



Is patenting activity impeding the academic performance of South African University researchers?

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A B S T R A C T

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The present study investigates whether activities related to the patenting of inventions impede or are in conflict with the academic performance of university professors, particularly the publication or the production of public knowledge. The Poisson regression model is used taking into account the confounding effects of other variables deemed to affect the publication productivity, viz.; research/faculty orientation, collaboration, etc. The study is conducted in South Africa, where university R&D is highly funded by the private sector, compared to other countries, viz. USA, UK, Germany, etc. Furthermore, within the South African institutions of learning, there are more incentives to publish than to invent. It is found that: (i) inventiveness and academic performance can co-exist and re-enforce each other, (ii) professors who are inventive have a broader network of researchers-collaborators and (iii) perform highly academically (from the NRF-rating perspective) and publish more than those who do not invent at all.

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1. Introduction

The relevance of the university research to the needs of society is increasing the interests in the phenomenon of the entrepreneurial university. Universities are thus undergoing transformations that broaden their traditional mission of teaching, conducting basic research and delivering public service. Universities are becoming more and more active participants in regional and national economic development through technology transfer, and commercialization of their research outputs [1–5]. This situation can well explain the high priority expressed towards the benefit of the short-range perspective of research results in many higher education institutions. This generally results in a strong interest for a proper follow-up of ideas from university research to significant applications in commerce or in industry [6,7].

Other scholars, for example, Slaughter and Rhoades [8] and Vavakova [9] have however raised concerns and pessimism based on the view that the increased interest in research activities of commercial value can mislead and negatively affect the core mission of a university: that of teaching and producing public knowledge.

Universities are thus challenged to respond to the interest of the society and industry as well as of the faculty and the students. An interesting way forward, would be the one which has been put forward by, for example, Guldradsen and Smeby [10] and Wallmark [11]. Those authors suggest that universities should increase the patenting activities and relevant skills through inventions while still retaining the proper balance between fundamental and applied research.

The present study assumes that activities leading to patenting of inventions and academic performance, including the production of public knowledge can co-exist peacefully. The foregoing assumption is based on previous studies showing that

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the commercialization of scientific research does not affect the capacity of firms to produce public knowledge [12], and can even be associated with an increase in the publication capacity of academic researchers [13,14].

The main objective of this work is to investigate whether inventive activities impede, or are in conflict with, academic performance, particularly the capacity of South African University researchers to teach and train future researchers and produce public knowledge. The study first identifies the inventive activities of the academics of five South African universities. The inventive activity is measured by the number of patent applications. Only domestic patent applications, i.e. those applied to CIPRO (Company and Intellectual Property Registration Office) for the last 10 years, are considered.

The academic performance or the capacity of producing public knowledge of the identified inventors is then examined. To this end, the research performances of professors, in the form of rankings, are first identified from the National Research Foundation (NRF)-rating electronic database. The number of articles published in the peer-reviewed journals by those researchers over the past 10 years (obtained from the ISI Science database) is then identified. Finally a control group of professors is created and the academic performances of the two groups are compared.

First, a summary of the South African patent system and the NRF evaluation and rating system are given in sub-sections 1.1 and 1.2, respectively. Next, follow: a brief theoretical background (section 2), a description of data (section 3), a layout of the research design and methodology (section 4), a discussion (section 5) and a conclusion (section 6).

1.1. Overview of the context of research and technology transfer in the South African institutions of higher learning

Technology transfer activity in the South African higher education institutions is in its early stages. Some of these institutions, for example, the University of Pretoria, the University of the Witwatersrand, Johannesburg, the University of Cape Town, the University of Stellenbosch, etc. have operating Technology Transfer Offices, though those are still in their early stage of development and not comparable to their sister offices in developed countries.

The technology transfer activities in the South African higher education institutions are small in size. That is believed to negatively affect the performance of innovative activities, such as patenting, licensing, creation of start-up companies in those institutions. The country's industrial R&D intensity in general is categorized as low relative to the international standard, and this can partly be attributed to environment that is not conducive to research. In a survey conducted by Pouris, South African heads of research, managers of technology transfer stations, deans of faculty, university chancellors, were interviewed about issues of technology transfer. The survey found a low industrial demand for research coupled with low research capacity in the higher education sector. It is believed that universities may face capacity constraints in future as both local and international demands for universities' services are increasing above universities' ability.

