Cohort Group	1 = 1970-1979; 0 = others 1 = 1980 - 1989; 0 = others 1 = 1990 - 1999; 0 = others 1 = 2000 - 2009; 0 = others
Fields of Study	1 = Chemistry/chemistry-related; 0 = others 1 = Biology/Biology-related; 0 = others 1 = Physics/physics related; 0 = others

Fig. 2. Number of publications in the past five years.

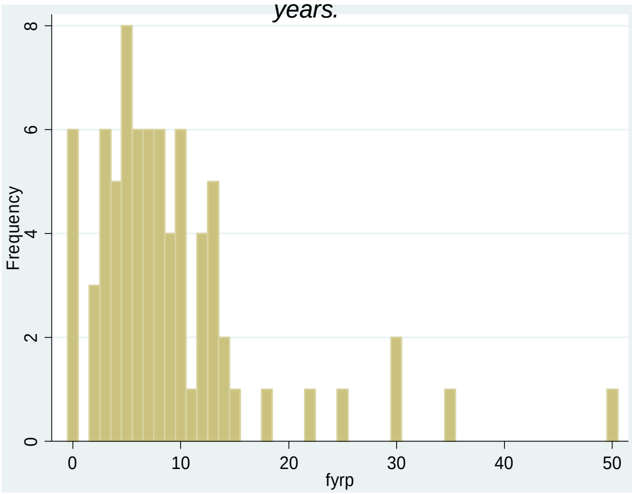
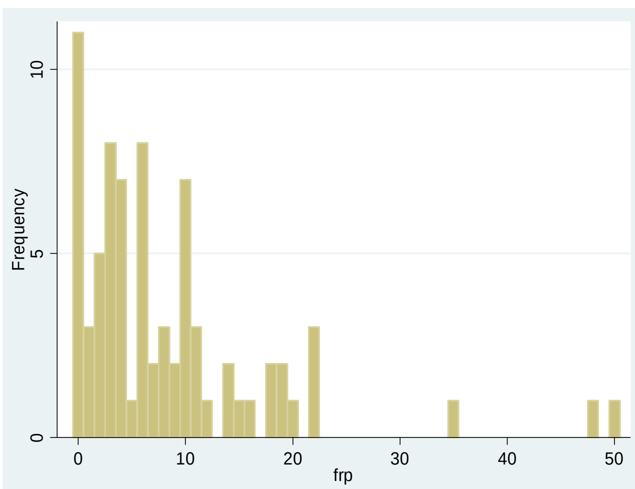


Fig. 3. Number of foreign publications submitted for current status



Data analysis and presentation of results

Descriptive statistics

Table 1 presents the descriptive statistics of the variables. The age distribution shows that the mean age of the scientist was 46.12 years with a minimum of 31 years and a maximum of 64 years. A further analysis of the age distribution according to the age brackets shows that 3.9 per cent were less than 36 years, while 16.9 percent were aged between 36 and 39 years, 27.3 were between 40 and 44 years, 19.5 per cent were between 45 and 49 years, 14.3 per cent were between 50 and 54 years, 5.2 per cent were between 54 and 59 years and 12 per cent were over 59 years old. The results show that the bulk of the researchers who responded to the survey were from the age of 40 to 44 years followed by those between the ages of 45 to 48 years. The smallest proportion of researchers responding was those less than 36 years. The bulk of the researchers interviewed were those who we believe belong to the age group most actively engaged in research activities.

The distribution of scientists among the four major cohort groups shows that the highest proportion of the researchers accounting for 45.5 per cent belongs to cohort 2 followed by cohort 1 with 31.2 per cent and cohort 3 with 31.2 per cent. The least number of scientists belong to the 4th cohort.

