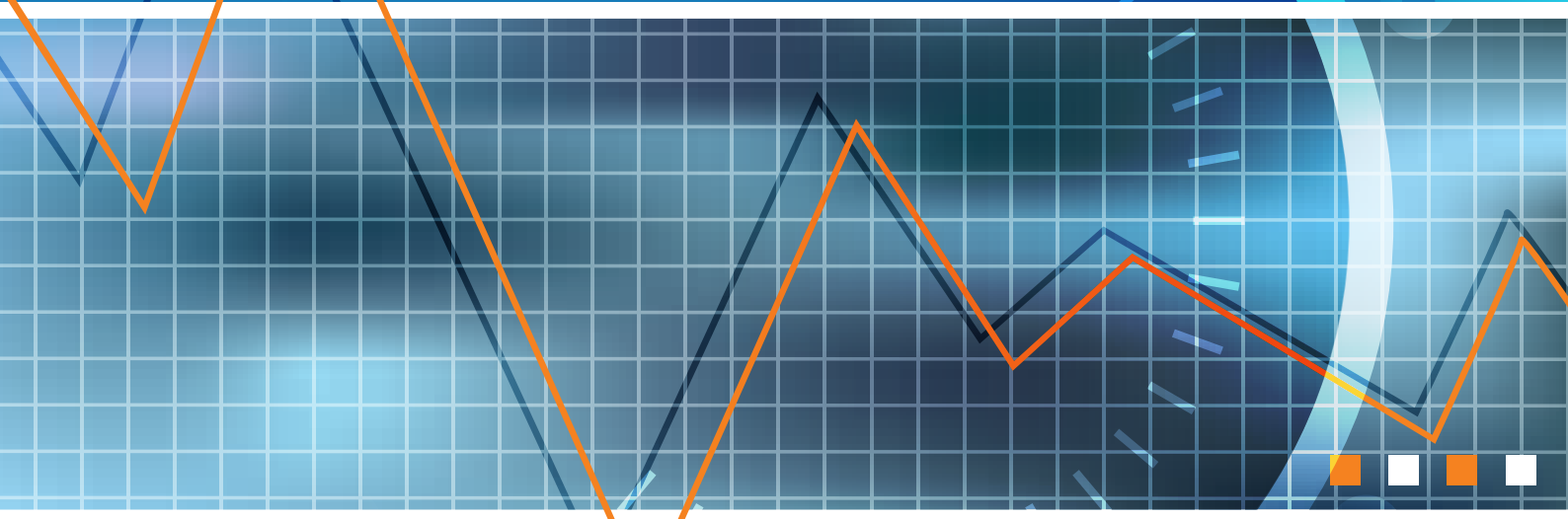
South African Science, Technology and Innovation Indicators

2014

National Advisory Council on Innovation



science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NACI
NATIONAL ADVISORY COUNCIL ON INNOVATION


innovation
for a better future

CONTENTS

CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome
ARC	Agricultural Research Council
ARV	Antiretroviral
BRICS	Brazil, Russia, India, China and South Africa
CO_2	Carbon Dioxide
DHET	Department of Higher Education and Training
DST	Department of Science and Technology
FDI	Foreign Direct Investment
FTE	Full-Time Equivalent
FWCI	Field Weighted Citation Impact
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
HIV	Human Immunodeficiency Virus
HRDS-SA	Human Resource Development Strategy of South Africa
IDC	Industrial Development Corporation
IP	Intellectual Property
MDGs	Millennium Development Goals
MRC	Medical Research Council
NDP	National Development Plan
NECSA	South African Nuclear Energy Corporation
NRDS	National Research and Development Strategy
NRF	National Research Foundation
NSC	National Senior Certificate
OECD	Organization of Economic Cooperation and Development
PBMR	Pebble Bed Modular Reactor
PDIs	Previously Disadvantaged Individuals
PhD	Doctor of Philosophy
PPP	Purchasing Power Parity

ACRONYMS (CONTINUED)

R&D	Research and Development
RIMS	Research Information Management System
SA	South Africa
SAAO	South African Astronomical Observatory
SADC	Southern African Development Community
SET	Science Engineering and Technology
SU	Stellenbosch University
TB	Tuberculosis
dti	Department of Trade and Industry
UCT	University of Cape Town
UJ	University of Johannesburg
UK	United Kingdom
UKZN	University of KwaZulu Natal
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	University of Pretoria
US	United States of America
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WITS	University of the Witwatersrand

FOREWORD

I am pleased to present the 2014 update of the South African Science, Technology and Innovation Indicators booklet produced annually by the National Advisory Council on Innovation (NACI). In developing this publication, NACI draws from the 2002 National R&D Strategy (indicators logic model framework) which specifically identified indicators for an assessment of the health of the national system of innovation (NSI) and the tracking thereof over time as a basis for performance measurement. The recently published Ministerial Review Report requires a strong evidence based and data driven approach in assessing the NSI. Therefore progress in improving the functioning of the NSI depends on the availability, collation, maintenance (and even analysis) of both quantitative and qualitative STI indicators.

This report is aimed at providing core South African science, technology and innovation indicators with a view to assessing the performance of the NSI and includes extensive data obtained from a wide spectrum of local and international data sources. Data included in this publication mostly cover the past ten years (2004 – 2013) in order to allow for a proper trend analysis over a period of time.

Each year we strive to improve this publication so that it may continue to be more useful. In the last financial year (2013/14) NACI undertook a study that identified gaps in available indicators used in the assessment of the NSI. Some of the new indicators identified in this study are innovation networks, foreign direct investment networks and higher education system resources. In response to this study and taking into consideration the STI policy landscape the following are some of the new indicators included in this publication: 1) Dinaledi Schools data; 2) Matriculation data for Physical Science; 3) data on different types of scientific publications; 4) information on knowledge networks, i.e. collaborations; and 5) information on the mobility of South African researchers.

It is NACI's view that the development of the South African indicator system should be a collaborative process and there is much that our stakeholders can do to both assist and drive improvements in indicators measurement. It is in this spirit that I wish to extend my appreciation to various groups and individuals for sharing the data and information that informed the development of these indicators.

Dr Azar Jammine
Project Leader: NACI Monitoring, Evaluation and Indicators

KEY HIGHLIGHTS

South Africa's share of world exports for high technology manufacturing industries remains low at 0,09% for pharmaceutical industry; 0,07% for computer, electronics and the optical industry; and 0,14% for the aerospace industry in 2013. Technological progress and innovation are key in revitalising these industries along with the other labour absorbing industries promoted by IPAP and the NDP. Despite a 32% decrease in the number of South African patent applications in various patent offices from 2008 to 2012 compared with 2004 to 2008, the South African patents filed in the United States of America (US) and United Kingdom (UK) increased in the period 2009 and 2012 compared to the previous periods. Most of South Africa's medical technology patents are filed in the US. In 2012, about 31,9% of these patents were published at the United States Patent and Trademark Office (USPTO). Similarly, most of South Africa's industrial design applications are filed at the USPTO although the international destination for most of South Africa's trade mark applications is in China, the US being second.

31,9%
Share of SA Worldwide Patents in Medical Technologies Published at USPTO

For the first time in nine years, there was a decline in pharmaceutical imports in 2013 of 3% compared with 2012 while there was a countervailing dramatic increase in exports from this sector of 43,5%, from 2012 to 2013. This is an early sign of import substitution in the pharmaceutical industry, although more time is needed to monitor this new development. Overall, the direction of South African trade is shifting from developed high-income economies to the developing countries in East Asia and the Pacific. During 2013, merchandise exports to developing countries in East Asia and Pacific accounted for 34,9% of all South African merchandise exports compared with 4,3% in 2004. Conversely, the share of merchandise exports to high-income countries fell to 36,1% in 2013, representing a significant reduction from the 2006 export share value of 74,3%.

34,9%
Merchandise Exports to Developing Countries in East Asia & Pacific

In terms of the technology balance of payments (TBP), technology payments decreased by 4,8% and 4,2% in 2012 and 2013, respectively. Moreover, technology receipts increased by 2,3% in 2012 and decreased by 6,7% in 2013. The decline in technology payments is offset by the recent increase in foreign direct investment (FDI) net inflows. Although there was a decline in FDI net inflows as a percentage of GDP in 2009 of 0,94% and in 2010 of 1,67%, there was an increase of 1,11% from 2012 to 2013, such that the actual net inflow of FDI in 2013 was 2,32% of GDP. Foreign direct investment is one of the effective strategies that can be used for technology acquisition and absorption, in addition to technology payments for a right to use the intellectual property (IP) in the form of royalties, licenses, trademarks and research and development (R&D) services.

2,32%
Foreign Direct Investment Net Inflows as Percentage of GDP

Technology assimilation from FDI inflows or acquired IP requires skilled and capable research and technical staff with appropriate formal or informal knowledge networks. South Africa has a low percentage of full-time equivalent (FTE) researchers per thousand workforce (1,5% in 2012), although on a positive note, there was an increase of 9,2% in the number of doctoral degrees being awarded between 2012 to 2013. The NDP has identified, as a challenge, the low proportion of teaching staff in higher education institutions with doctoral qualifications. Although there has been a gradual improvement each year, the numbers are still low. In 2012, the proportion of higher education staff with doctoral qualifications was 39,3% at traditional universities, 25,0% at comprehensive universities, and 14,7% at universities of technology.

1,5%
Researchers per 1 000 Workforce (FTE)

Knowledge networks through research collaborations are useful in complementing the small research community in the country. Most international research collaborations are with developed countries. In 2013, about 84,1% of research papers were co-authored with at least one author from countries such as US, England, Germany, Australia, France, Netherlands, Canada, Switzerland, Italy and Sweden. In terms of sectors, 90% of South Africa's research output in 2013 had at least one author from higher education institutions, with only 10% from science councils and 0,9% from the business sector. Both business sector and science councils collaborate mainly with the universities, but there is a low level of research collaboration between science councils and the business sector.

90,0%
Share of the Country's Scientific Publications with at Least One Author from the Higher Education Institutions

Investment in future R&D capacity is necessary in order to stimulate South Africa's innovation capacity. The Human Resource Development Strategy of South Africa (HRDS-SA), Schooling 2025 and the NDP aim to increase the number of high school learners who pass mathematics with at least a 50% pass mark. In 2014, only about 12,5% of learners passed grade 12 mathematics with at least a 50% pass mark. This represents a decrease from 14,4% in 2013 and 13,6% in 2012. Enrolment in science, engineering and technology (SET) qualifications at South African public higher education institutions was also low, at just 28,8% of the total in 2013, a slight increase from 28,7% in 2012. A large proportion of the students from African countries outside of SADC enrol for SET degrees at South African public higher education institutions (48,9% in 2013).

28,8%
Total SET Enrolment at Public Higher Education Institutions

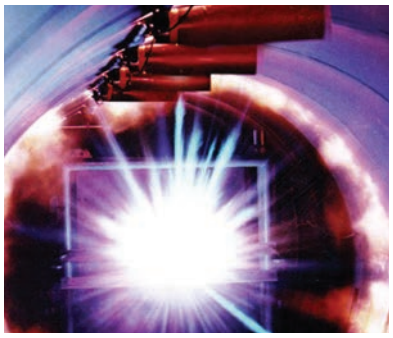
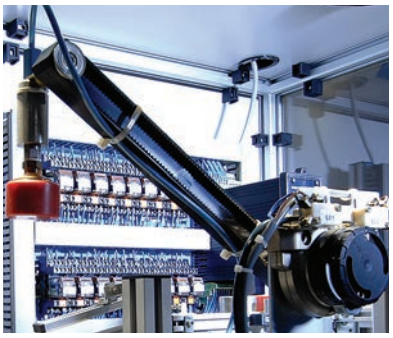
KEY HIGHLIGHTS (CONTINUED)

One method suggested by the NDP to reduce the high unemployment rate is through upscaling of manufacturing, especially those industries which are labour intensive. Unfortunately, manufacturing value-added (as % of GDP) has decreased from 15,3% of GDP in 2004 and 14,0% in 2009, to 13,9% in 2014. The services sector is the largest contributor to GDP in terms of value added, rising from 64,1% in 2004, 67,6% in 2009 to 68,9% in 2014. According to the Industrial Policy Action Plan 2013/14 – 2015/16 (IPAP), manufacturing has a critical role to play as a driver of innovation and productivity growth; for exports through value-added products that improve the trade balance; for creation of employment opportunities (especially for women); and to catalyse the infrastructure build programme.

13,9%
Manufacturing Value-Added as Percentage of GDP

A successful South African system of innovation needs to be responsive to issues that affect quality of life, economic growth and the environment. Although there is a continued improvement of the literacy rate in various categories (adults in general, youth, males and females), there are key issues that also need to be addressed such as the high HIV/AIDS prevalence rates for the adult population (aged 15 – 49 years), which was 16,8% in 2014 and 16,7% in 2013. In terms of youth aged 15 to 24 years, the HIV/AIDS prevalence is encouragingly declining, reaching 8,7% in 2014. The high unemployment rate (25,1% in 2014) and inequality, are also issues that need to be addressed through implementation of the National Development Plan (NDP).

13,1%
HIV/ AIDS Prevalence for Adults Aged 15 – 49 Years

1 FUTURE R&D CAPACITY

In order to build a strong and responsive science and innovation system, that can enable a rapid economic growth through revival and creation of the new industries, it is necessary to invest on the future research and innovation capacity. The indicators that are used in this chapter to measure and analyse the progress on human capital development are SET enrolments at public higher education institutions, performance of Dinaledi schools as well as analysis of a performance on Mathematics and Physical Science at grade 12 level.

1.1 SET Enrolments

In 2013, the total SET enrolment of the total public universities' students enrolled was at 28,8%, a small increase from the 2012 value of 28,7% (**Table 1.1** and **Figure 1.1**). Undergraduate percentage SET enrolment was also at 28,8%, an increase of 0,4% from 2012. Although postgraduate SET enrolment was higher than that of the undergraduates in 2013 (29,2%), there was a decrease in SET enrolments in 2013, of 0,8%.