The country's higher education sector's R&D dependence on business enterprise funding is more than five times the average of that of the OECD countries. Twenty percent of R&D expenditures of the median institution in South Africa come from business sectors. On average, 50% universities expenditures come from the same business sector. For comparison, the AUTM (2004) survey [15] in the USA revealed that the average dependence on industry is 7.5%. Another survey conducted in the UK shows that university dependence on industry is only 5.8% [16]. There is thus fear amongst many university principals, deans, and public policy makers, etc. that, in long-term, such strong dependence can shift the academic R&D away from basic and long-term, mission oriented research towards short-term industry relevant consultancy and research in South Africa. These fears are also mirrored through the asymmetry in incentives devoted to academic excellence outputs, particularly publishing journal articles and innovative excellence output, e.g., patenting, licensing, creation of spin-off firms, and other technology transfer activities. The idea that rewards will be bestowed on academics based on publication alone, for example, is certain. These rewards range from increase in financial support, i.e., 8–75% of the subsidy either for research account or as a supplement to their salaries, recognition, job promotion, etc. These are uncertain and not well defined in the case of technology transfer related activities. This situation can partly explain why academics are more inclined to publishing than to technology transfer activities. In most institutions, royalties from intellectual property rights are shared among faculty/department and inventor(s). Among other reasons believed to be inhibiting technology transfer activities are: the lack of sufficient time; other duties such as teaching, administration, etc.; lack of sufficient government supports; negative perception of university work by industry; lack of broad and sufficient cooperative innovative activities with industry; scarcity among faculties of personnel with prior business and management background and/or experience. By comparison, for example, only 17% of faculties in South African universities have business backgrounds while, in the UK 34% are from a business background [16].

Some progress has been made. A recent bill aiming at promoting the IPR capacity in publicly financed research institutions is noteworthy, though still currently under consideration in Parliament. The targeted publicly-financed institutions include: the Agricultural Research Council, the Council for Geoscience, the Council for Industrial and Scientific Research, the Council for Mineral Technology, the Human Sciences Research Council, the Medical Research Council, the National Research Foundation, the South African Bureau of Standards and the Water Research Commission. The higher education institutions are also targeted. Among other important things, the bill aims, for example, at:

- (1) Defining the right of the state of IP derived publicly financed research.
- (2) Providing for a uniform system of IP management through establishment of the function of a National IP Management Office.

- (3) Providing for more effective protection of IP emanating from publicly funded research.
- (4) Giving preference to small micro medium enterprise and broad based black economic empowerment entities in granting licenses to commercialize IP derived from publicly financed research.
- (5) Providing for benefit sharing by inventor employees, and their institutions in the economic benefits flowing from publicly financed IP.

The Act is expected to be applicable to the following categories of IP coming from publicly financed research:

- (1) Patentable inventions as defined under the Patent Act, 1978 (Act No 57 of 1978)
- (2) One or more of the following in as far as they form an integral part of a patentable invention under the Patent Act, 1978 (Act No 57 of 1978):
 - (i) Copyrights in any work related to patentable invention as defined in the copyright Act 1978 (Act No 98 of 1978)
 - (ii) Aesthetic and functional design related to patentable inventions, as defined in the Design Act, 1993 (Act No 195 of 1993)
 - (iii) A mark related to patentable inventions as defined in the Trade Mark Act, 1993 (Act No 194 of 1993).

The Act shall extend the protection of copyright, aesthetic and functional designs, or marks which form an integral part of a non-patentable invention. The Act shall also extend to the protection of basic scientific research results that are capable of forming the basis for a patentable invention but are not yet capable of protection under the patent Act, 1978 (Act No 57 of 1978) due to them falling within the prohibition of Section 25 (2) (a)–(c) and (e)–(g) excluding (d) of the Patent Act, 1978 (Act No 57 of 1978).

The South African Patent System is administered by CIPRO (Company and Intellectual Property Registration Office) located in Pretoria, South Africa. In terms of the South African Patent Act (1978), a patent application may be filed by inventors, applicants or through the assistance of an expert in the patent matter (e.g. an attorney). South Africa is one of the 124 countries that accept the Patent Cooperation Treaty (PCT), allowing individuals to file an application at both local and international levels. Internationally, the treaty designates the countries in which applications are feasible (<http://www.cipro.co.za>).

