Science in South Africa: The dawn of a renaissance?[1]

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During the last ten years, science in South Africa has been the subject of a multitude of changes. Not least of these is the change to the rating of scientists by the National Research Foundation (NRF). Provided that the plan of the Minister of Science and Technology to increase the research and development expenditure in the country materialises, South Africa may be on the verge of a scientific renaissance.

In a scientometric analysis of South Africa's research performance during 2000–2010, it was found that a multitude of government initiatives had been introduced, the effects of which were evident in the country's research outputs. In contrast with earlier investigations, it was found that South Africa's world share of publications is on the verge of reaching the highest contribution ever. South Africa improved its international ranking by two positions during this period, and was ranked 33rd in the world during 2010.

Background

In 2001, social scientists joined their peers in the natural sciences and engineering to participate in the evaluation and rating system of the NRF, which is based solely on previous performance and research outputs. In 2007, the Department of Science and Technology (DST) introduced the Ten-year Innovation Plan, and established the Technology Innovation Agency and the South African National Space Agency during 2008. The Intellectual Property Rights from Publicly Financed Research and Development Act (Act 51 of 2008), was also promulgated in 2008.

The Ten-year Innovation Plan sets high objectives for the innovation system in the country, and has the following vision:

- Be one of the top three emerging economies in the global pharmaceutical industry, based on an expansive innovation system using the nation's indigenous knowledge and rich biodiversity.
- Deploy satellites that provide a range of scientific, security and specialised services for the government, the public and the private sector.
- Achieve a diversified, supply-secured sustainable energy sector.
- Achieve a 25% share of the global hydrogen and fuel cell catalysts market with novel platinum group metal catalysts.
- Be a world leader in climate science and the response to climate change.
- Meet the 2014 Millennium Development Goal to halve poverty.

Similarly, the Department of Education (as it was then known) introduced the New Funding Formula (NFF) for higher education institutions in 2003.

According to this formula, higher education institutions are supported financially on the basis of their research outputs (number of publications and number of postgraduate students produced).

The pinnacle of all initiatives was probably the DST's Strategic Plan for 2011–2016, which was accompanied by a statement by the Minister of Science and Technology that "South Africa will be able to spend R45 billion on research and development by 2014 and reach its target for gross expenditure on research and development of 1.5% of GDP".

The DST indicated that during 2008/09, the country spent R21 billion (or 0.92% of GDP) on research and development.

These initiatives should be seen in the context of past assessments, which had invariably identified a decline in the country's science outputs.

South Africa's research performance

The research conducted to identify South Africa's science performance up to 2010 focused on how South African science has fared during the last decade, how South Africa's share of

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world publications has changed during the past decade, and which major scientific disciplines were emphasised by the country's research system in terms of activity and impact.

For bibliometric analysis (the research methodology used), an appropriate database is required. The ISI-Thomson Reuters databases (Science Citation Index Expanded, Social Sciences Citation Index and Arts and Humanities Citation Index) were identified as the most appropriate for this study, as they cover the most prestigious journals in the world in all fields and constitute a unique information platform.

For South Africa, the ISI Thomson Reuters databases are particularly appropriate, as the educational authorities and universities direct researchers to publish mainly in the journals covered by these databases. The indicators of research activity are the country's contribution in terms of the number of publications in the international literature, the country's share in the world literature, the activity index and the relative citation index. The activity index is the ratio of the country's share of the world publication output in a given field to the country's share of the world publication output in all science fields. An activity index of 1 indicates that the country's research output in the given field corresponds to the world average. A relative citation index above 1 indicates that the country's publications in the particular field attract more than average citations, while an index of less than 1 indicates that it attracts fewer citations.

South Africa's research performance

An analysis of South African publications for the period 1980–2010 (see Figure 1), shows that after a long period of consolidating around 3 500 publications per year, the number rose steeply between 2004 and 2010. In 2010, the database contained 7 468 articles with at least one South African address. A similar analysis of the country's share of the world's publications for the same period (see Figure 2) indicates a peak during 1987 (0.65%) and then a decline, with the lowest point in 2003 (0.47%). Since then, the share gradually increased to 0.65% in 2010.