Table 1.1: Higher Education SET Enrolments

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total SET Enrolments	202 552	329 805	211 585	214 682	224 950	237 055	251 334	264 447	273 282	283 622
% Total SET Enrolments	27,2	28,7	28,5	28,2	28,1	28,3	28,1	28,2	28,7	28,8
% Undergraduate SET Enrolments	27,7	29,4	29,0	28,2	28,1	28,2	28,0	28,1	28,4	28,8
% Postgraduate SET Enrolments	23,3	25,6	27,0	28,3	28,2	28,3	28,7	28,4	30,0	29,2
% PDIs Total SET Enrolment	70,6	71,3	72,3	73,1	74,6	75,4	76,2	76,9	77,4	78,2
% Female Total SET Enrolments	44,7	43,5	43,8	44,1	44,6	45,1	44,9	44,8	45,2	45,5

Source: DHET "Higher Education Information Management System"

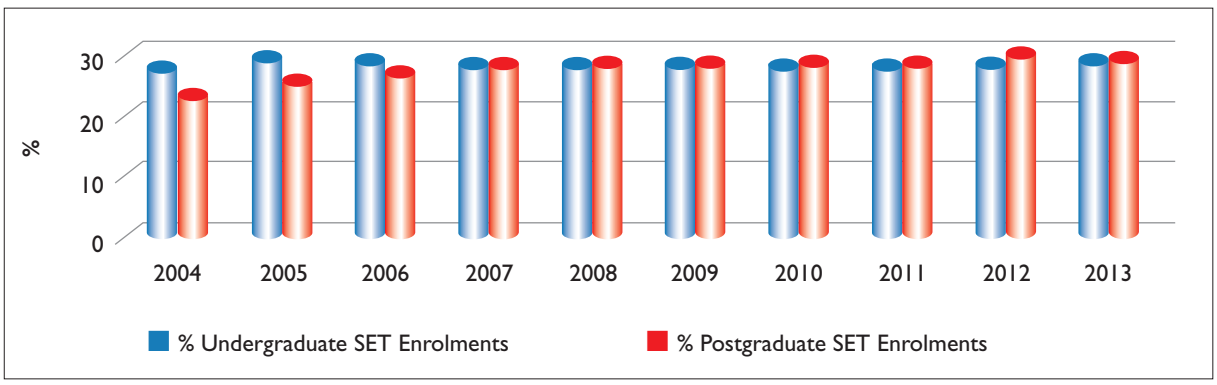


Figure 1.1: Trends in Undergraduate and Postgraduate SET Enrolments

FUTURE R&D CAPACITY (CONTINUED)

Between 2004 and 2013, undergraduate and total SET enrolments have increased slightly, by just under 2% whereas the postgraduate SET enrolment rate increased significantly between 2004 and 2007 from 23,3% to 28,3%). Postgraduate SET enrolment has since remained nearly constant at 28% from 2007 to 2011, increasing slightly to 28,7% and 28,8% in 2012 and 2013, respectively.

As **Figure 1.2** shows, the proportion of SET enrolment by Africans, Coloureds and Indians is growing steadily, rising from 70,6% in 2004 to 78,2% in 2013, a yearly average increase of 0,84%.

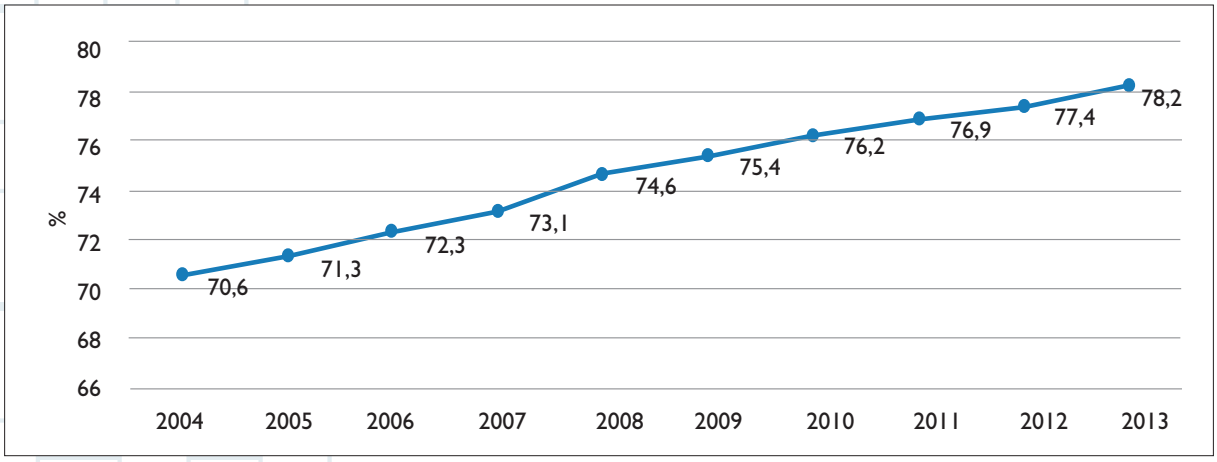


Figure 1.2: Trend in Proportion of SET Enrolment of Africans, Coloureds and Indians (PDIs)

After falling in 2005, to 43,5%, from 44,7% in 2004, the proportion of female SET enrolment has been gradually increasing, rising in 2005 from 43,5% to 45,5%. The percentage of females passing grade 12 Mathematics (shown in section 1.3), however, remains quite low. Therefore, raising the proportion of female SET enrolment at the universities will be a challenge.

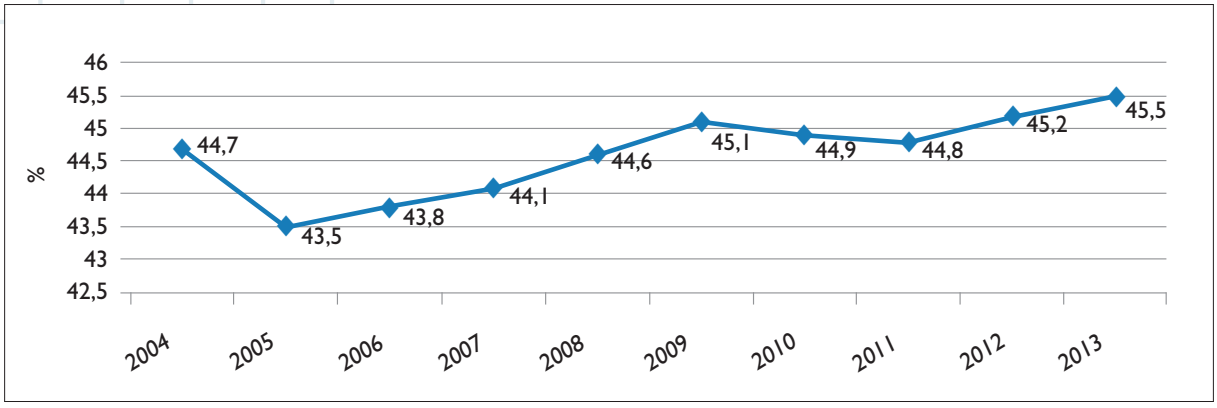


Figure 1.3: Trend in Percentage Female SET Enrolment

Table 1.2 and **Figure 1.4** show that although the students from African countries outside of SADC represent only 1,2% of enrolments at South African public universities, 48,9% of those students enrol for SET qualifications. This percentage SET enrolment is much higher than South Africa's SET enrolment level of 28,4%. 30,6% of students from SADC countries and other foreign nationals enrolled for SET qualifications in 2013.

Table 1.2: SET Enrolments in South African Public Higher Education by Nationality (2013)

Nationality	Total Enrolments	% SET Enrolments
South Africans	909 839	28,4
SADC excluding SA	53 800	30,6
Other African Nationals	11 919	48,9
Other Foreign Nationals	6738	30,6

Source: DHET "Higher Education Information Management System"

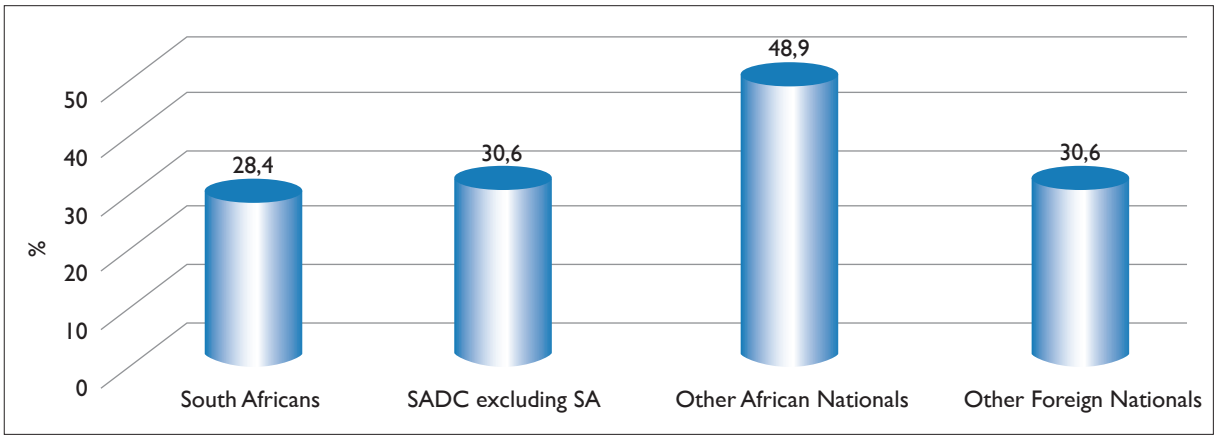


Figure 1.4: Percentage SET Enrolments by Nationality in South African Public Higher Education

1.2 Dinaledi Schools

The Dinaledi schools project was introduced in 2001 by the previous Department of Education to "increase the number of matriculants with university-entrance mathematics and science passes"[i]. This project is part of implementation of the National Strategy for Mathematics, Science and Technology Education, through selection of promising schools "that have demonstrated their potential for increasing learner participation and performance in mathematics and science, and providing them with the resources and support to improve the teaching and learning of these subjects"[i]. The NDP also entrusts the Dinaledi schools to increase the number of grade 12 learners passing with mathematics. In 2014, the proportion of Dinaledi schools to the total number of schools writing grade 12 exams was 8,19% up from 6,6% in 2011 **(Table 1.3)**.

FUTURE R&D CAPACITY (CONTINUED)

Table 1.3: Performance of Dinaledi Schools at Grade 12 Level

	2011	2012	2013	2014
Total Number of Dinaledi Schools	410	506	506	500
Total Number of non-Dinaledi Schools	6 182	6 118	6 179	6204
Average Number of Learners who Wrote from Dinaledi Schools	135	150	165	143
Average Number of Learners who Wrote from non-Dinaledi Schools	71	71	77	75
Pass Rate at Dinaledi Schools	77	80	75	81
Pass Rate at non-Dinaledi Schools	68	70	84	72

Source: Department of Basic Education

On average, there are more learners writing grade 12 exams at the Dinaledi schools as compared to non-Dinaledi schools, which is in line with the NDP vision, although this average number of learners who wrote grade 12 exams decreased from 165 in 2013 to 143 in 2014 **(Figure 1.5)**.The average number of learners who wrote grade 12 exams from non-Dinaledi schools also decreased from 77 in 2013 to 75 in 2014.

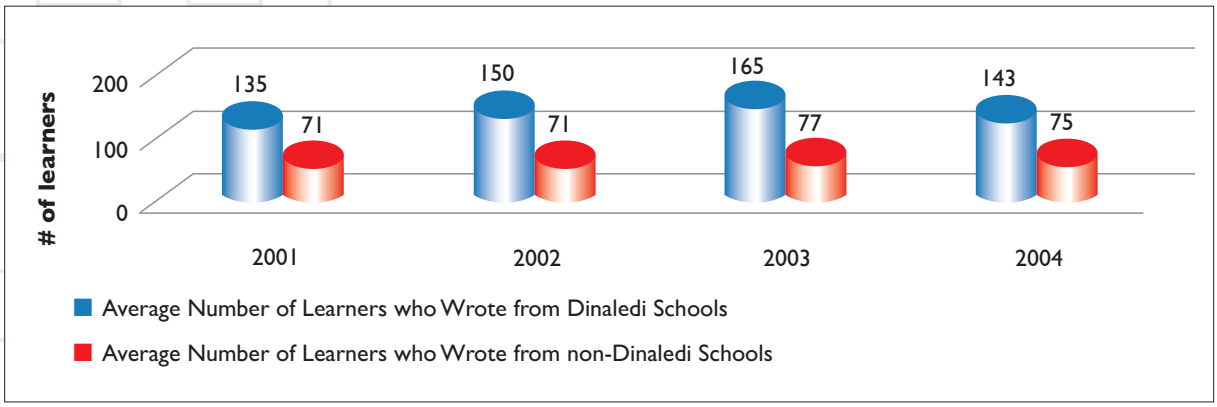


Figure 1.5: Comparative Number of Learners Writing Matric (NSC) at Dinaledi Schools

Despite a 5% drop in grade 12 pass rate at the Dinaledi schools in 2013 **(Figure 1.6)**, there have been some gains in 2014, with an average pass rate increasing from 75% in 2013 to 81% in 2014, equating to an increase of 6%.