Copies of patent applications and some patents granted are compiled in registers which are accessible to public. Registers are in many volumes and are arranged chronologically in CIPRO's library. Indexes and cards are available in the library and can facilitate the search of patent applications, grants, and other intellectual property information. An electronic database of intellectual property, like patents, copyright, etc. is in the development phase and does not cover all the information available. Core information in patent application files appears in the following order: application number (and date), type of application (complete or provisional), title of application, name(s) of applicant(s), name(s) of inventor(s), country of priority, priority number, and priority date.

1.2. *The NRF-rating and evaluation system*

The NRF evaluation and rating system was developed in South Africa and has been in operation since 1984. The approach yields ratings resulting from an extensive, deep, and long-term evaluation by peers going beyond the traditional quantitative bibliometric counts and integrating various researchers' inputs. The process of evaluating and rating researchers, is conducted by national and international peers/reviewers, and is based primarily on the quality of the research outputs during the past seven years. Research outputs could include publications in peer-reviewed journals, books or chapters in books, peer-reviewed published conference proceedings, other significant conference proceedings including published abstracts, keynote or plenary addresses, patents, artifacts and products, technical and other reports. Other measurable outputs that could be considered include annotated bibliographies, CD-ROMS, development and production of software, electronic publications, plant breeding rights, research guides, vaccines, web sites, etc. The research outputs are made available by the researcher upon request but appropriate and concise descriptions are to be included in the application for evaluation and rating.

The assessment period for which research outputs are considered for evaluation is seven years. The closing date on 28 February 2007, for example, is taken from 1 January 2000 to 31 December 2006. Further research outputs amounting to a maximum of the ten best research outputs of the period proceeding the last ten years could also be included. The assessment panels include members of respective specialist committees, an independent assessor, and a chairperson who is either a member of the NRF executive or a researcher of international repute. The role of the specialist committees is to assess, based on the reviewers' comments, the standing of applicants amongst their peers and to assign ratings to applicants on the basis of the statements contained in the reviewers' reports. The objectivity of the foregoing reports is also assessed in the light of the factual information included in the submitted documents.

Key research areas include: Animal and Veterinary Sciences, Anthropology, Development Studies, Geography, Sociology and Social Work, Biochemistry, Chemistry, Communication, Media Studies, Library and Information Sciences, Earth Sciences, Economics, Management, Administration and Accounting, Education, Engineering, Health Sciences, Historical

Studies, Law, Literary Studies, Languages and Linguistics, Mathematical Sciences, Microbiology and Plant Pathology, Performing and Creative Arts, Physics, Plant Sciences, Political Sciences, Policy Studies and Philosophy, Psychology, and Religious Studies.

Applicants select the assessment panel relevant to their application. The role of the assessment panels in the evaluation process is to make recommendations to the NRF based on the assessment of the reviewers' report. Members of these panels do not act as peers of the applicants. The assessment is purely based on: (i) the quality of the research-based outputs of the last seven years as well as the impact of the applicant's work in his/her field and how it has impacted on adjacent fields, (ii) an assessment of the applicant's standing as a researcher in terms of both a South African and international perspective, (iii) the quality and appropriateness of the journals, books, conference proceedings, etc. in which the applicants' work is published, and (iv) other research-based contributions. The rating categories include (Web version of NRF Evaluation Dataset) [17] the following.

1.2.1. *A-rated (leading internationally acclaimed researchers)*

Researchers who are unequivocally recognized by their peers as leading international scholars in their field for the high quality and impact of their recent research outputs. The category A includes two sub-categories A1 and A2. A1 are researchers who are recognized as leading scholars in their field internationally for the high quality and wide impact beyond a narrow field of specialization of their recent research outputs. A2 are researchers who are recognized as leading scholars in their field internationally for the high quality of their research outputs.

1.2.2. *B-rated (internationally acclaimed researchers)*

These are researchers who enjoy considerable international recognition by their peers for the high quality of their recent research outputs. Reviewers are convinced that the applicant is an independent researcher enjoying considerable international recognition for the high quality and impact of his recent research outputs. The category B has three sub-categories B1, B2, and B3, but these are not described here.