The gender composition shows that 77.9 per cent of the researchers were male while the remaining 22.1 per cent were female. The distribution of number of children shows an average of 2.96 with a minimum of 0 and maximum of 9 children. Promotion was measured by the average number of years it took to earn a promotion. The result shows a mean of 5.65 years with a minimum of 0 years and maximum of 14 years. In our survey, 41.6 percent of the scientists have participated in foreign conferences in the past five years while the remaining 58.4 per cent did not attend any international conference. Moreover, only 14.3 per cent of the scientists got their PhD awarded from outside Nigeria while most of them accounting for 85.7 per cent, got their Ph.D. awarded from Nigerian universities. About 49.4 per cent of the

Table 1. Summary Statistics of the variables

	Mean	Std. Dev.
5-year publications counts	8.987	8.281
Foreign publications to status	8.434	9.589
Ability (Second class Upper/First Class)	0.649	0.481
Age (years)	46.143	8.246
Age1 (<36 yrs)	0.039	0.195
Age2 (36-39 yrs)	0.169	0.377
Age3 (40-44 yrs)	0.273	0.448
Age4 (45-49 yrs)	0.195	0.399
Age5 (50-54 yrs)	0.143	0.352
Age6 (55-59 yrs)	0.052	0.224
Age7 (>59 yrs)	0.130	0.338
Cohort 1 (1970-1979)	0.312	0.466
Cohort 2 (1980-1989)	0.455	0.501
Cohort 3 (1990-1999)	0.143	0.352
Cohort 4 (2000-2009)	0.091	0.290
Professor	0.130	0.338
Associate Professor	0.091	0.290
Senior Lecturer	0.234	0.425
Lecturer 1	0.364	0.484
Below Lecturer 1	0.182	0.389
Field 1 (Drug production related)	0.299	0.460
Field 2 (Agriculture related)	0.416	0.496
Field 3 (Fundamental science)	0.403	0.494
Number of children	2.961	1.802
Experience (years)	15.558	8.841
Promotion (Average number of yrs/promotion)	5.647	3.151
Gender (Male)	0.779	0.417
Conference attendance	0.416	0.496
Foreign Ph.D.	0.143	0.352
Grant	0.494	1.021

Table 2. Negative Binomial Regression Results (accounting for age effect)

	FYRP	dy/dx	FRP	dy/dx
Intercept	2.2417 (0.4676)[a]		3.0884 (0.3601)[a]	
Ability	-0.1188 (0.1864)	-0.8873 (1.3983)	-0.0428 (0.1913)	-0.2324 (1.0438)
Age1 (<36 yrs)	0.0552 (0.7675)	0.4155 (5.9282)	-0.2190 (0.9303)	-1.0702 (4.1053)
Age2 (36-39 yrs)	0.0666 (0.4962)	0.5001 (3.8047)	0.0378 (0.4516)	0.2066 (2.4978)
Age3 (40-44 yrs)	0.1544 (0.4134)	1.1744 (3.2462)	0.2202 (0.3821)	1.2506 (2.2674)
Age4 (45-49 yrs)	-0.3013 (0.4575)	-2.0260 (2.8564)	0.1156 (0.4114)	0.6464 (2.3740)
Age5 (50-54 yrs)	0.2867 (0.3602)	2.3370 (3.2395)	-0.3913 (0.3146)	-0.8486 (1.3210)
Age6 (55-59 yrs)	0.3569 (0.3618)	3.0891 (3.6734)	0.1259 (0.2932)	0.7192 (1.7711)
Associate Professor	-0.3993 (0.4010)	-2.5062 (2.1563)	-0.8150 (0.2143)[a]	-3.2411 (0.6566)[a]
Senior Lecturer	-0.0791 (0.3490)	-0.5687 (2.4599)	-1.4442 (0.2290)[a]	-5.8027 (0.7959)[a]
Lecturer 1	-0.4701 (0.4500)	-3.2528 (2.9482)	-2.3089 (0.3518)[a]	-11.0341 (1.7159)[a]
Below Lecturer 1	-1.4645 (0.4848)[a]	-7.3888 (1.7440)[a]	-3.3116 (0.4375)[a]	-9.5668 (0.8316)[a]
Field 1	0.1528 (0.2154)	1.1570 (1.7063)	0.4201 (0.1524)[a]	2.4804 (1.0348)[b]
Field 2	0.0195 (0.1405)	-0.1431 (1.0351)	0.2828 (0.1434)[b]	1.5711 (0.8165)[b]
Number of children	-0.0391 (0.0434)	-0.2868 (0.3158)	-0.0148 (0.0485)	-0.0800 (0.2626)
Promotion	0.0203 (0.0276)	0.1490 (0.1997)	0.0396 (0.0263)	0.2134 (0.1380)
Gender	0.0121 (0.1814)	0.0887 (1.3226)	0.1137 (0.1474)	0.5949 (0.7526)
Conference attendance	0.4383 (0.1315)[a]	3.3564 (1.0504)[a]	-0.0471 (0.1167)	-0.2530 (0.6270)
Foreign PhD	-0.2535 (0.3375)	-1.6991 (2.0982)	-0.6112 (0.3497)[c]	-2.6735 (1.2635)[b]
Grant	0.1060 (0.0671)	0.7780 (0.4953)	0.0646 (0.0635)	0.3486 (0.3484)