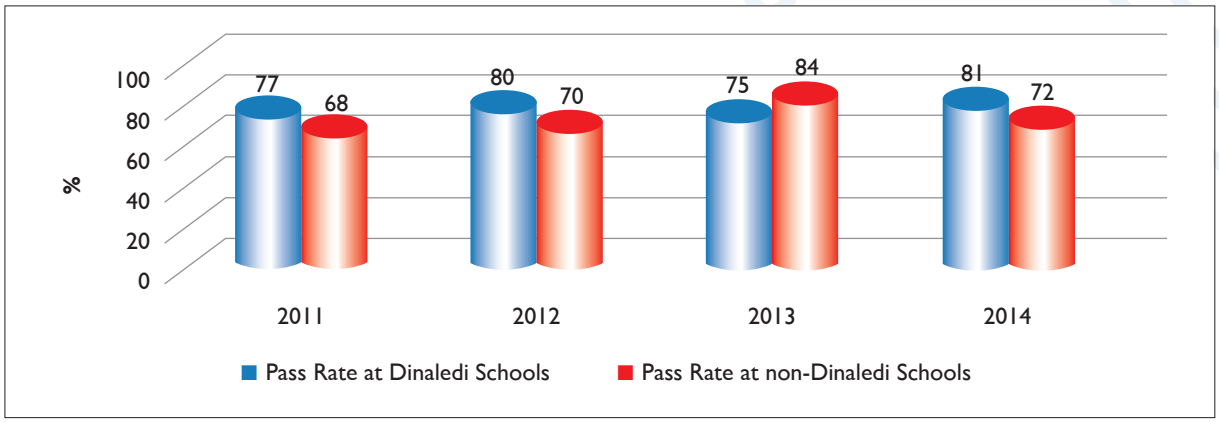


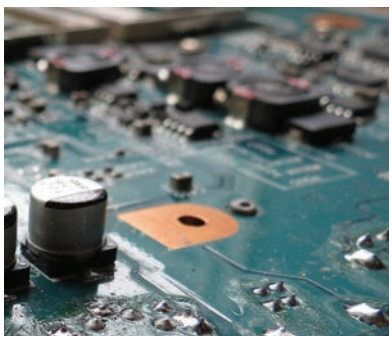
Figure 1.6: Comparative Matric (NSC) Pass Rates at Dinaledi Schools

1.3 Matrics with Mathematics and Physical Science

The Human Resource Development Strategy of South Africa (HRDS-SA) aims to increase the number of learners passing grade12 Mathematics with at least 60% in order for them to be admitted for professional studies in critical and scarce skills areas. As **Table 1.4** shows, 30 782 learners achieved this HRDS-SA target in 2014, which is just 7,6% of all the learners passing grade 12 during that year. For Physical Science, 22 116 or just 5,5% of the learners achieved more than 60% pass rate.

A 50% pass rate achievement in Mathematics and Physical Science is desired by both the NDP and Schooling 2025 plan of the Department of Basic Education. In sync with the decreasing number of students passing grade 12 in 2014 (8,2%), the number of learners passing Mathematics and Physical Science also decreased from 2013 to 2014 (a decrease of 20,2% and 19,7% respectively).

In terms of gender, although a high proportion of female learners do pass Mathematics and Physical Science matric with at least 40% (47,2% and 47,7% respectively in 2014), the proportion of the number of female learners passing both of these subjects at more than 60% is comparably low. In 2014, out of the learners who passed Mathematics with at least 60%, 45,3% were females. Females accounted for 43,4% for Physical Science passes achieving a 60% mark or better. As discussed previously in section 1.1, the low proportion of female learners passing matric Mathematics and Physical Science has a negative consequence on universities' SET enrolment for female students.



FUTURE R&D CAPACITY (CONTINUED)

Table 1.4: Matric Mathematics and Physical Science

	2008	2009	2010	2011	2012	2013	2014
Total Matric Passes	344 794	339 114	364 513	348 117	377 829	439 779	403 874
Mathematics (> 40%)	89 186	85 491	81 473	67 592	80 707	97 786	79 048
% Females who Passed Mathematic at > 40%	48,4	48,3	48,3	46,2	47,5	48,2	47,2
Mathematics (> 50%)	62 388	52 866	50 195	41 586	51 231	63 151	50 365
% Females who Passed Mathematics at > 50%	47,9	47,4	47,3	44,8	46,0	46,4	45,3
Mathematics (> 60%)	41 667	31 786	30 543	24 577	30 355	37 782	30 782
% Females who Passed Mathematics at > 60%	47,8	46,6	46,5	43,8	44,8	44,4	43,6
Physical Science (> 40%)	61 480	45 531	60 943	61 128	70 074	78 676	62 031
% Females who Passed Physical Science at > 40%	46,5	45,9	47,8	46,3	48,1	48,9	47,7
Physical Science (> 50%)	32 524	22 329	37 853	37 106	43 639	47 030	37 749
% Females who Passed Physical Science at > 50%	46,5	45,7	46,5	44,4	46,2	45,9	45,3
Physical Science (> 60%)	16 620	10 308	22 759	21 840	25 640	26 467	22 116
% Females who Passed Physical Science at > 60%	47,3	45,9	45,9	43,9	44,6	43,4	43,4

Source: Department of Basic Education

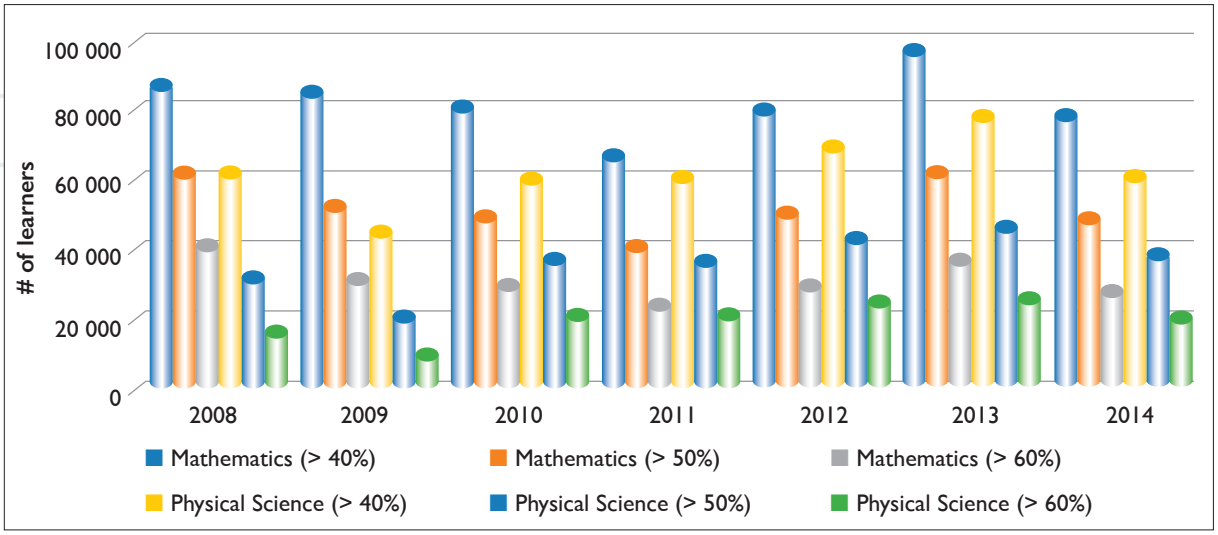


Figure 1.7: Trends in Number of Learners Passing Matric Mathematics and Physical Science

2 CURRENT R&D CAPACITY

Research capacity is needed in order to stimulate industrial competitiveness through innovation, creation and retention of jobs and improvement in quality of life. This section reports on the performance of the South African science system through indicators of knowledge generation, knowledge generation collaboration and a specific focus on higher education knowledge generation capacity and the networks.

2.1 Knowledge Generation

As **Table 2.1** and **Figure 2.1** show, the South Africa's knowledge generation output is on the rise, although the country's share of the world's publications has stabilised at 0,75 in both 2012 to 2013. Encouragingly, in 2013, the impact of South Africa's publications was slightly higher than the world's average (citations relative to the world of 1,02), a sharp increase compared to the 2012 value of 0,92%. This data shows that while South Africa's research output is increasing, the quality of this output is improving even more.

Table 2.1: Total Number of South African Scientific Publications

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of Publications (WoS)	4 527	4 803	5 451	6 125	6 950	7 632	8 168	9 486	10 179	10 585
Number of Publications (Scopus)	6 820	7 573	8 447	9 036	9 911	11 162	12 169	13 475	15 026	16 178
% World Share (WoS)	0,50	0,51	0,55	0,58	0,62	0,65	0,67	0,73	0,75	0,75
Citations Relative to the World (WoS)	0,99	0,99	1,00	0,98	0,97	0,96	0,97	0,93	0,92	1,02

Source: Thomson Reuters "Incites"

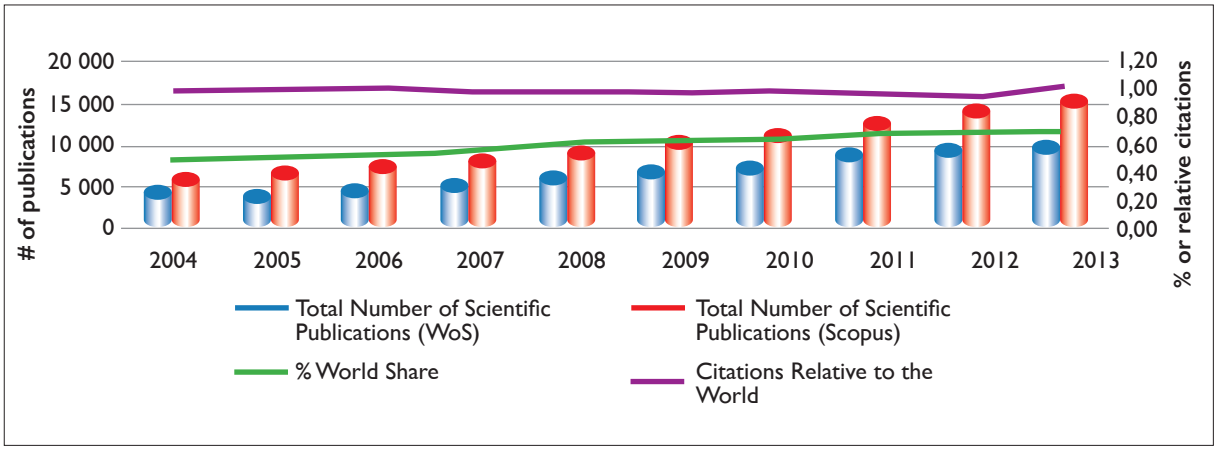
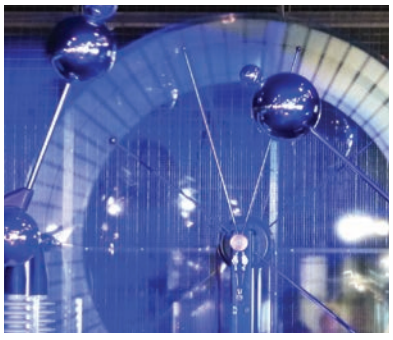


Figure 2.1: Trend in South African Scientific Publications

CURRENT R&D CAPACITY (CONTINUED)

With the increasing number of South Africa's scientific publications, it is important to understand the performance by different research fields. The Organization of Economic Cooperation and Development (OECD) Frascati Manual classification is used for this purpose. As **Table 2.2** and **Figure 2.2** show, most scientific publications are in Natural Sciences (50,12% in 2009 – 2013) followed by Medical and Health Sciences (15,07%), Engineering and Technology (15,07%), Social Sciences (14,69%), Agricultural Sciences (7,09%) and Humanities (5,21%). The research output of Social Sciences is the fastest growing. During the period 1994 – 1998, the contribution of this field on South African total research output was 8,57% but this increased to an average of 14,69% in 2009 – 2013 **(Figure 2.3)**. Publications in Medical and Health Sciences as well as Humanities are also on the rise in terms of their share of South African scientific publications.

As shown in **Figure 2.4**, although the Humanities appear to be a relatively small research field in South Africa, its world share of publications is the largest (1,37% in 2009 – 2013) followed by Social Sciences (1,14%), Agricultural Sciences (0,99%), Natural Sciences (0,72%), Medical and Health Sciences (0,56%) and Engineering and Technology (0,47%). This is based on the fact that different disciplines have different publishing norms. The average world share in scientific publications has increased in all the research fields between the periods 1999 – 2003, 2004 – 2008 and 2009 – 2013, which shows a consistent growth in research output for all the fields. In terms of citations relative to the world, there was growth for Natural Sciences, Medical and Health Sciences and Agricultural Sciences between the periods 1999 – 2003 and 2004 – 2008 **(Figure 2.5)**. Recently, the world relative impact has been constant, just below 1,00 for most scientific fields, except for humanities that had an average of 1,05 relative impact for the period 2009 – 2013.



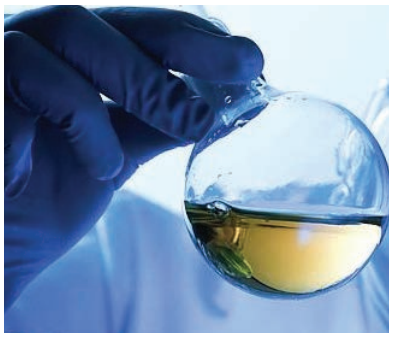


Table 2.2: Scientific Publications in Various Scientific Fields

		Natural Sciences	Engineering & Technology	Medical & Health Sciences	Agricultural Sciences	Social Sciences	Humanities
Number of Publications	1994 - 1998	10 104	2 620	4 748	1 354	1 561	693
	1999 - 2003	11 375	2 991	5 162	1 565	1 816	811
	2004 - 2008	14 911	4 210	7 134	2 051	3 408	1 460
	2009 - 2013	23 081	6 941	12 064	3 267	6 767	2 397
Citations Relative to the World	1994 - 1998	0,93	0,97	0,88	0,98	0,75	0,9
	1999 - 2003	0,93	0,95	0,94	0,92	0,81	0,96
	2004 - 2008	0,98	0,94	0,98	0,99	0,77	0,87
	2009 - 2013	0,98	0,94	1.00	0,99	0,81	1,05
% World Share of Publications	1994 - 1998	0,54	0,38	0,39	0,79	0,56	0,71
	1999 - 2003	0,54	0,38	0,39	0,82	0,61	0,41
	2004 - 2008	0,57	0,39	0,44	0,84	0,89	1,29
	2009 - 2013	0,72	0,47	0,56	0,99	1,14	1,37
% Publications in a Country[1]	1994 - 1998	55,47	14,38	26,07	7,43	8,57	3,8
	1999 - 2003	56,86	14,95	25,8	7,82	9,08	1,67
	2004 - 2008	53,53	15,11	25,61	7,36	12,23	5,24
	2009 - 2013	50,12	15,07	26,2	7,09	14,69	5,21

Source: Thomson Reuters "Incites"

Box 1: Chapter Terminology

In this chapter document/article counts and inter-sector co-authorship patterns are discussed. The relevant statistics are derived from the journals covered mostly in the Web of Science of Thomson Reuters.