1.2.3. *C-rated (established researchers)*

These are researchers with a sustained recent record of productivity in the field who are recognized by their peers as having: (i) produced a body of quality work, the core of which has coherence and attests to ongoing engagement with the field, and (ii) demonstrated the ability to conceptualize problems and apply research methods to investigating them. This category has three sub-categories: C1, C2, and C3 but these are not detailed here.

1.2.4. *P-rated (promising young researchers)*

They are normally researchers younger than 35 years of age, who have held the doctorate or equivalent qualification for less than 5 years at the time of application. Based on the exceptional potential demonstrated in their published doctoral work and of their research outputs in their early post-doctoral careers these researchers are considered likely to become future leaders in their field.

1.2.5. *Y-rated (Young researchers)*

They are normally younger than 35 years and have held the doctorate or equivalent qualification for less than 5 years at the time of application. They are recognized as having the potential to establish themselves as researchers within a five-year period after evaluation. This recognition is based on their performance and productivity as researchers during their doctoral studies and/or early post-doctoral careers.

1.2.6. *L-rated (Late entrant researchers)*

Persons normally younger than 55 years, who previously were established as researchers or who previously demonstrated potential through their own research products. These researchers are considered to be capable of fully re-establishing themselves as researchers within a five-year period after evaluation. Candidates in this category are South African citizens or foreign nationals who have been residents in South Africa for five years during which time they have been unable for practical reasons to realize their potential as researchers. Candidates eligible in this group are: black researchers, female researchers, researchers employed in a higher education institution that lacked a research environment, or researchers who were previously established as researchers and who have returned to a research environment.

2. Theory

2.1. *Factors that can influence the performance of a university professor*

2.1.1. *Collaboration (and network of collaborators)*

It is assumed in this study that through proprietary research and patenting of inventions, university researchers can become a pole of attraction through which a wide array of networks can be established and consolidated with research institutions including industry, governments, etc. Such networks considerably facilitate bi-directional diffusion and transfer of tangible and intangible assets between the university and other stakeholders. Through a research sponsored project, for example, the university can learn industry or market needs. Through collaborations, feed-back, peer-review, audition, or

other means of evaluating and communicating research outcomes, university researchers can gain various skills and those can only leverage his overall performance.

The value of knowledge and technology produced in formal or informal networks of scientists depends on the conjoining of equipment, material resources, organizational, and institutional arrangements for work and the unique scientific and technical human capital embodied in individuals. At individual scientist, discipline, field or network level, the value is the capacity to create new knowledge and technology [18]. Networks of social relations can increase the efficiency of information diffusion by minimizing redundancy, typically those characterized by weak ties [19].

Collaboration or network is part of a researcher's social capital. Some authors have suggested that social capital in the form of high levels of trust diminishes the probability of opportunism and reduces the need for costly monitoring of the learning process and thus reduces the cost. Social capital encourages cooperative behavior, thereby facilitating the development of new forms of association and innovative organization. The concept, therefore, is central to the understanding of institutional dynamics, innovation, and value creation [19].

According to Moran and Ghoshal and in line with Schumper's view, all new resources, including knowledge, are created through two major generic processes: combination and exchange. Exchange of information amongst network members is the key benefit that can be obtained from the network capital. Elements previously unconnected are combined or novel ways of combining elements previously associated are developed either incrementally or radically. As those resources and/or elements are held by different parties, exchange is a prerequisite for their combination, and so is the knowledge thus created. This exchange could involve, for example, the transfer of explicit knowledge, either individually or collectively held, as is the case in the exchange of information within the scientific community or via the internet.

The present work assumes that innovative professors can attract other researchers from industry, academia, and government research institutions and thus obtain a wide network of collaborators. We agree with the view of Rigby and Edler [20] that collaboration between researchers can improve the research quality through peer review-like mechanism. We then suggest that the capacity to publish and the inventiveness can peacefully co-exist within the same individual and the same institution.

Most collaborating organizations seek from their partners' resources and complementary technological capabilities needed to improve their performance [21,22]. The crucial role of scientists' career in establishing the social capital has been given considerable weight by several scholars [18,19]. Their view implies that through relationships between firm and scientists and engineers, a transfer of a scientist's social capital in addition to his or her human capital to the firm is facilitated.