These figures should be examined in context. Even though South Africa had improved its ranking since 2000 by only two positions in 2010, it more than doubled its number of publications. During that period, South Africa also overtook Argentina, New Zealand, the Ukraine and Hungary. However, Portugal and Iran overtook South Africa. It is interesting that Brazil, Russia, India and China (the BRIC countries) are all scientifically stronger than South Africa in terms of research. In 2010, China produced 124 822 publications, India 40 711, Brazil 31 274 and Russia 26 374. South Africa produced only 7 468 (see Table 1). The performance of the country's main scientific disciplines was also investigated. In an analysis of the world share and activity indices of 22 scientific disciplines for the two periods 2000–2004 and 2006–2010, only geosciences, molecular biology and multidisciplinary research exhibited a decline.

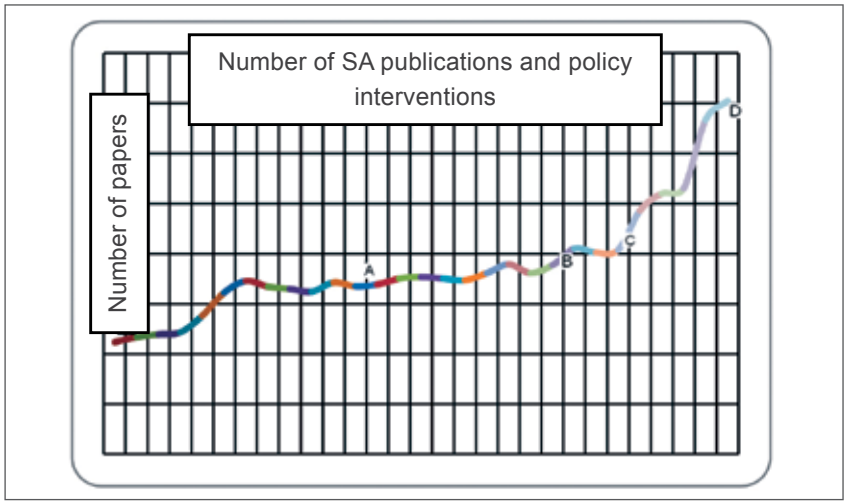

Figure 1: Trend in South African publications (1981–2010) amid policy interventions

A: Sanctions were lifted. B: Social sciences were incorporated in the NRF. C: Introduction of the NFF. D: ISI increases the number of South African journals indexed.