Journals: Thomson Reuters and Elsevier selects journals each year (based on their journal selection procedures that are slightly different) and the selected journals become part of the Web of Science and Scopus databases respectively. The journals selected are notable for their relatively high citation rank within their corresponding science and engineering subfields; journals of only minor interest are excluded.

Articles: Articles are attributed to countries or sectors by the country or sector of the institutional addresses given in the articles, not by the national origins or the citizenship of the authoring scientists or engineers. If no institutional affiliation is listed, the article is excluded from the counts in this chapter. One unit is allocated to all co-authors and institutions present in each article (no fractional counting).

Co-authorship: Co-authorship refers to institutional co-authorship. An article is considered co-authored only if it shows different institutional affiliations; multiple listings of the same department of an institution are considered one institutional author. The same logic applies to cross-sector and international collaboration

[1] A total is not 100% due to overlap of some publications accross more than one research field

CURRENT R&D CAPACITY (CONTINUED)

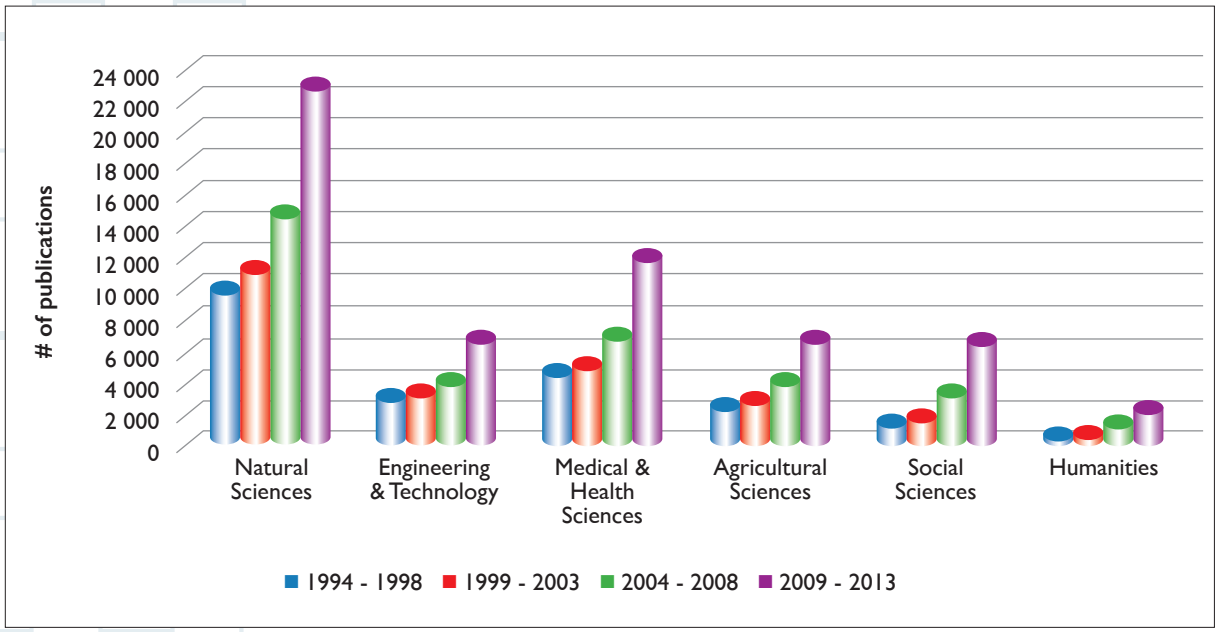


Figure 2.2: Trends in Scientific Publications in Various Research Fields (Five Year Groupings)

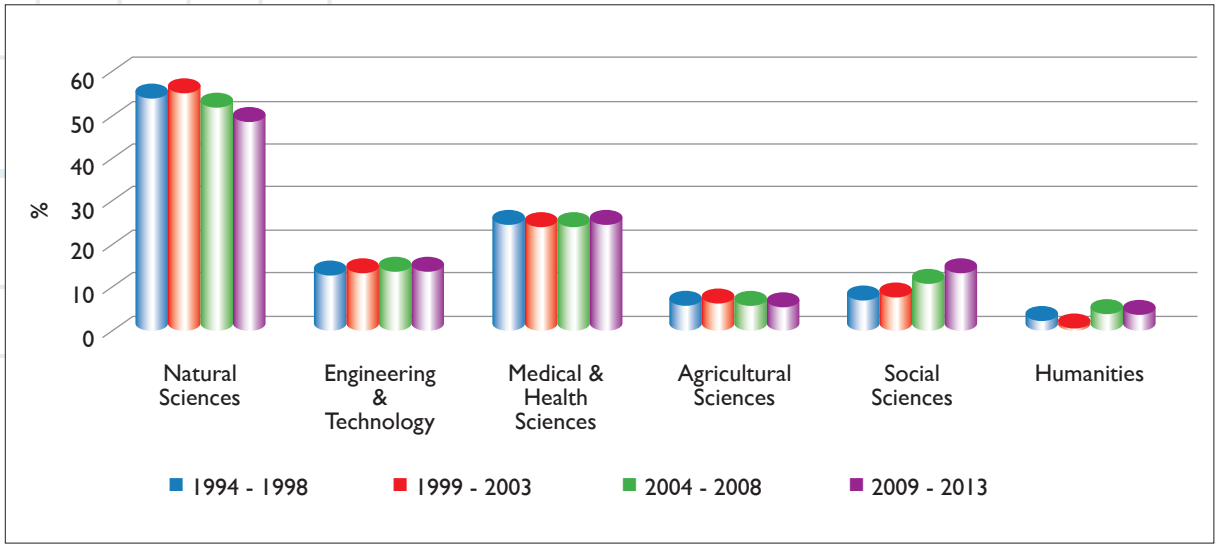


Figure 2.3: Percentage Distribution of Scientific Publications in Various Research Fields

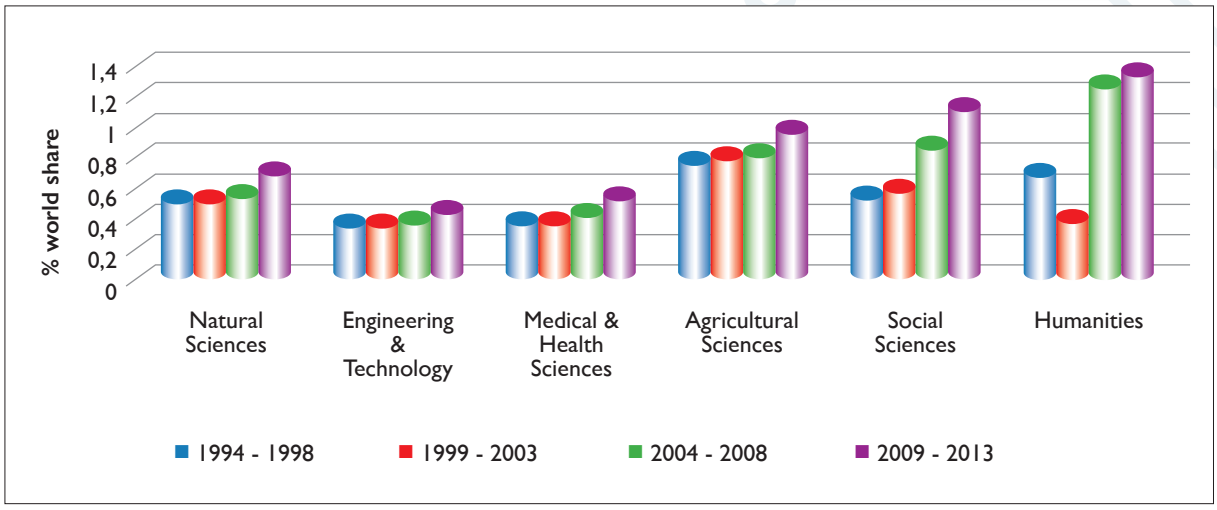


Figure 2.4: Percentage World Share of SA Scientific Publications in Various Research Fields

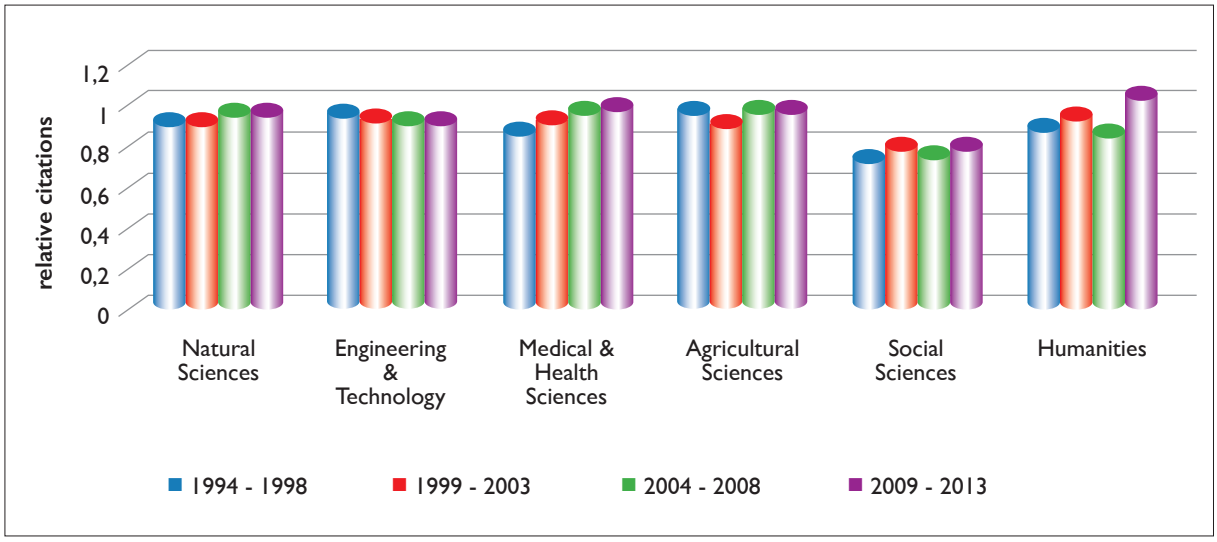


Figure 2.5: Citations in Various Research Fields Relative to the World

Table 2.3 shows that most scientific publications are journal articles (an average of 73,9% in 2009 – 2013) followed by meeting abstracts (7,7%), conference proceeding papers (5,9%), with other sources accounting for the remaining 2,6%. Journal articles increased significantly between the periods 2004 – 2008 and 2009 – 2013 **(Figure 2.6)** which further illustrate the quality of South Africa's scientific outputs. With investments such as travel grants provided by the National Research Foundation (NRF), the number of conference proceedings papers is increasing although it is declining as a share of South African scientific publications **(Figure 2.7)**.

CURRENT R&D CAPACITY (CONTINUED)

Table 2.3: South African Scientific Publications by Type of Document

		Articles	Proceedings Papers	Letters	Meeting Abstracts	Editorials	Book Reviews	Other Reviews	Others
Number of Scientific Publications	1994 - 1998	17 036	2 466	1 346	1 125	932	842	496	889
	1999 - 2003	19 254	2 051	949	1 489	989	731	753	177
	2004 - 2008	26 487	2 552	836	3 073	1 488	995	1 375	1 622
	2009 - 2013	43 458	3 485	940	4 520	2 334	1 100	2 667	342
% Share of SA Publications	1994 - 1998	67,8	9,8	5,4	4,5	3,7	3,4	2,0	3,5
	1999 - 2003	73,0	7,8	3,6	5,6	3,7	2,8	2,9	0,7
	2004 - 2008	68,9	6,6	2,2	8,0	3,9	2,6	3,6	4,2
	2009 - 2013	73,9	5,9	1,6	7,7	4,0	1,9	4,5	0,6

Source: Thomson Reuters "Incites"