Professors with industrial funding generally collaborate more than their colleagues with no external funding do [10]. They develop broader collaboration and co-operate more frequently with groups outside of the higher education sector. This feature is believed to result from subsequent funding arrangements and requirements. It may also be tied to broader developments towards triple helix networks of knowledge production where university research becomes more relevant and accessible to society. These collaborations can, further, build up a capacity for shared problem solving and for developing technological knowledge that can potentially satisfy demanding expectations and meet market requirements.

Research materials, equipments, and services are usually expensive and require external funds. It has been observed that researchers with high scientific quality works are very likely to attract industry and take many external contracts [22] and thus have at their disposal means for conducting research. This can be an additional explanation of why professors with external funding generally produce more scientific outputs compared to colleagues with no such funding. Researchers with industrial collaboration appear to be more likely to produce results of both commercial value and high scientific quality [10].

2.1.2. *Research orientation*

Most science, technology and innovation scholars consider the difference in research field orientation, culture, etc. while comparing the performance of the latter.

The core assumption here is that science based fields publish more compared to the traditional engineering or purely technical oriented fields. The latter are inclined to consult, and commercialize their results than to publish.

The bibliometric results used to measure the publication capacity, notably at the aggregate level of a department, may thus refer to specific circumstances (e.g. publication habits) within a department, but also to the internal characteristics of the research field in which the department is active. Bibliometric methods focus specifically on the research task and, more in particular, on the contribution to the development of knowledge at the international research front [23]. The SCI, produced by the Institute for Scientific Information (ISI) in Philadelphia covers the core, i.e., most journals in the natural and life sciences. The SCI coverage of scientific journals is often regarded as less adequate in the more technical or applied fields of science (these are usually communicated in conference proceedings and reports) than in basic natural and life science disciplines. Such proceedings often appear in conference books and consequently they are hardly covered by SCI.

SCI also contains non-journal material, such as published proceedings, multi-authored books, monographs and thematic collections of papers. SCI journals are an important communication medium for most science based disciplines and thus covers most technological sectors under our investigation, i.e. chemicals, polymers, materials, electronics, microbiology, pharmacy, and biotechnology. An increasing number of conference proceedings are being published in regular journals (often as special issues).

2.2. *Hypothesis*

The following hypothesis is put forward based on the literature review: Inventiveness does not impede the academic productivity of a university professor.

3. Data

The overall research design is to investigate whether inventiveness can impede the productivity of a university professor. There are three major sources of data: patent applications from CIPRO, publication data from the ISI web of science, and the details of the professors obtained from their CVs. The ISI Web of Science was extensively used to obtain the number of publications for each professor. The name and the initials as well as the address or the affiliation of each author/inventor (professor) were appropriately entered on the Science Citation Index Expanded (SCI-EXPANDED) database to obtain the number of publications for the time span under consideration (1996–2000).

3.1. Data source

Five universities, with intense patent activities, including Stellenbosch University (SUN), University of Pretoria (UP), University of Cape Town (UCT), University of the North-West (UNNW), and University of Witwatersrand (WITS) were investigated. It appeared that for the last 10 years, South African universities have very few patent applications abroad (USPTO and EPO). This prompted us to focus our investigation on domestic patenting activities as indicated by patent applications to CIPRO. The present study is the first that uses data from CIPRO. The present study focuses on university-owned patents where inventors are employed by universities. Patents were collected and investigated for the period 1996–2006. Hard copies of application files have been obtained from the Patent file Database, at CIPRO (Company and Intellectual Property Registration Office) in Pretoria. The patent application indexes, cards, and registration book were also used for verification of accuracy. Applications were counted manually and covered the whole year, i.e. from January to December. For the year 2006, the count went up to July. Details about application dates, names, and addresses of inventor and co-inventor(s), applicants and assignees were obtained from the application files. For each claim, only the provisional application was used to avoid double or multiple counts. Complete applications were only used when the provisional was not available. Additional details of applicants, faculties and inventors were obtained from university and faculty web sites. Names of professors with patents and of those of a control group with no patents were obtained from faculty web sites and their NRF-rating (categories) were obtained from the NRF-evaluation and rating database.