FYRP = Number of publications in the past five years.
FRP = Number of foreign papers presented for current status

scientists have also won international grants while 50.6 per cent did not win any grant in the recent 5 years.

The distribution of scientists according to their academic ranks shows that the latest group 36.4 per cent belongs to the rank of lecturer 1. This was followed by 23.4 per cent in the rank of senior lecturers and 18.0 per cent who were below lecturer 1. The smallest group 9.1 per cent were professors.

The fields of studies included in the survey were grouped into three. The first group comprises chemistry, biochemistry and pharmacy departments. The second group comprises plant science, animal science, botany and microbiology, while the third group comprises physics, mathematics and electronics engineering. The highest proportion of the researchers 41.6 per cent were from the second group, field 2. This was followed by the third group, field 3, with 40.3 per cent of the researchers while field 1 comprises 29.9 per cent of the researchers.

Table 3. Negative Binomial Regression Results (accounting for Cohort effect)

	FYRP	dy/dx	FRP	dy/dx
Intercept	2.1019 (0.4544)[a]		3.0742 (0.3284)[a]	
Ability	-0.2787 (0.1428)[b]	-2.1188 (1.1130)[b]	-0.0262 (0.1620)	-0.1438 (0.8921)
Cohort 1 (1970-1979)	0.9918 (0.4582)[b]	9.1439 (5.3844)[b]	-0.4694 (0.3527)	-2.3616 (1.6211)
Cohort 2 (1980-1989)	0.2807 (0.4254)	2.0729 (3.1735)	-0.3674 (0.2800)	-1.9915 (1.5288)
Cohort 3 (1990-1999)	0.3165 (0.3658)	2.5891 (3.3425)	-0.1295 (0.2419)	-0.6769 (1.2138)
Associate Professor	-0.5422 (0.3888)	-3.2024 (1.8545)[b]	-0.7178 (0.2758)[a]	-2.9927 (0.8688)[a]
Senior Lecturer	-0.3292 (0.3014)	-2.2072 (1.8809)	-1.0144 (0.2284)[a]	-4.4326 (0.8973)[a]
Lecturer 1	-1.0161 (0.3859)[a]	-6.6628 (2.4058)[a]	-1.8014 (0.2952)[a]	-8.6601 (1.4420)[a]
Below Lecturer 1	-2.31907 (0.4580)[a]	-10.0606 (1.4439)[a]	-2.7355 (0.4328)[a]	-8.4654 (0.9986)[a]
Field 1	0.1465 (0.2175)	1.0985 (1.6927)	0.3925 (0.1718)[b]	2.3344 (1.1772)[b]
Field 2	0.0155 (0.1568)	0.1130 (1.1433)	0.2666 (0.1413)[c]	1.4986 (0.8214)[c]
Number of children	-0.0478 (0.0391)	-0.3477 (0.2827)	0.0306 (0.0357)	0.1675 (0.1929)
Promotion	0.0718 (0.0276)[a]	0.5228 (0.1990)[a]	-0.0005 (0.0324)	-0.0028 (0.1771)
Gender	0.0069 (0.1687)	0.0505 (1.2234)	0.2231 (0.1514)	1.1497 (0.7482)
Conference attendance	0.4934 (0.1323)[a]	3.7717 (1.0624)[a]	-0.0519 (0.1200)	-0.2826 (0.6533)
Foreign PhD	-0.2937 (0.3014)	-1.9254 (1.8107)	-0.5832 (0.2438)[b]	-2.6096 (0.9151)[a]
Grant	0.0288 (0.0638)	0.2096 (0.4638)	0.0677 (0.0562)	0.3704 (0.3093)