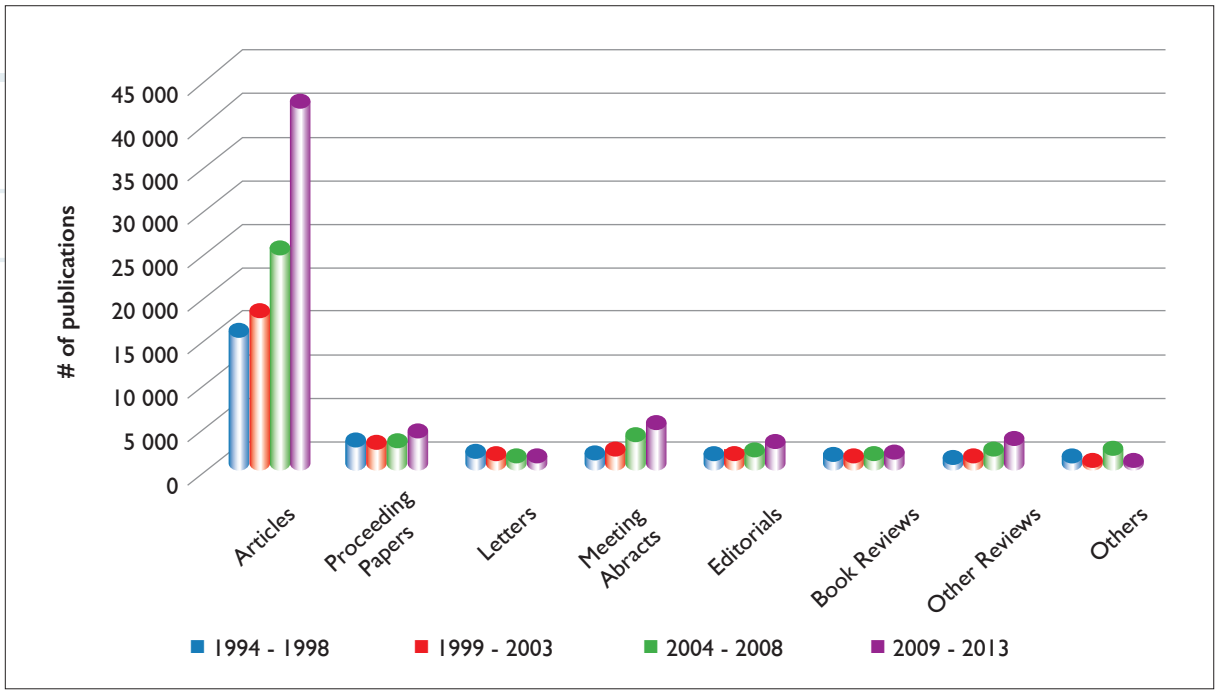


Figure 2.6: Trends in Different Type of South African Scientific Publications

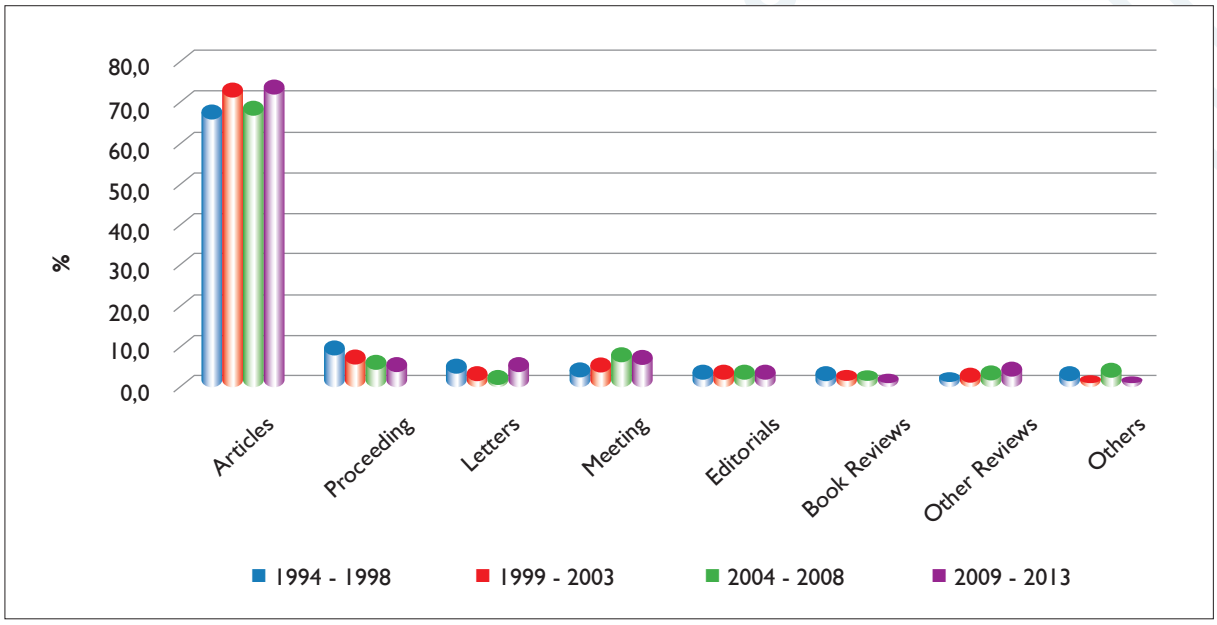


Figure 2.7: Percentage Share of Different Types of South African Scientific Publications

Table 2.4 reports on the knowledge generation efficiency in South Africa for different scientific fields. The comparison in this case needs to be done carefully as each scientific field has a unique structure with different capital and staff compositions and requirements. As an example, more R&D expenditure goes into the Engineering and Technology research field (US $840,3 million in 2012) which is an equivalent of 29% of South African GERD, although in terms of scientific publications output, only 12,4% are from this field. In terms of focus, the Engineering and Technology field is expected to produce relatively less publications. The fields with more scientific publications per million US $ R&D expenditure are typically focused on basic research (e.g. Natural Sciences, Medical and Health Sciences as well as Humanities) whereas those with less scientific publications per investment on R&D are focused more on applied research and/ or they are more capital intensive.

Table 2.4: South African Knowledge Generation Efficiency in Various Research Fields (2012)

	Natural Sciences	Engineering & Technology	Medical & Health Sciences	Agricultural Sciences	Social Sciences	Humanities
R&D Expenditure (million US $)	800,1	840,3	500,3	220,5	487,2	59,2
Proportion of R&D Expenditure (%)	27,4	29	17,2	7,6	16,8	2
Number of Scientific Publications	5 107	1 485	2 769	659	1 491	464
Proportion of Scientific Publications (%)	42,6	12,4	23,1	5,5	12,5	3,9
Scientific Publications per Million US $ R&D Expenditure	6,4	1,8	5,5	3,0	3,1	7,8

Source: R&D expenditure data from DST "National Survey of Research and Experimental Development" and publications data from Thomson Reuters "Incites"

2.2 Knowledge Networks

In this section, the South Africa's the top research collaborations around the world are analysed, emphasising BRICS and African countries.

2.2.1 Top Research Collaborations

As **Table 2.5** shows, South Africa's science system is becoming more collaborative as indicated by an increase in the number of documents published with at least one author from other countries. The majority of research collaborations are with the top 10 countries that are all developed economies (US, England, Germany, Australia, France, Netherlands, Canada, Switzerland, Italy and Sweden). In 2013, South African researchers published about 84,1% of scientific papers with at least one author from these countries. This is an increase of 28,7 percentage points if compared with the 2004 level. From 2011 onwards, the other BRICS countries (Brazil, China, India and Russia) have overtaken the top 10 African countries in terms of importance as research collaborating partners of South Africa.

Table 2.5: Proportion of SA Scientific Publications with Authors from Selected Countries

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Top 10 World Collaboration	55,4	57,0	57,5	59,6	61,0	62,1	66,8	70,2	82,8	84,1
BRICS Collaboration	4,0	4,6	4,3	4,7	6,2	5,3	7,1	9,1	12,1	13,2
Top 10 Africa Collaboration	3,9	4,7	4,7	5,2	6,3	6,6	8,0	8,7	10,2	9,8

Source: Thomson Reuters "Incites"

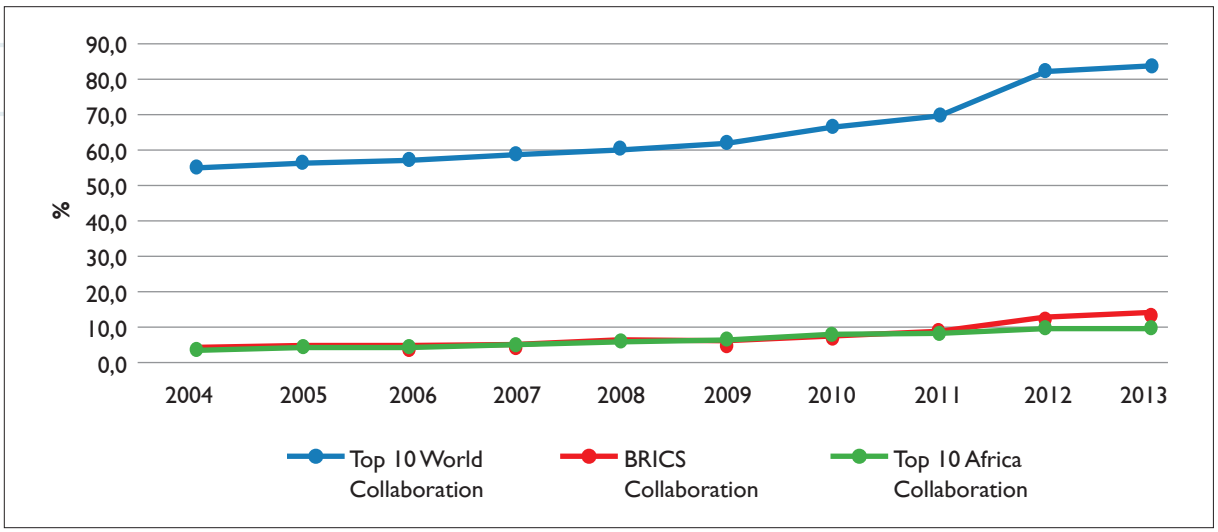


Figure 2.8: Trends in Proportion of SA Collaborative Scientific Publications with Selected Countries

2.2.2 World Collaboration

As **Table 2.6** and **Figure 2.9** show, from the top 10 collaborating countries that South Africa has with the developed countries, the United States is the top collaborator (with a total share of South Africa's publications of 15,9%, during 2009 – 2013) followed by England (10,1%), Germany (5,8%), Australia (5,2%), etc. The collaborations that are growing rapidly for these groups of countries are those with France, Netherlands, Switzerland, Italy and Sweden. Overall, the research network has strengthened with these top collaborating countries for the period 1994 to 2013.

Table 2.6: Top South African Knowledge Generation Collaborations with the World

		SA-US	SA-ENGLAND	SA-GERMANY	SA-AUSTRALIA	SA-FRANCE	SA-NETHERLANDS	SA-CANADA	SA-SWITZERLAND	SA-ITALY	SA-SWEDEN
Number of Collaborative Publications	1994 - 1998	1 770	1 081	672	452	304	165	353	148	189	84
	1999 - 2003	2 882	1 821	1 114	878	696	502	540	304	344	259
	2004 - 2008	5 078	3 126	1 757	1 398	1 199	984	1 033	653	540	509
	2009 - 2013	9 354	5 961	3 395	3 054	2 838	2 332	2 215	1 801	1 622	1 534
% of SA Publications	1994 - 1998	7,0	4,3	2,7	1,8	1,2	0,7	1,4	0,6	0,8	0,3
	1999 - 2003	10,9	6,9	4,2	3,3	2,6	1,9	2,0	1,2	1,3	1,0
	2004 - 2008	13,2	8,1	4,6	3,6	3,1	2,6	2,7	1,7	1,4	1,3
	2009 - 2013	15,9	10,1	5,8	5,2	4,8	4,0	3,8	3,1	2,8	2,6

Source:Thomson Reuters "Incites"

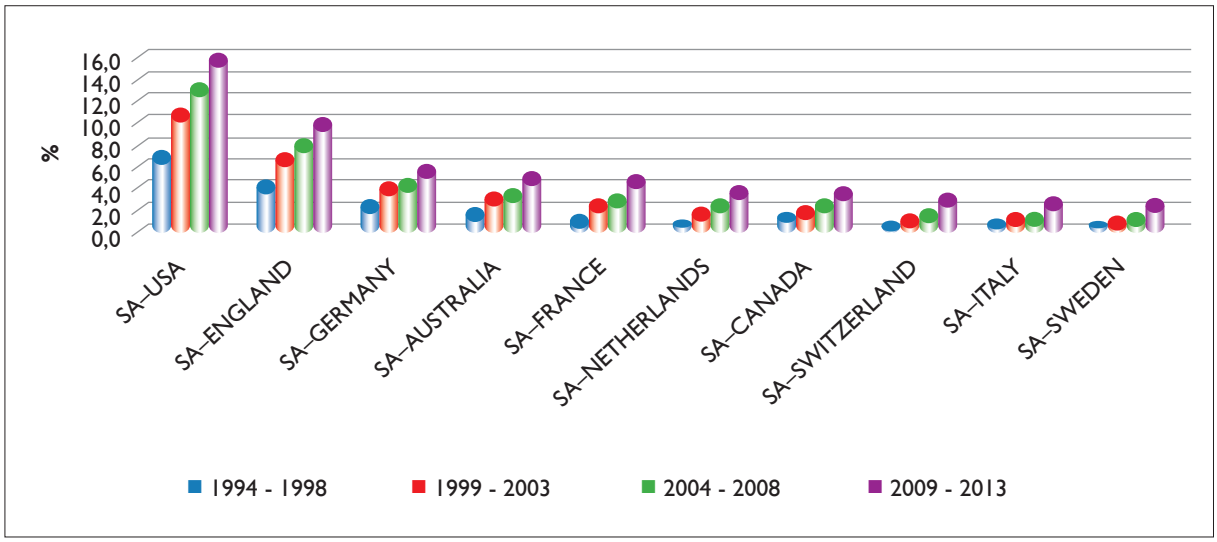


Figure 2.9: Percentage Share of Most prolific Collaborating Countries with South Africa for Knowledge Generation

CURRENT R&D CAPACITY (CONTINUED)

2.2.3 Africa Collaboration

Most scientific research collaborations in Africa are with Nigeria (with a share of 1,4% during the 2009 - 2013 period) followed by Kenya (1,1%), Zimbabwe (0,8%), Uganda (0,7%), etc. **(Table 2.7** and **Figure 2.10)**. There are few research collaborations with North African countries such as Egypt and Morocco, although they have a higher proportion of researchers (FTE per 1 000 employed) compared with South Africa. Research collaborations with these countries (including other African countries with the superior human capital) can help to strengthen further the South African science system. A platform such as Science, Technology and Innovation Strategy for Africa can be used in leveraging collaboration with African countries.