3.2. Measures

Variables specification

- 1) Inventiveness (Inv). $Inv = 1$ for professor(s) who had at least a patent application. $Inv = 0$ for professor(s) with 0 patent application. Inventiveness is measured through patent application counts.
- 2) Publication capacity (Y). This is measured through the number of publications counts.
- 3) Collaborative capacity (L). It is measured through count of the number of co-author(s) that appear on a journal article. The professor (inventor or non-inventor) whose collaborative capacity was investigated was not considered in the count of co-author(s).
- 4) Faculty orientation (F). $F = 1$ for professors from the faculty of natural science, pharmacy or medical fields. $F = 0$ for the professors from the faculty of engineering or technology.

4. Research design and methodology

The SAS GENMOD procedure for the Poisson regression model is used to model the association between publication profiles (Y) of inventive and non-inventive professors, as dependent variable and inventiveness and non-inventiveness as independent variables. Other independent variables including collaboration (L) and research orientation of a professor (F) are also considered in the model.

5. Results and discussion

From the 213 patent applications obtained for the five universities, the University of Pretoria had the highest patent activities with 31% and was followed by the University of Stellenbosch, which had 26.3%. The University of Witwatersrand had 17.4%, the University of Cape Town, 17% and the University of the NorthWest was the last with 8.5%. It is important to point out that the number of patent applications at CIPRO for all the institutions of higher learning from 1996 to 2006 was about 244. Fifty-eight of those have also been filed abroad (USPTO and/or WIPO) and patents where South African was listed as the inventor(s) or co-inventor(s) in foreign patents (USPTO, EPO and/or WIPO) number about 70.

The results show that inventors of all patents are NRF-rated (see Table A1 in [appendix](#)). This means that peer-reviewers collectively acknowledge the contribution of the inventors academic progress, as clearly illustrated in Table 1, which presents the NRF-rating, or scores, of an (experimental) group made of inventive professors.

Table 1
NRF-rating of inventive professors.

| Rank | Number of professors |
|---------|----------------------|
| A-rated | 3 |
| B-rated | 17 |
| C-rated | 10 |
| P-rated | – |
| Y-rated | – |
| L-rated | – |
| Total | 30 |

NOTE: the scale parameter was held fixed.

These ratings clearly suggest that inventive professors are further established researchers, and internationally recognized as being independent and leading scholars. Most inventors who are not rated have completely moved into the industry (in South Africa or abroad) or have retired.

To find out whether patenting inventions impede, or are in conflict, with publication of articles, we then model the publication profiles of two groups of professors in peer-reviewed journal articles from 1996 to 2006. The two groups of professors have been selected from the departments with the highest inventive activities.

Each group contains 30 professors from the 5 South African universities under investigation, Stellenbosch University (SUN), the University of Cape Town (UCT), the University of Pretoria (UP), the University of the North-West (UNNW) and the University of the Witwatersrand (WITS). All professors are predominantly male and are mainly aged between 45 and 65 years. All professors have been employed by at least one of the 5 universities and have been randomly selected from the departments with more inventive activities. These are: Botany, Biochemistry, Chemistry, Chemical Engineering, Civil Engineering, Electrical, Electronic and Computer Engineering, Mechanical Engineering, Metallurgical Engineering, Microbiology, Molecular and Cell Biology, and Physics and Nutrition. Professors of the control group have no patent applications and all professors of the experimental group have been patenting inventions for the past ten years.

First, we analyzed the publication and co-publication profiles of the two groups of professors.

Fig. 1 compares the publication profiles of inventive and non-inventive professors. It appears that the two distributions are positively skewed and generally follow the same trend, though the profile of inventors is higher than that of non-inventors.

Fig. 2 compares the co-publication/co-authorship profiles of inventive and non-inventive professors. It appears that the two distributions are positively skewed and generally follow the same trend, though the profile of inventors is higher than that of non-inventors.

We then model the publication profiles of inventive and non-inventive professors using the Poisson regression, using the log as a link function. The analysis of the parameter estimates for the model and their levels of significance (see Table A2 in the

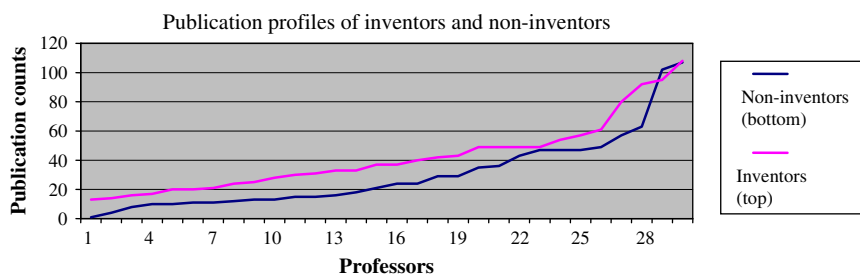


Fig. 1. Publication profiles of inventive and non-inventive professors.