FYRP *= Number of publications in the past five years.*
FRP *= Number of foreign papers presented for current status*

Econometric results

The distribution plot of the counts of publications of researchers in the previous 5 years is presented in Fig. 2 and Fig. 3. The figure suggests using Poisson, maximum likelihood or negative binomial models. Results from Poisson regression reject the model. Hence, we adopted the negative binomial regression model for the first equation. The second equation is a dichotomous one, so we adopted the probit regression model. The econometric results are presented in tables 2 to 7. The results of the Negative binomial model for number of publications were presented in Table 2 to Table 4. The difference between the tables is that the age brackets were used in Table 2, while it was replaced with cohort effect in Table 3. In table 4, they were replaced with age and age-square. Similarly, econometric results presented in Table 5 to Table 7 follow

Indian Journal of Science and Technology Vol. 5 No. 2 (Feb 2012) ISSN: 0974- 6846

the same pattern. However, we adopted the probit model for the analysis, whereby scientists were dichotomized into two groups according to their productivity. A scientist who was able to come up with a research proposal and sent out for possible funding in the previous five years was assumed to be productive and hence classified as 1, while those who had not presented any proposal for funding were categorized into the second group and labeled zero in the dichotomous model.

Table 4. Negative Binomial Regression Results

	FYRP	dy/dx	FRP	dy/dx
Intercept	4.6714 (3.0741)		4.6714 (3.0741)	
Ability	-0.0530 (0.1956)	-0.3360 (0.1775)[c]	-0.0530 (0.1956)	-0.0293 (1.0871)
Age	-0.0783 (0.1335)	-0.0174 (0.1647)	-0.0783 (0.1335)	-0.4295 (0.7390)
Age^2	0.0009 (0.0014)	-0.0001 (0.0018)	0.0009 (0.0014)	0.0047 (0.0079)
Associate Professor	-0.8649 (0.2384)[a]	-0.3818 (0.3954)	-0.8649 (0.2384)[a]	-3.4391 (0.7038)[a]
Senior Lecturer	-1.1616 (0.2586)[a]	-0.3587 (0.3200)	-1.1616 (0.2586)[a]	-4.9620 (0.9427)[a]
Lecturer 1	-2.0170 (0.3710)[a]	-0.9039 (0.4160)[b]	-2.0170 (0.3710)[a]	-9.7367 (1.7462)[a]
Below Lecturer 1	-3.0335 (0.4562)[a]	-2.0557 (0.4362)[a]	-3.0335 (0.4562)[a]	-9.1303 (0.9332)[a]
Field 1	0.3589 (0.1681)[b]	0.2773 (0.2256)	0.3589 (0.1681)[b]	2.1246 (1.1311)[c]
Field 2	0.2524 (0.1424)[c]	0.0434 (0.1580)	0.2524 (0.1423)[c]	1.4207 (0.8154)[c]
Number of children	0.0268 (0.0379)	-0.0546 (0.0408)	0.2367 (0.0379)	0.1468 (0.2059)
Promotion	0.0131 (0.0263)	0.0566 (0.0279)[b]	0.0131 (0.0263)	0.0718 (0.1427)
Gender	0.1741 (0.1587)	0.1300 (0.1811)	0.1741 (0.1587)	0.9113 (0.8047)
Conference attendance	-0.0456 (0.1204)	0.4445 (0.1499)[a]	-0.0456 (0.1204)	-0.2495 (0.6567)
Foreign PhD	-0.6347 (0.3432)[c]	-0.1509 (0.3943)	-0.6347 (0.3432)[c]	-2.8022 (1.2655)[b]
Grant	0.0577 (0.0620)	0.0774 (0.0676)	0.0577 (0.0620)	0.3162 (0.3447)

First, we looked at the effect of age and cohort effects; we examined the age effects separately from the cohort effect to avoid the problem of identification as discussed by Hall *et al.* (2005). The age effect is presented in Tables 2 and 4, while the cohort effect is presented in Tables 3 and 6. We collapsed the age brackets into one variable in addition to its square in Table 4. The first table presenting the result of the Negative binomial model with number of publications as the dependent variable shows that age had no significant impact on scientific productivity. Likewise, in table 4, age and $(age)^2$ also did not have a significant impact on productivity. However, in the probit model presented in

Table 5, age was found to have a negative impact on productivity but this was only significant for scientists in the age brackets (45-49 years) and (50-54 years). Moreover in Table 7, where we collapsed the age brackets into one single variable, the probit model shows that age had a negative and significant impact on productivity. Moreover, a positive and significant non-linear relationship was also recorded. This implies that productivity of scientists increases with age up to a point beyond which it starts to decline, the turning point was found to be 44 years.