Table 2.7: Top South African Knowledge Generation Collaboration with Africa Countries

		SA-NIGERIA	SA-KENYA	SA-ZIMBABWE	SA-UGANDA	SA-MOROCCO	SA-TANZANIA	SA-CAMEROON	SA-MALAWI	SA-NAMIBIA	SA-ZAMBIA
Number of Collaborative Scientific Publications	1994 - 1998	17	33	70	5	5	12	2	8	42	16
	1999 - 2003	71	104	131	23	12	33	24	19	54	31
	2004 - 2008	271	223	210	142	22	119	78	100	176	78
	2009 - 2013	826	660	462	413	318	314	296	279	250	235
% of SA Scientific Publications	1994 - 1998	0,1	0,1	0,3	0,0	0,0	0,0	0,0	0,0	0,2	0,1
	1999 - 2003	0,3	0,4	0,5	0,1	0,0	0,1	0,1	0,1	0,2	0,1
	2004 - 2008	0,7	0,6	0,5	0,4	0,1	0,3	0,2	0,3	0,5	0,2
	2009 - 2013	1,4	1,1	0,8	0,7	0,5	0,5	0,5	0,5	0,4	0,4

Source: Thomson Reuters "Incites"

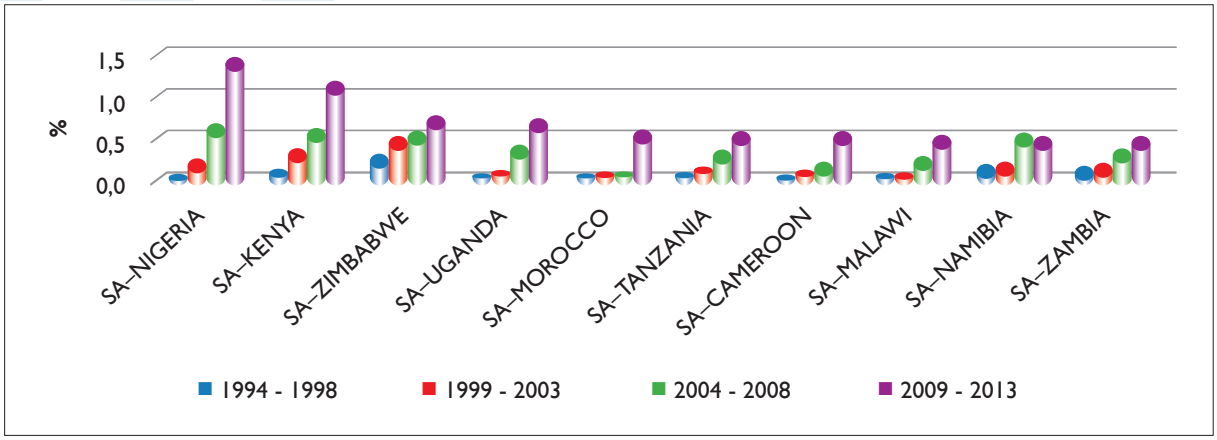


Figure 2.10: Percentage Share of Africa Knowledge Generation Collaboration to South African Publications

2.2.4 BRICS Collaboration

For the BRICS research collaboration, China is the leading collaborating country, followed by India, Brazil and Russia **(Table 2.8** and **Figure 2.11)**. Between 2009 and 2013, at least one author from China co-authored on average 2,3% of total South African scientific publications. This is a small change in comparison to the 1994 – 1998 period when Russia was the top BRICS collaborating partner with South Africa, followed by India and Brazil. Russia is technologically advanced[ii], hence it is important to further strengthen its research collaboration with South Africa.

Table 2.8: South African Knowledge Generation Collaboration with BRICS Countries

		SA-BRAZIL	SA-RUSSIA	SA-INDIA	SA-CHINA
Number of Collaborative Publications	1994 - 1998	70	124	76	40
	1999 - 2003	131	152	162	157
	2004 - 2008	324	226	369	428
	2009 - 2013	1 057	776	1 282	1 363
% of SA Publications	1994 - 1998	0,3	0,5	0,3	0,2
	1999 - 2003	0,5	0,6	0,6	0,6
	2004 - 2008	0,8	0,6	1,0	1,1
	2009 - 2013	1,8	1,3	2,2	2,3

Source: Thomson Reuters "Incites"

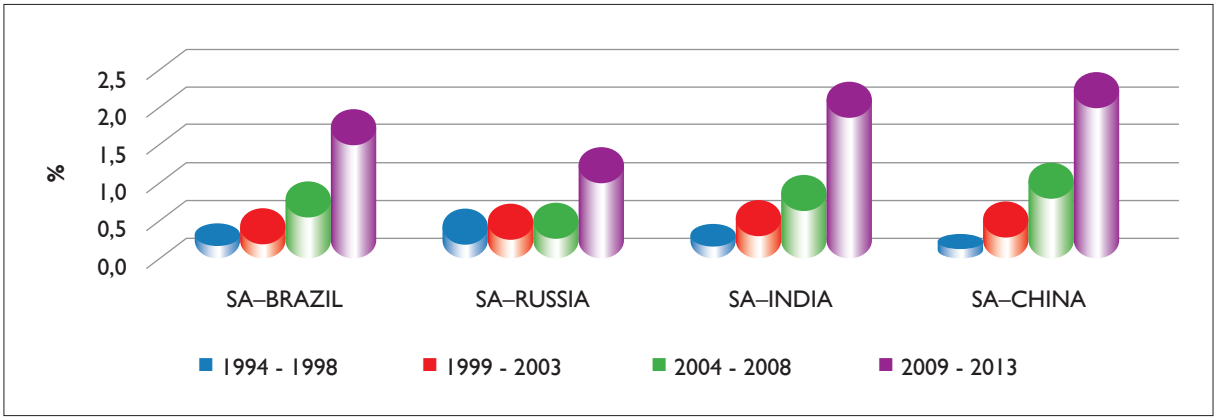


Figure 2.11: Percentage Share of BRICS Knowledge Generation Collaboration to South African Publications

2.3 Higher Education Research Publications and Inter-Sectorial Collaboration[2]

The main research output of the higher education institutions (apart from students training) are publications. Research publications play an important role within the country's scientific system. Universities are receiving government subsidies, according to the number of research publications their members of staff produce. Publications are an important indicator of research performance.

[2] All the data in this section is sourced from Quantitative Evidence Research cc

CURRENT R&D CAPACITY (CONTINUED)

Figure 2.12 shows the number of documents (articles; reviews; conference proceeding; etc.) produced annually by the country's universities. **Figure 2.13** shows the number of articles produced by the country's universities. Articles are the main component of documents. Both figures show a substantial increase during the 2000s.

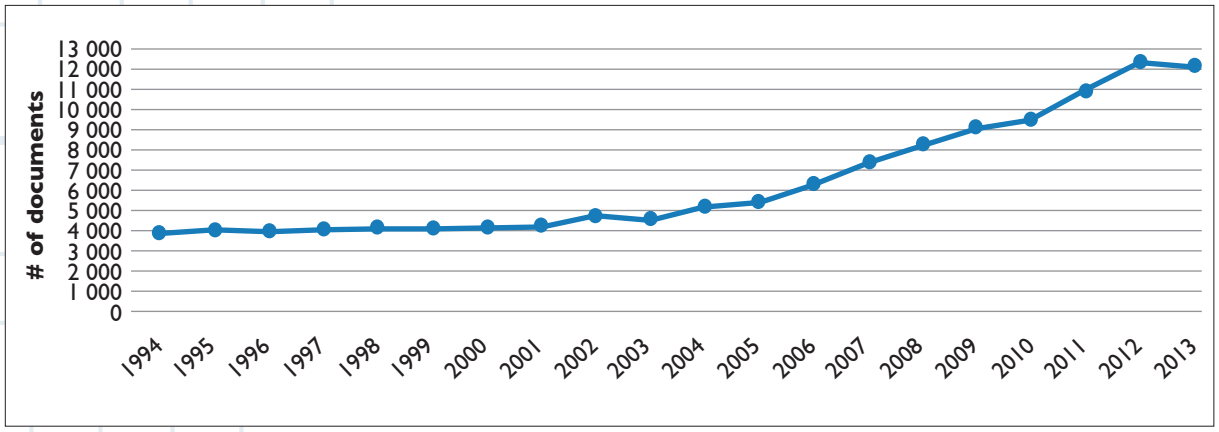


Figure 2.12: Number of Documents Produced by the SA Universities

The number of articles **(Figure 2.13)** captured by Thomson Reuters appears to have tripled from around 3 000 per year during the late 1990s to more than 9 000 during 2013.

A number of articles[iii] investigated the forces underlying the increase in the number of publications. The factors identified include the government's subsidy to universities for research publications; the expanded coverage of local journals by Thomson Reuters; the NRF's researcher rating system and others.

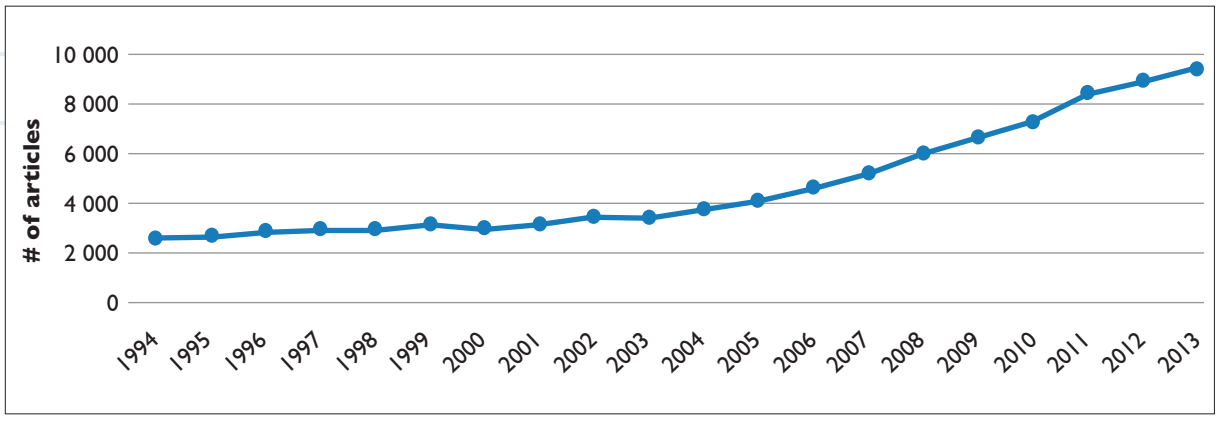


Figure 2.13: Number of Research Articles Produced by South African Universities

Figure 2.14 shows the universities' share in the country's articles. Universities during the end of the period were contributing to 90% of the country's research.

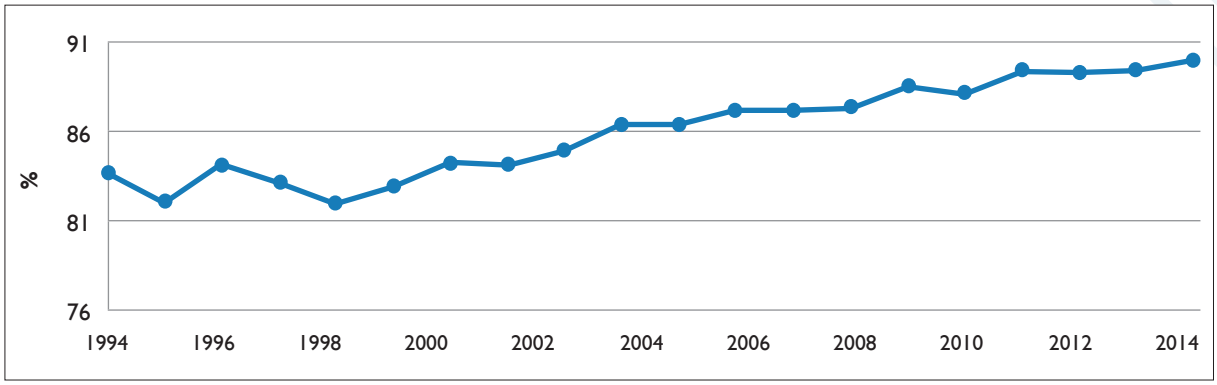


Figure 2.14: Universities' Percentage Share in Country's Articles (University/ SA Articles)

Table 2.9: Countries collaborating with South African Universities (2009-2013)

University of Cape Town	
Country/Territories	**Record Count**
US	2 485
England	2 138
France	900
Germany	876
Australia	825
Netherlands	713
Canada	675
Switzerland	634
Italy	574
Spain	503

University of Witwatersrand	
Country/Territories	**Record Count**
US	1 965
England	1 139
Australia	741
Germany	637
France	566
Switzerland	496
Canada	470
Sweden	468
Netherlands	455
China	435

University of Pretoria	
Country/Territories	**Record Count**
US	911
England	436
Netherlands	327
Australia	318
Germany	264
France	205
Belgium	200
Canada	182
Switzerland	138
Scotland	137

University of Johannesburg	
Country/Territories	**Record Count**
US	541
England	415
Germany	370
Australia	360
Canada	348
Netherlands	329
France	326
Italy	320
Japan	316
Russia	305

University of KwaZulu Natal	
Country/Territories	**Record Count**
US	1 230
England	811
France	403
Germany	334
Canada	327
Australia	298
Switzerland	254
Sweden	250
India	219
Netherlands	212

Stellenbosch University	
Country/Territories	**Record Count**
US	1 027
England	680
Germany	542
Australia	360
Netherlands	330
France	327
Canada	269
Switzerland	218
Belgium	196
China	186

CURRENT R&D CAPACITY (CONTINUED)

Table 2.9 shows the countries with which the various South African universities collaborate. The US and England appear to be the major collaborators of all universities on the list. Germany also appears among the top five countries of co-authoring countries. Netherlands, Australia, France and Canada are also on the list of major co-authorship countries with South African universities.