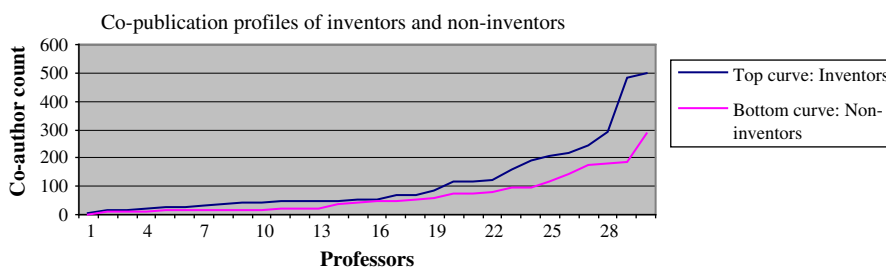


Fig. 2. Co-publication profiles of inventive and non-inventive professors.

appendix) reveals that there is a (i) strong positive effect of the inventiveness on the publication performance (p -value: 0.0029), (ii) a strong positive effect of faculty orientation on the publication performance (p -value: 0.0128) and (iii) a strong positive effect of collaboration on publication performance (p -value: <0.0001). It is worth mentioning that amongst the population of inventors there were 15 professors from the faculty of engineering and 15 from the faculty of science. Within the population of non-inventors, there were 21 professors from the faculty of science and 9 from the faculty of engineering. This is evidence that the composition of the sample did not affect negatively or unfairly the performance of non-inventors with regard to faculty orientation.

6. Conclusion

The perception that entrepreneurship, particularly the conduct of market relevant research and inventing, impede academic excellence, i.e., basic research, teaching and publishing in universities, of course, calls for an in-depth policy enquiry, particularly in those countries where these perceptions prevail for reasonable science and technology policy making.

The aim of this study was to investigate whether patenting activity is an impediment to the capacity of South African university researchers to produce public knowledge.

It is worth noting that in South Africa, on one hand, university R&D is dominantly funded by the private sector, unlike in many developed countries, such as the USA, UK, Germany, etc. On the other hand, within the foregoing institutions of learning, there are more incentives to publish than to invent, as discussed in Section 1.1. This configuration significantly compels most professors to orient their research programs more into the applied or market relevant than in basic research fields. Professors researching in market relevant fields, particularly inventors or innovators are perceived as useful to industry and are thus more likely to qualify for industry grants than those who entirely lecture or invest into basic research. Innovative professors receive more grants than non-innovative professors, as they can still publish their results in various journal articles, in addition to financial support, and other incentives that other university researchers receive from university and/or government funding bodies. This allows the former professors to attract to their research centers more post graduate and doctoral student-researchers, local and international research fellows, as well as visitors amongst the international leading or star researchers; regularly attend national as well as international conferences. These professors also attend regular seminars in local industries and thus build a broad social capital based on their network of collaborators.

We used both the NRF-rating and the publication counts of professors as performance metrics of professors. It is found that there is no convincing evidence to support the pessimistic idea that patenting impedes the academic performance of the university researchers. Most inventors are NRF-rated and those who are not, have completely moved into industry (in South Africa or abroad). It is important to note that the NRF-rating data gives just a qualitative (a pilot) indication of the academic capacity of a researcher. These are not considered in the model as they include both the dependent and the independent variables.

The quantitative evidence suggests that the two activities, i.e. patenting and academic performance, particularly publication activity, can peacefully co-exist and may even re-enforce each other. Professors who are active in patenting activities are also academically performing as those whose entire careers are dedicated to the production of public knowledge and teaching.

Research orientation, in the present context, has a significant effect on the publication performance. Professors from the faculty of engineering publish less than professors from the faculty of science.