Table 5. Probit Regression results accounting for age effects Dependent Variable: Submitted a Research Proposal for funding (SRPF) = 1, otherwise = 0

	(SRPF)	dy/dx
Intercept	1.3229 (1.5868)	
Ability	0.3776 (0.4808)	0.1365 (0.1767)
Age2 (36-39 yrs)	-1.4097 (1.4825)	-0.5189 (0.4673)
Age3 (40-44 yrs)	-1.5709 (1.3467)	-0.5627 (0.4093)
Age4 (45-49 yrs)	-1.9265 (-1.9265)	-0.6629 (0.3607)[b]
Age5 (50-54 yrs)	-1.9044 (1.1666)	-0.6512 (0.2650)[b]
Age6 (55-59 yrs)	-1.1625 (1.1534)	-0.4388 (0.3834)
Associate Professor	-0.5771 (1.2292)	-0.2200 (0.4780)
Senior Lecturer	-0.4037 (1.1032)	-0.1487 (0.4126)
Lecturer 1	-0.9313 (1.1625)	-0.3358 (0.4017)
Below Lecturer 1	-1.3692 (1.3637)	-0.5064 (0.4318)
Field 1	0.6328 (0.5630)	0.2065 (0.1706)
Field 2	-0.0815 (0.4719)	-0.0289 (0.1682)
Number of children	0.0297 (0.1295)	0.0105 (0.0457)
Promotion	0.0863 (0.0796)	0.0305 (0.0282)
Gender	-0.05688 (0.04926)	-0.1822 (0.1393)
Conference attendance	0.9303 (0.4139)[b]	0.3089 (0.1239)[b]
Foreign PhD	-2.0733 (1.3771)	-0.6830 (0.2742)[b]
Grant	1.5214 (0.6152)[b]	0.5386 (0.1749)[a]

The results with the cohort effects are presented in Tables 3 and 6. In Table 3 the Negative binomial results show that the earliest cohorts, i.e. scientists employed in the 1970s when the Nigerian labour market was still very robust, produced more articles than the latest cohort. At 5 per cent level of significance, scientists employed in 1970s wrote 9.14 more articles than scientists in the latest cohort. However, in the probit model, none of the cohort variable was significantly related to the dependent variable.

Table 6. Probit Regression results accounting for cohort effects Dependent Variable: Submitted a Research Proposal for funding (SRPF) = 1, otherwise = 0

	(SRPF)	dy/dx
Intercept	0.2917 (1.3740)	
Ability	0.0215 (0.4477)	0.0073 (0.1524)
Cohort 1 (1970-1979)	0.8007 (1.3698)	0.2431 (0.3605)
Cohort 2 (1980-1989)	0.0778 (1.1926)	0.0263 (0.4021)
Cohort 3 (1990-1999)	0.6224 (1.1049)	0.1802 (0.2583)
Associate Professor	-0.6976 (1.2883)	-0.2623 (0.4990)
Senior Lecturer	-0.8951 (1.1522)	-0.3281 (0.4205)
Lecturer 1	-1.8224 (1.2715)	-0.6134 (0.3458)
Below Lecturer 1	-2.0714 (1.4013)	-0.6978 (0.3114)[b]
Field 1	0.5918 (0.5020)	0.1847 (0.1457)
Field 2	-0.0602 (0.4852)	-0.0205 (0.1653)
Number of children	-0.0030 (0.1198)	-0.0010 (0.0406)
Promotion	0.0981) (0.0837)	0.0332 (0.0285)
Gender	-0.5554 (0.4960)	-0.1692 (0.1312)
Conference attendance	0.9829 (0.4129)[b]	0.3095 (1153)[a]
Foreign PhD	-0.8875 (0.9519)	-0.3327 (0.3570)
Grant	1.3325 (0.5017)[a]	0.4517 (0.1332)[a]

Next, we considered the impact of researchers' ability on productivity. We expected researchers with second class upper degree and above to be more productive than those with less than second class upper degree. However, results from the count model suggest the contrary. Tables 3 and 4 show that scientists with first and second class upper division degrees were less productive than those with degrees that were below second class upper division. However, in the probit model, the opposite result was obtained. Scientists with first class and second class upper division were found to be more productive than those with less than second class upper division degree, although this was statistically insignificant.