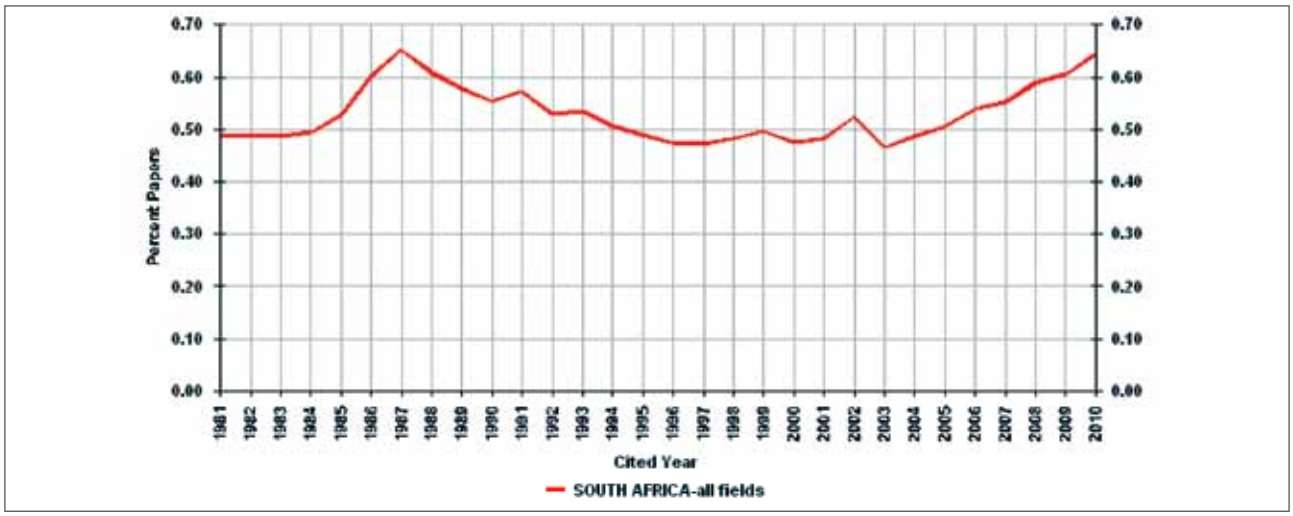

Figure 2: South Africa's share of world publications in all fields (1981–2010)

→ *Table 1: Country ranking according to number of publications in 2000 and 2010*

Ranking	Country	Publications 2000	Ranking	Publications 2010
1	USA	255 099	1	330 339
2	Japan	72 029	5	72 607
3	UK	71 775	3	90 004
4	Germany	67 272	4	86 978
5	France	48 065	6	62 324
6	Canada	33 649	7	53 519
7	Italy	31 157	8	50 691
8	Russia	28 629	15	26 374
9	China Mainland	24 566	2	124 822
10	Spain	22 230	9	43 693
11	Australia	21 386	12	38 753
12	The Netherlands	19 169	14	30 532
13	India	16 538	10	40 711
14	Sweden	15 055	19	19 770
15	Switzerland	14 185	17	21 960
16	South Korea	13 448	11	39 397
17	Brazil	10 465	13	31 274
18	Belgium	9 977	21	16 535
19	Poland	9 751	20	19 192
20	Israel	9 678	24	11 574
21	Taiwan	9 652	16	23 715
22	Denmark	7 900	23	11 702
23	Finland	7 494	27	9 777
24	Austria	7 105	25	11 284
25	Turkey	5 303	18	21 846
26	Norway	4 896	28	9 227
27	Greece	4 876	26	10 105
28	Mexico	4 862	29	9 170
29	New Zealand	4 465	34	7 172
30	Argentina	4 402	35	7 123
31	Czech Republic	4 322	32	8 684
32	Ukraine	4 306	43	4 422
33	Hungary	4 105	41	5 061
34	Singapore	3 634	31	8 811
35	South Africa	3 617	33	7 468
36	Portugal	3 141	30	8 975
37	Ireland	2 697	36	6 492
38	Egypt	2 290	39	5 386
39	Romania	1 955	37	6 356
40	Chile	1 906	42	4 623
41	Slovenia	1 616	45	3 193
42	Iran	1 291	22	16 391
43	Thailand	1 232	40	5 155
44	Malaysia	859	38	5 664
45	Pakistan	620	44	4 232

Plant and animal sciences remained static, contributing to 1.57% of the world literature. The activity indices for 2006–2010 show that space science, immunology and social sciences have moved into the fields of revealed priorities that are overemphasised in the country (activity index above 1).

However, a number of important disciplines like materials science, molecular biology and engineering are underemphasised. Social sciences appear to be the discipline with the highest growth (growing from a world share of 0.52% during 1990–1994 to 1.22% during 2006–2010).

In an analysis of the relative citation index (an indicator of research quality) of the various disciplines for the periods 2000–2004 and 2006–2010, only three disciplines appear to have dropped in ranking during the period: computer science, molecular biology and psychiatry/psychology. The country's relative citation index moved from 0.69% during 2000–2004 to 0.88% during 2006–2010.

An analysis of South Africa's scientific performance during 2000–2010 shows that research publications in South Africa are on an ascending path, and the country's world share of publications is on the verge of reaching the highest contribution in history.