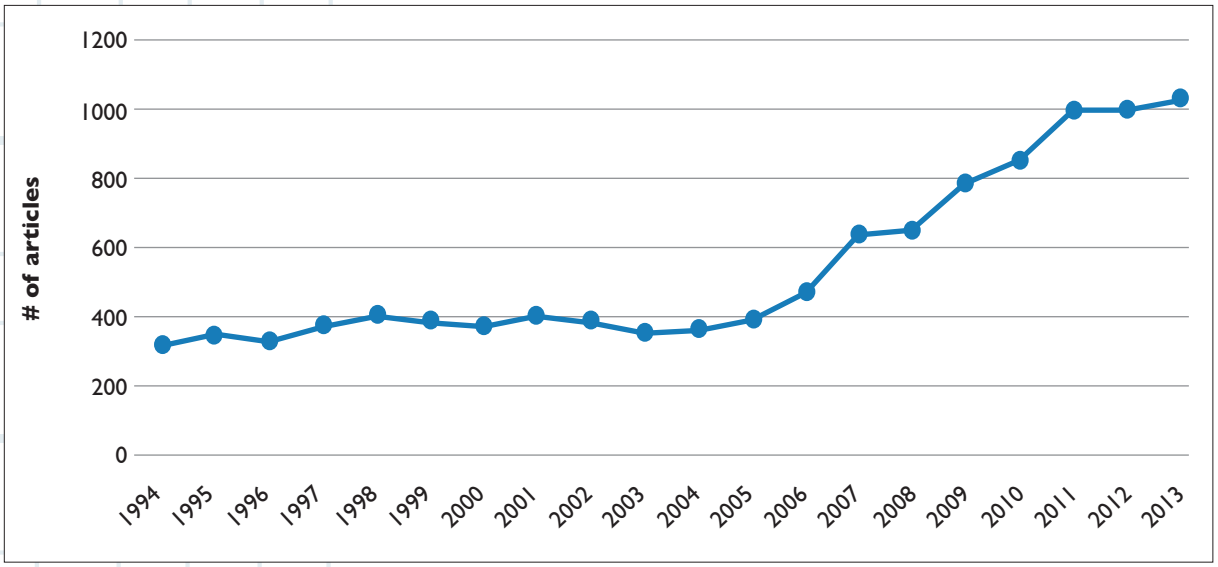


Figure 2.15: Number of Articles Produced by Science Councils

The sector was producing approximately 400 articles per year during the 1990s. During the 2010s the number has reached 1 000 and it appears to be stabilising at this level.

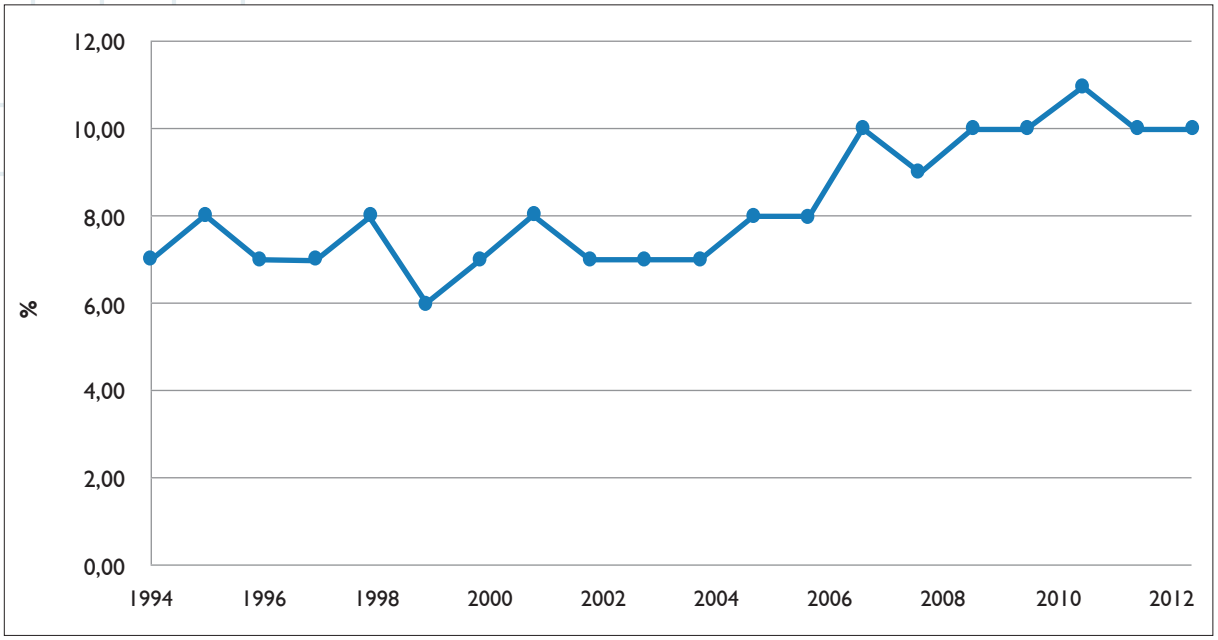


Figure 2.16: Percentage Share of Articles Produced by Science Councils in South Africa

Figure 2.16 shows the share of science councils' articles within the national number of articles produced. Science Councils appear to produce approximately 10% of the research in the country. The trend appears to have been flat over the 1994 - 2005 period and after a jump it appears to have stabilised again just above 10% after 2008.

Figure 2.20 shows the number of articles produced by business sector authors. It is apparent that in South Africa businesses undertake limited research. During the end of the period 1994 - 2013 the sector produced approximately 100 articles per year.

Figure 2.18 shows the share of business sector articles in the national set of publications. The share appears to be on a declining path.

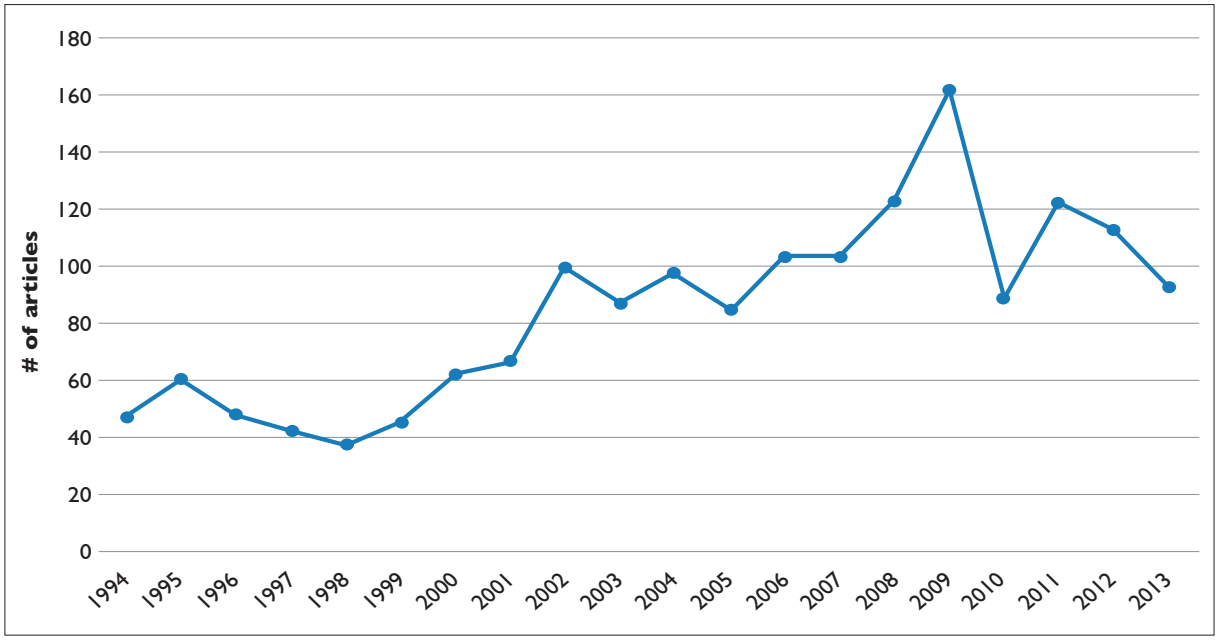


Figure 2.17: Number of Articles Produced by Business Sector

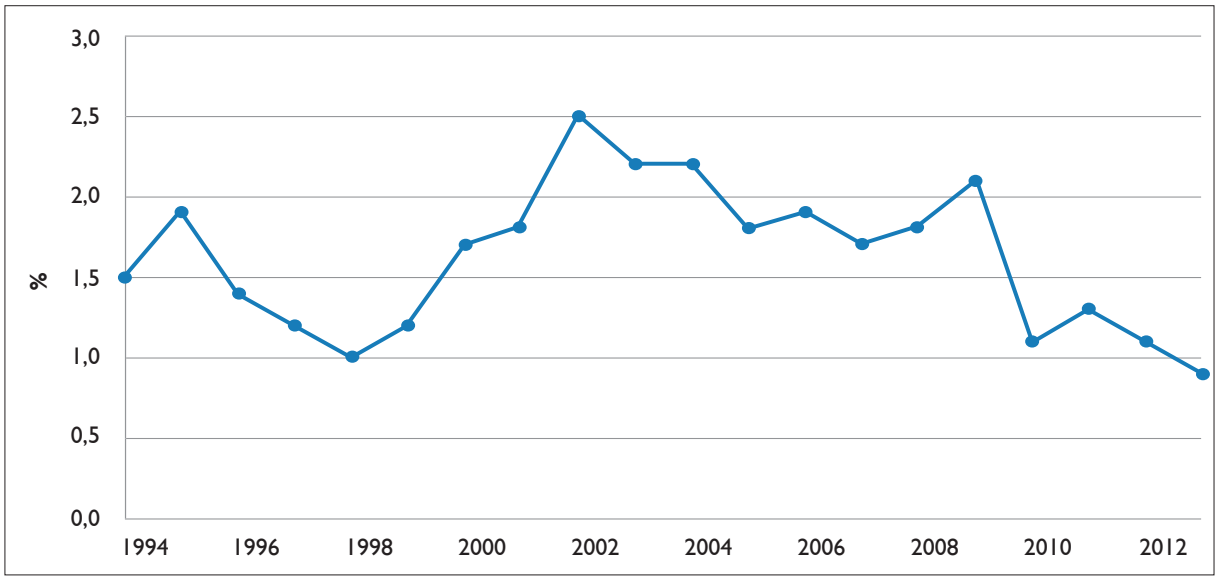


Figure 2.18: Percentage Share of Articles Produced by the Business Sector in South Africa

Table 2.10: Most Prolific Organisations in Publishing in Higher Education; Science Councils and Business Sector

Major University Performers (2009 - 2013)	
Universities	**Record Count**
University of Cape Town	11 278
University of Witwatersrand	8 409
Stellenbosch University	7 686
University of Pretoria	7 494
University of KwaZulu Natal	7 150

Major Research Council Performers (2009 -2013)	
Research Councils	**Record Count**
National Research Foundation	3 617
Council for Scientific and Industrial Research	1 847
MRC	1 209
ARC	387
MINTEK	139

Major Business Sector Performers (2009 - 2013)	
Business Sector	**Record Count**
Sasol	187
Necsa	89
PBMR	35
Clinvet Int Pty Ltd	30
GAD Consulting Serv	28
Element Six	28

Table 2.10 shows the most prolific organisations in the three sectors and the number of articles they produced during the 2009 - 13 period. Universities produce the largest and business organisations the smallest number of publications. Under the ambit of the National Research Foundation, the national research facilities reporting to it are included (e.g. SAAO).

Table 2.11 shows the inter-sectoral co-authorship outputs for three five-year periods: 1999 - 2003; 2004 - 2008 and 2009 - 2013). Co-authorship data are indicators of collaboration at the sectoral level. This data has the potential to show the integration of R&D activities. The table makes profound an increasing trend in integration as measured by co-authorship. For example, the number of co-authored articles between at least two universities increased from 1 559 articles during the 1999 - 2003 period to 6 455 articles during 2009 - 2013.

Table 2.11: Inter-Sectoral Co-Authored Articles

1999 - 2003			
	Higher Education	Science Councils	Business Sector
Higher Education	1 559	731	112
Science Councils	731	66	11
Business Sector	112	11	2

2004 - 2008			
	Higher Education	Science Councils	Business Sector
Higher Education	2 893	1 687	198
Science Councils	1 687	150	25
Business Sector	198	25	10

2009 - 2013			
	Higher Education	Science Councils	Business Sector
Higher Education	6 455	3 896	350
Science Councils	3 896	349	61
Business Sector	350	61	40

The higher education institutions appear to be the driving force in the inter-sectoral integration. Universities produce substantially more co-authorship articles between themselves, and the country's science councils and the business sector than the other sectors combined. **Table 2.12** shows the co-authored shares of the various sector combinations in the three five-year periods. Only local organisations are included in the analysis.

Table 2.12: Inter-Sectoral Co-Authorship Percentage Shares

Percentage Share			
1999 - 2003			
	Higher Education	Science Councils	Business Sector
Higher Education	65	30	5
Science Councils	90	8	1
Business Sector	90	9	2
2004 - 2008			
	Higher Education	Science Councils	Business Sector
Higher Education	61	35	4
Science Councils	91	8	1
Business Sector	85	11	4

CURRENT R&D CAPACITY (CONTINUED)

2009 - 2013			
	Higher Education	Science Council	Business Sector
Higher Education	60	36	3
Science Councils	90	8	1
Business Sector	78	14	9

For example, during 2009 - 2013, 60% of the co-authored articles of the higher education institutions were between the institutions in the sector, 36% are co-authorships with science councils and 3% with business sector organisations.

Table 2.13 shows the scientific disciplines emphasised in inter-sectoral collaboration. Co-authorship with the business sector is very limited.