The result of the impact of academic rank on productivity revealed that professors were more productive than researchers of other academic ranks. In the Negative binomial results presented in table 2, the result was found to be significant for only researchers below the rank of lecturer 1 when we considered the count of publication in the previous five years. However, when we considered the counts of foreign publications, the results were found to be significant for all the other

Table 7. Probit Regression Dependent Variable: Submitted a Research Proposal for funding (SRPF) = 1, otherwise = 0

	SRPF	dy/dx
Intercept	18.2179 (8.8657)[a]	
Ability	0.3678 (0.4548)	0.1288 (0.1627)
Age	-0.8196 (0.3984)[b]	-0.2801 (0.1375)[b]
Age^2	0.0087 (0.0042)[b]	0.0087 (0.0042)[b]
Associate Professor	-0.3241 (1.0742)	-0.1178 (0.4058)
Senior Lecturer	-0.1950 (1.0976)	-0.0684 (0.3920)
Lecturer 1	-0.7952 (1.1465)	-0.2810 (0.4005)
Below Lecturer 1	-1.3951 (1.3145)	-0.5118 (0.4278)
Field 1	0.7691 (0.5215)	0.2273 (0.1458)
Field 2	-0.0993 (0.4604)	-0.0341 (0.1586)
Number of children	0.0600 (0.1253)	0.0205 (0.0428)
Promotion	0.0932 (0.0744)	0.0319 (0.0254)
Gender	-0.4194 (0.4729)	-0.1328 (0.1365)
Conference attendance	1.0288 (0.4120)[a]	0.3253 (0.1171)[a]
Foreign PhD	-2.0223 (1.1560)[c]	-0.6814 (0.2515)[a]
Grant	1.4901 (0.5494)[a]	0.5092 (0.1440)[a]

academic ranks. This result is in support of the works conducted in the United States by Blackburn *et al.* (1978) and Dickson (1983) for Canadian researchers and Kyvik (1990) for Norwegian universities. However, in the probit model, the impact of academic rank was not statistically significant.

The analysis of impact of field of studies on productivity shows that researchers in the field of chemistry, biochemistry and pharmacy grouped as field 1 and those in the field of plant and animal science, microbiology and botany, grouped as field 2 were found to be more productive than researchers in field 3 comprising physics, electronics and mathematics. In the negative binomial model comprising the age classification variables, researchers in field 1 were found to write 2.48 more articles, while those in field 2 wrote 1.57 more articles than those in field three. In the second model comprising the cohort effect variable and third model where the age brackets were collapsed into one variable, the results were basically not different from the first model. However, when we dichotomize the researchers into two, i.e. researchers who had been able to come up with research proposals for possible external financing and those who did not have any, our results changed. First, researchers in field 2 were found to be less productive than researchers in field 3. However, none of the results was found to be statistically significant. The results are consistent with the observation that fields vary in terms of patterns of publication. However, when it comes to producing papers that could attract possible funding, there wass no significant difference among the three fields of studies.

The impact of number of children on scientific productivity was not significant in all our specifications, although our results fluctuated between positive and negative signs. In the negative binomial specification, the results were basically negative while in the probit model, the results were basically positive, but none of them had a significant impact on productivity.

The role of promotion in scientific productivity was examined by computing the average number of years it took to earn a promotion and subsequently uncovering the effect of that on productivity. In our first specification in which the age brackets were considered, promotion was found to have a positive but not significant impact on productivity. However, in the second specification where we replaced the age effect with the cohort effect, promotion was found to exert a positive and significant impact on productivity, at 1 per cent level of significance, one level of promotion leads to an increase of 0.52 papers. We need to exercise caution however in interpreting this result, because of the possible presence of endogeneity, in which promotion may lead to higher productivity while productivity may also lead to promotion.