Forces that contributed to the growth of science in South Africa

In an article on some trends and implications of a bibliometric analysis of South Africa's scientific outputs, Michael Kahn (published in the *South African Journal of Science* in 2011) suggested that the growth in the country's publications for the periods 1990–1994 and 2004–2008 was the result of a number of factors. "There are greater rewards for publishing; there is a shift towards health science fields with high publication rates, there are more South African journals indexed by the Web of Science… there may be more PhD students available to assist with research and the system is more open [to] co-publication with foreign parties."

Changes that may have affected the country's publication performance include the introduction of social sciences into the NRF's responsibilities, more publications being covered by the ISI Thomson Reuters databases and the provision of incentives by the Department of Education.

In a scientometric impact assessment of the NRF rating system, Dr Roula Inglesi-Lotz and Prof Anastassios Pouris of the University of Pretoria's Institute for Technological Innovation used the before/after control impact (BACI) method to identify the impact of the NRF rating system on social sciences publications in the country.

Table 2: South Africa's world share and activity indices by discipline

Discipline	2000–2004	Activity index	2006–2010	Activity index
Agriculture science	0.58	1.18	0.70	1.19
Biology and biochemistry	0.35	0.71	0.54	0.92
Chemistry	0.31	0.63	0.39	0.66
Clinical medicine	0.40	0.82	0.45	0.76
Computer science	0.22	0.45	0.28	0.47
Economic and business sciences	0.46	0.94	0.86	1.46
Engineering	0.32	0.65	0.38	0.64
Environmental/ecology	1.26	2.57	1.39	2.36
Geosciences	1.19	2.43	1.09	1.85
Immunology	0.49	1.00	1.09	1.85
Materials science	0.25	0.51	0.28	0.47
Mathematics	0.46	0.94	0.58	0.98
Microbiology	0.57	1.16	0.78	1.32
Molecular biology	0.25	0.51	0.24	0.41
Multidisciplinary	2.93	5.98	1.60	2.71
Neuroscience and behaviour	0.17	0.35	0.22	0.37
Pharmacology and toxicology	0.39	0.80	0.42	0.71
Physics	0.24	0.49	0.28	0.47
Plant and animal science	1.57	3.20	1.57	2.66
Psychiatry/psychology	0.45	0.92	0.69	1.17
Social sciences, general	0.76	1.55	1.22	2.07
Space science	0.89	1.82	1.05	1.78
Overall country	0.49		0.59	

Table 3: Relative impact of South Africa's publications during 2000–2004 and 2006–2010

Discipline	Relative impact 2000–2004	Relative impact 2006–2010
Agriculture science	0.74	0.82
Biology and biochemistry	0.56	0.81
Chemistry	0.65	0.70
Clinical medicine	0.86	1.15
Computer science	1.10	0.90
Economic and business sciences	0.38	0.40
Engineering	0.81	0.85
Environmental/ecology	0.83	0.95
Geosciences	0.79	0.89
Immunology	0.71	1.09
Materials science	0.76	0.77
Mathematics	0.82	1.12
Microbiology	1.00	1.27
Molecular biology	0.79	0.76
Multidisciplinary	0.36	0.41
Neuroscience and behaviour	0.63	0.71
Pharmacology and toxicology	0.58	0.70
Physics	0.71	0.93
Plant and animal science	0.72	0.93
Psychiatry/psychology	0.67	0.61
Social sciences, general	0.81	0.86
Space science	0.77	1.35
Overall country	0.69	0.88

They found that the number of social sciences publications in South Africa had increased by 24.7% after 2001 because of their inclusion in the NRF's evaluation and rating system. However, the discipline contributed only 10.6% to the country's publications in 2008.

The NFF for higher education institutions appears to have played an important role in the increase of the number of publications in South Africa. According to this funding formula of the Department of Higher Education and Training, higher education institutions in South Africa receive financial support according to their research outputs (number of publications and number of postgraduates). Universities, in turn, provide incentives to staff to improve their publication profiles.

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About the author

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