The publication count results show that inventors publish slightly more than non-inventors do. Inventor(s) collaborate or co-publish slightly more than non-inventor(s), although the trends of the two groups are much similar (Fig. 2). The inventiveness effect may thus be increasing the network of collaborators and this has the potential to promote and facilitate the spill over or transfer of knowledge that can leverage the publication capacity. In a recent work, Lubango and Pouris [24] found that professors with previous industry working experience were more inventive than those who do not have such experience in South African higher education institutions. This observation was in line with those of Bozeman and Corley [19,24,25], which showed that professors who have previous industry working experience have broader social networks, broader social capital, and stronger ties with industry and funding bodies than those whose entire career has been spent in a university. It is thus believed that previous industry working experience not only increases technical capital but also increases social networks and social capital of a researcher which can be translated in research outputs of higher national and international standards. One of the reasons believed to increase the performance of professors who invent is that their career trajectory exposes them to business and industry or private sector environments. They can thus easily build large networks and strong ties, with peers and various types of researchers in various and strategic areas of their field, through which knowledge flows and grows and resulting higher productivity.

Publication and patenting are not in conflict although some have a confounding effect on collaboration/co-publication of professors have been identified. This can be regarded as a possible difference between South Africa and other countries which are substantially supported by industry and emphasize less basic research. We also suggest that the context of research in South African higher institutions of learning where there are more incentives to publish than to patent or innovate (as explained in Section 1.2) can be motivating inventors to publish. When conducted concurrently, in the context of countries such as South Africa, inventive activities can strengthen, and not reduce, publication capacity of university professors.

Appendix.

Table A1

Distribution of patent applications by departments from 1996 to 2006 and the NRFratings.

| Department | Number of applications and NRFratings (in brackets - Yes = 1, No = 0) | | | | |
|----------------------------|---|---------|---------|---------|---------|
| | UP | UCT | WITS | SUN | UNNW |
| Biochemistry | 3 (3) | 1 (1) | - | 4 (4) | - |
| Biomedical Engineering | - | 3 (3) | - | - | - |
| Botany | 4 (4) | - | - | - | - |
| Chemical Engineering | 10 (10) | 5 (5) | 5 (5) | 2 (2) | 5 (5) |
| Chemical Pathology | - | 3 (3) | - | - | - |
| Chemistry | 1 (1) | 1 (1) | 1 (1) | 10 (10) | 2 (2) |
| Civil Engineering | 2 (2) | 1 (1) | 2 (2) | 1 (1) | 1 (1) |
| EEC* Engineering | 11 (11) | 1 (1) | 2 (2) | 10 (10) | 7 (7) |
| Educational Psychology | 1 (1) | - | - | - | - |
| Entomology | 1 (1) | - | - | - | - |
| Forestry and Wood Science | - | - | - | 3 (3) | - |
| Internal Medicine | - | 3 (3) | - | - | - |
| Mechanical Engineering | 5 (5) | - | 2 (2) | 3 (3) | - |
| Medical Genetics | - | - | 2 (2) | - | - |
| Medical Virology | - | - | - | 2 (2) | - |
| Metallurgical Engineering | 7 (7) | - | - | - | - |
| Microbiology | 5 (5) | - | - | 14 (14) | - |
| Molecular and Cell Biology | - | 11 (11) | 4 (4) | - | - |
| Pharmacology | 4 (4) | 4 (4) | 2 (2) | - | - |
| Physics | 2 (2) | 2 (2) | 9 (9) | - | - |
| Physiology | - | - | 1 (1) | - | - |
| Nutrition | - | - | - | - | - |
| Radiation Oncology | 1 (1) | - | - | - | 1 (1) |
| Veterinary Science | 3 (3) | - | - | - | - |
| Others ^a | 6 | 1 | 6 | 7 | 2 |
| Total | 66 (60) | 36 (35) | 37 (31) | 56 (49) | 18 (16) |

*(EEC Engineering) denotes Electrical, Electronic and Computer Engineering.

^a indicates that the details of inventors have not been obtained. Figure in brackets denotes the NRFrating.

Table A2

Parameters estimates for the model.

| Parameter | Estimate | p-Value |
|-----------|----------|---------|
| Intercept | 3.1166 | <0.0001 |
| Inv | 0.1460 | 0.0029 |
| F | 0.1447 | 0.0128 |
| L | 0.0027 | <0.0001 |

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