Productivity was not found to vary by gender. In our Negative binomial model specifications, men were found to be more productive than women, while in our probit models, men were found to be less productive than women. These findings were not significant.

Participation at international conferences was found to exert a positive impact on productivity. In our first specification accounting for the age effects and using the Negative binomial model, those who participated in conferences were found to write 3.36 more articles than those who did not participate, this result was also confirmed when we accounted for the cohort effect. In our binomial specifications in which those who had produced one or more research proposal for funding, those who had participated in conferences were also found to be more productive than those who had not. At 1 per cent level of significance, those that were exposed to foreign conferences were about 32 per cent more productive than those who were not.

The impact of the country of award of PhD was found to play a significant role in scientific productivity. Ex-ante, we expected that researchers who got their PhD awarded from Europe, especially UK, and those from North America, would be more productive than those from Nigeria. However, the opposite was the case for our sample. In all our specifications, foreign PhD holders were found to be less productive than Nigerian PhD holders. In our first specification, at 5 per cent level of significance, foreign PhD holders were found to write 2.67 fewer articles than their local counterparts considering their counts of foreign publications. This was also true of our second specification where the cohort effect was specified to replace the age effect in the first specification. In the third specification also, where the age categories were collapsed into one variable, our results still remained virtually unchanged. In the probit model, our result was consistent with those found in the Negative binomial specification. However, the result shows that foreign PhD holders wrote 68 per cent less articles than the Nigerian PhD holders. Our results support that of Gonzalez-Brambila and Veloso (2007) in a study of Mexican researchers. A possible explanation for this result in Nigeria may be attributed to possible frustration on the part of foreign trained scientists who upon arrival in Nigeria, had to face adverse research environment.

Access to foreign grants was found to be compatible with scientific productivity. In all our specifications, foreign grants were found to exert a positive impact on productivity. However, was only significant in the probit specification models. At a 1 per cent level of significance, those with foreign grants were found to write about 45-50 per cent more articles than those without grant.

Summary conclusions and recommendations

This work examined the determinants of scientific productivity among a cross section of Nigerian academics in two universities in Nigeria. Given the confounding effect of age and cohort effect in a cross sectional study, we decided to specify our models accounting for age effects and cohort effects separately. Our findings revealed that age has no significant impact on scientific productivity when we considered the counts of publications in the previous five years, while the cohort effect had a positive and significant effect. Our results seem to confirm Levin and Stephan (1991) suggestion that age does very little in explaining scientific productivity. However, when we considered a researcher's productivity in terms of their ability to come up with research proposals for possible external funding, age was found to have a negative impact on productivity, while the cohort effect still had a positive but not significant impact on productivity.

Field of research was also found to have a significant impact on scientific productivity. Scientists in the field of chemistry, bio-chemistry, pharmacy, and those in the field of plant science, animal science, microbiology were found to be more productive that those in the field of physics, mathematics and electronics. Our results attest to the fact that knowledge generation and diffusion may be more universal in certain fields than others. The exact sciences comprising biology, health sciences and chemistry can produce articles more easily than those in the fundamental sciences.

Conference attendance was found to have a positive impact on productivity. Researchers who attended international conference in the previous years were found to be more productive than those who did not attend, although the result may reflect endogeneity, it suggests that the government and policy makers could boost productivity by putting in place programmes to support attendance at international conferences.

The place of experience cannot be underplayed in scientific productivity. This is well manifested in academic rank of the researchers. Researchers below the rank of professors were found to be less productive than the professors. The higher productivity of the professors may be explained by virtue of the fact that they supervise more graduate students which results in more articles than lecturers below the rank of professors.

In line with findings from this study, the following policy recommendations are made. First, given the importance of conference attendance in scientific productivity, we recommend that government should establish a funding mechanism that will greatly expose Nigerian scientists to international conferences. In fact, international conference attendance should be a component of postgraduate training especially in the field of science. More so, there may be a need for the government and universities to establish collaborations with universities abroad, especially in the United States of America and United Kingdom. This will no doubt enhance scientific productivity of Nigerian academics.

Furthermore, given the fact that professors were more productive than other cadres of academics, there is a need for government to quickly extend the retiring age of professors as demanded by the Academic Staff Union of Universities (ASUU) from 60 to 70 years. This will definitely be in the best interest of the universities and Nigeria as a country in general.

These results, however, should not be taken as conclusive as our sample size may be too small to generalize findings from this work. Moreover, this study is a cross sectional one which may omit several other factors contributing to scientific productivity.

Acknowledgements

I wish to express my profound appreciation to the following people. First, Carolyn McClain Young for the sponsorship of my postdoctoral training at Georgia State University, second, is Professor Paula Stephan of the same university for the mentoring in this field of study. I really appreciate all the comments and suggestions she offered. I also want to express my appreciation to those who helped in the administration of the questionnaires. These include; Kelvin Olabanji and his colleagues at the department of economics, Obafemi Awolowo University, Ile-Ife Nigeria. Finally, I thank my reviewers for the useful suggestions made.

References

1. Astin HS (1978) Factors affecting women's scholarly productivity. In: The Higher education of women : Essays in honor of Rosemary Parks, Astin HS & Hirsch WZ (Eds.), Praeger, NY.
2. Avital M and Collopy F (2001) Assessing research performance: Implications for selection and motivation, case western reserve university, USA. Sprouts: Working Paper on Information Sys. 1(14). http://sprouts.aisnet.org/1-14.
3. Bernier C, Gill W and Hunt R (1975) Measures of excellence of engineering and science departments: A chemical engineering example. *Chem. Eng. Edu. Vol? 194-197.*
4. Blackburn RT, Behymer CE and Hall DE (1978) Correlates of faculty publications. *Sociol. Edu.* 51(2), 132-141.
5. Cole S (1979) Age and scientific performance. *The Amer. J. Sociol.*, 84(4), 958-977.
6. Dickson VA (1983) The determinants of publications rates of faculty members at a Canadian university. *Can. J. Higher Edu.*13(2), 41-49.
7. Goodwin TH and Sauer RD (1995) Life cycle productivity in academics research: Evidence from cumulative publication histories of academic economists. *Southern Econom. J.* 61(3), 728-743.
8. Holley JW (1977) Tenure and research productivity. *J. Higher Edu*. 6(2), 181-192.
9. Jones JE and Preusz GC (1993) Attitudinal factors associated with individual faculty research productivity in academic dentistry. *Perceptual & Motor Skills*. 76, 1191-1198.
10. Kyvik S (1990) Motherhood and scientific productivity, *Social Studies of Sci.* 20(1), 149-160.
11. Lee S and Bozeman B (2005) The impact of research collaboration on scientific productivity. *Social Studies of Sci.* 35, 673-702.
12. Levin SG and Stephan PE (1989) Age and research productivity of academic scientists. *Res. in Higher Edu.* 30, 5.
13. Levin SG and Stephan PE (1991) Research productivity over the life cycle: Evidence for academic scientists, *Amer. Econom. Rev.* 81(1), 114-132.
14. Long JS (1978) Productivity and academic position in the scientific career. *American Sociol. Rev.* 43(12).
15. Oyer P (2006) Initial labour market conditions and long-term outcomes for economists, *J. Econom. Perspec.* 20(3), 143-160.
16. Stephan P (1996) The economics of science. *J. Econom. Literature*. 34, 1199-1235.
17. Stephan P (2008) Job market effects on scientific productivity. In: Scientific competition, Albert M, Schmidtchen DD & Voigt S (Eds), Mohr Siebeck, Tubingen.
18. Stephan PE (2010) The economics of science, In: Handbook of the economics of innovation–Vol-1, Bronwyn H & Nathan Rosenberg, Acad. Press, Burlington. pp: 217-274.
19. Rebne D (1990) Determinants of individual productivity: A study of academic researchers. *Inst. Indust. Relations Publi. Center*, UCLA.
20. Vasil L (1996) Social process skills and career achievements among male and female academics. *J. Higher Edu.* 67(1), 103-114.
21. Weiss Y and Lillard L (1982) Output variability, academic labor contracts, and waiting times for promotion. *Res. Labor Econom.* 5, 157-188.