Table 2.13: Disciplines Emphasised in Inter-Sectoral Collaboration

Disciplines Emphasised (Higher Education & Science Councils 2009 - 2013)	
Materials Science	454
Physics	410
Chemistry	396
Environmental Sciences/Ecology	396
Science, Technology Other Topics	360
Infectious Diseases	294
Public Environmental Occupational Health	246
General Internal Medicine	235
Immunology	225
Microbiology	224

Disciplines Emphasised (Business Sector & Science Councils 2009 - 2013)	
Marine Freshwater Biology	14
Materials Science	14
Environmental Sciences/ Ecology	11
Science, Technology and Other Topics	10

Disciplines Emphasised (Business Sector & Higher Education 2009 - 2013)	
Chemistry	117
Engineering	112
Energy/Fuels	45
Materials Science	37
Nuclear Science Technology	35
Biochemistry/Molecular Biology	34
Environmental Sciences/Ecology	32
Physics	32
Genetics/Heredity	30
Marine Freshwater Biology	29

The major institutions participating in co-authorship efforts include:

Table 2.14: Major Performers in Inter-Sectoral Co-Authorship

Major University Performers (2009 - 2013)
Universities
Stellenbosch University
University of Witwatersrand
University of Pretoria
University of Cape Town
University of KwaZulu Natal

Major Research Council Performers (2009 -2013)
Research Councils
National Research Foundation of South Africa
Council For Scientific Industrial Research
MRC
ARC
MINTEK

Major Business Sector Performers (2009 - 2013)
Business Sector
Sasol
Necsa
PBMR
Clinvet Int Pty Ltd
Element Six

3 IMPORTED KNOW-HOW

The small size of South Africa's science system and the shortage of technical/scientific skills imply that the country will continue sourcing know-how from other countries, in order to catalyse technological innovation and technical progress. This section uses the technology balance of payments as well as foreign direct investment indicators in appraising the usage of foreign technology and know-how.

3.1 Technology Balance of Payments

As shown in **Table 3.1** and **Figure 3.1**, South Africa pays substantially more for foreign know-how compared to receipts from the right to use the country's intellectual property (IP). In 2013, the ratio of technology payments to technology receipts was 30,8: 1, compared with 34,8: 1 in 2009, 31,2: 1 in 2008 and 23,6: 1 in 2004. This shows that reliance on imported technology increased post the recession. In 2013 the ratio was back to pre-recession levels. The 1996 White Paper on Science and Technology recognises the opening of the South African economy to the global market and as a result, it encourages identification of niche markets in which international competitiveness can be improved. In addition, it supported an increase in technology investment and enhancement of productivity.

Table 3.1: South African Technology Balance of Payments (million US $)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Technology Payments	1 070,6	1 282,0	1 586,3	1 675,9	1 658,0	1 941,2	2 117,9	2 016,7	1 931,7
Technology Receipts	45,3	45,8	52,9	53,7	47,7	59,2	65,8	67,3	62,8

Source: The World Bank "World Development Indicators"

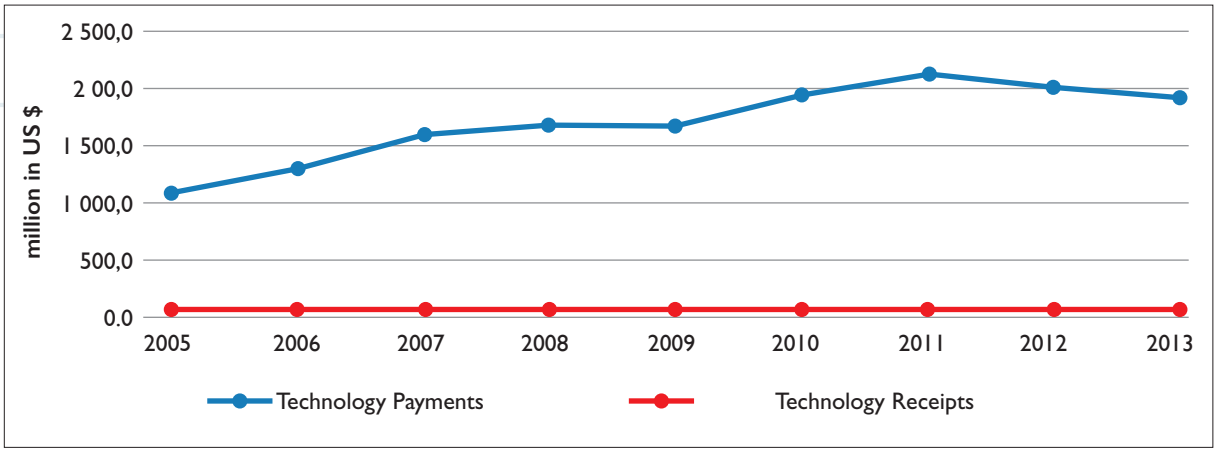


Figure 3.1: Trend in South African Technology Balance of Payment (million US $)

As a result of a decrease in technology payments in 2012 and 2013, technology payments per capita have also decreased during the same years, although the 2013 value (US $36,5) is still much higher than the 2005 value of US $22,5 **(Table 3.2)**. Since 2009, technology payments have been increasing slightly in comparison to the GDP, despite some decline in 2010. This indicates an appetite for technological know-how despite the turbulent economic conditions. Since 2005, the technology payments as a percentage of GERD have been increasing constantly.

Table 3.2: Level of South African Technology Payments

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Technology Payments per Capita (US $)	22,5	26,5	32,6	33,5	32,6	38,1	41,0	38,5	36,5
Technology Payments as a % of GERD	48,1	52,4	60,3	65,2	66,1	70,0	69,2	69,3	-
Technology Payments as a % of GDP	0,43	0,49	0,56	0,61	0,58	0,53	0,52	0,53	0,55

Source: Population and GDP data from The World Bank "World Development Indicators"; GERD data from DST "National Survey of Research and Experimental Development"

3.2 Foreign Direct Investment

There are different approaches used for technology catch-up strategies. In addition to technology acquisitions, foreign direct investment (FDI) can serve as a good source of global technological competency. **Table 3.3** and **Figure 3.2** show the cyclicality of net flows of foreign direct investment as a percentage of GDP. The FDI flows peaked at the beginning of the recession in 2008 (at 3,62% of GDP) but decreased in 2010 and 2011, followed by increases in 2012 and 2013. Depending on the nature of these FDIs, their rise in 2012 and 2013 may have offset the decrease in technology payments experienced during the same years.

Table 3.3: Level of South African Foreign Direct Investment Inflows

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Foreign Direct Investment, Net Inflows (% of GDP)	0,32	2,64	0,24	2,30	3,62	2,68	1,01	1,02	1,21	2,32

Source: The World Bank "World Development Indicators"

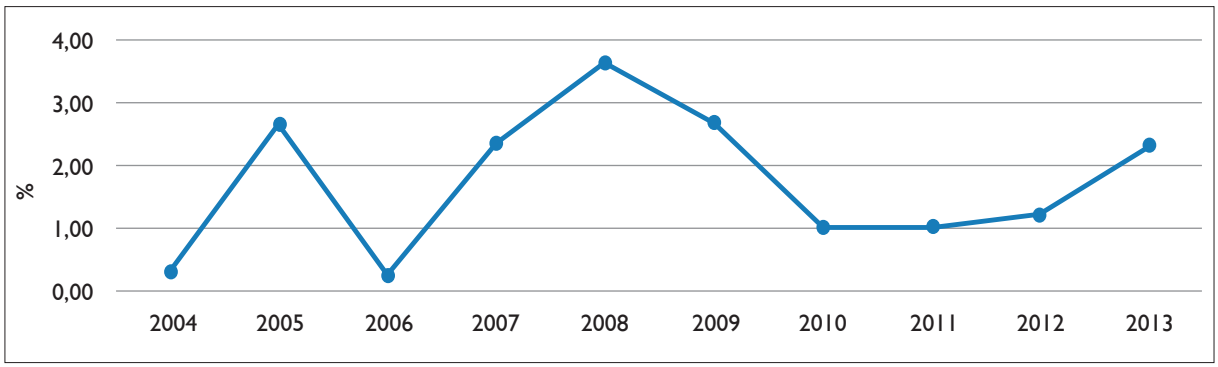


Figure 3.2: Trend in South African Foreign Direct Investment as a Percentage of GDP

4 SET HUMAN CAPITAL

4.1 Researchers

As shown in **Table 4.1**, South African human capital in science, engineering and technology (SET) areas is smaller in relation to the total number of people in employment than the OECD average. In 2011 and 2012, the number of researchers per thousand employed was at 1,5 which is below most of the OECD countries and two of the BRICS partners (Russia and China). Russia has a comfortably large SET human capital base (6,2% in 2012), which is slightly below the OECD average. The United States and the United Kingdom are already the major collaborating partners in the scientific research, which allows South Africa to access their much stronger SET human capital bases. An opportunity exists for South Africa to strengthen Africa collaboration with Arab countries, as well as other African countries such as Senegal, with a relatively favourable ratio of researchers as a percentage of total employment.

Table 4.1: Number of Researchers per Thousand Total Employment (FTE)

	2004	2005	2006	2007	2008	2009	2010	2011	2012
South Africa	1,6	1,5	1,5	1,4	1,4	1,5	1,4	1,5	1,5
OECD Total	6,7	6,9	7,0	7,0	7,2	7,5	7,5	7,7	-
Brazil	1,2	1,3	1,3	1,3	1,3	1,4	1,5	-	-
China	1,3	1,5	1,6	1,9	2,1	1,5	1,6	1,7	1,8
India	-	0,4	-	-	-	-	0,4	-	-
Russian Federation	7,1	6,8	6,7	6,7	6,4	6,4	6,3	6,3	6,2
United Kingdom	8,0	8,6	8,7	8,6	8,5	8,8	8,8	8,6	8,7
United States	7,8	7,7	7,7	7,6	8,1	8,8	8,5	8,8	-
Egypt	-	-	-	2,2	1,5	1,5	1,5	1,8	-
Morocco	-	-	2,0	2,0	2,0	-	2,3	2,6	-
Senegal	-	-	0,7	0,7	1,0	-	0,9	-	-

Source: OECD "Main Science and Technology Indicators"; Brazil , Egypt, India, Morocco and Senegal; data from UNESCO Institute of Statistics; South Africa data from DST "National Survey of Research and Experimental Development 2012/13"

The NDP aims to increase the proportion of academic staff with doctoral qualifications at South African higher education institutions from the baseline of 34% to over 75% by 2030. As **Table 4.2** shows, in 2012 the percentage of higher education staff with PhD degrees within the traditional universities was 39,3%, at the comprehensive universities, it was 25.0% and at the universities of technology, 14.7%.

Table 4.2: Percentage of Higher Education Academic Staff with Doctorate; Qualification at Various Universities (FTE)

	2005	2006	2007	2008	2009	2010	2011	2012
Traditional Universities	29,8	33,9	35,8	35,9	36,6	38,6	39,1	39,3
Comprehensive Universities	19,0	23,8	19,3	24,4	23,7	22,5	24,2	25,0
Universities of Technology	8,0	8,7	10,0	11,0	12,0	12,8	13,5	14,7

Source: DST "Research Information Management System (RIMS) database"

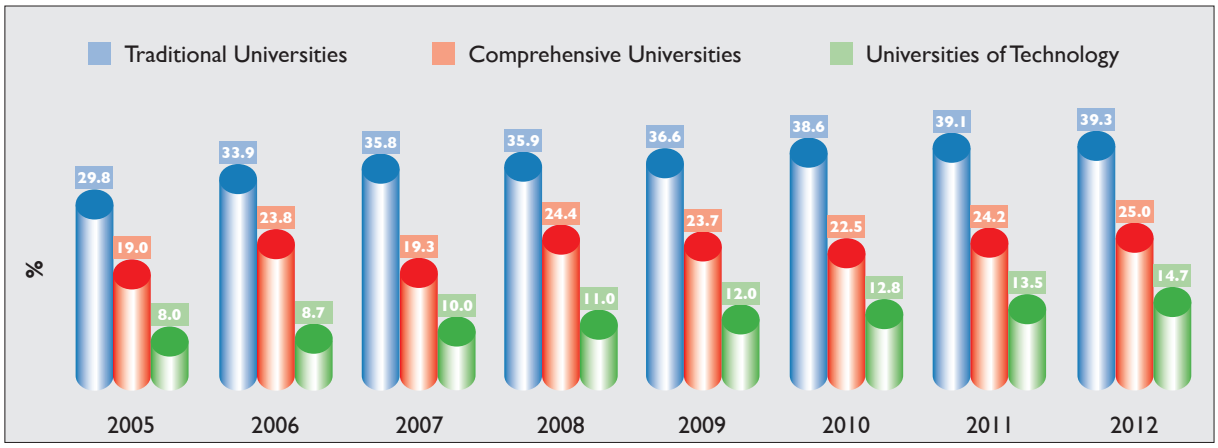


Figure 4.1: Trend in Percentage of Academic Staff with Doctoral Qualifications

Table 4.3 gives a breakdown of the higher education academic staff with doctoral qualifications in terms of gender, race and age. The majority of these higher education academic staff with PhDs are white males aged 50 and above. On average, less than 3,5% of academic staff aged less than 30 years have PhDs. More male academic staff in general are likely to have doctoral qualifications compared to their female counterparts (36,4% in 2012 compared to 25,3% for females).

SET HUMAN CAPITAL (CONTINUED)

Table 4.3: Proportion of Higher Education Academic Staff with Doctorate Qualification (FTE)

	2005	2006	2007	2008	2009	2010	2011	2012
Number of Staff with PhD	3 782	4 410	4 318	4 722	4 933	5 188	5 699	5 890
% Staff with PhD	22,9	27,1	26,8	28,6	29,1	29,9	30,9	31,3
% Female Staff with PhD	16,2	19,4	19,9	22,1	22,2	23,5	24,5	25,3
% Male Staff with PhD	28,0	33,0	32,1	33,8	34,7	35,2	36,2	36,4
% African Staff with PhD	13,4	15,0	15,7	17,8	18,7	19,8	21,2	21,6
% Coloured Staff with PhD	13,8	18,0	19,0	20,2	22,0	21,5	22,9	25,2
% Indian Staff with PhD	17,5	18,9	19,6	20,3	23,6	24,9	27,0	27,9
% African, Coloured and Indian Staff with PhD	14,3	16,2	17,0	18,6	20,1	21,0	22,5	23,2
% African, Coloured and Indian Female Staff with PhD	8,9	10,1	11,1	12,8	13,9	14,9	16,1	17,1
% African, Coloured and Indian Male Staff with PhD	18,0	20,6	21,2	22,6	24,4	25,3	27,1	27,7
% White Staff with PhD	28,6	34,0	32,4	35,1	35,5	36,2	37,2	37,7
% White Female Staff with PhD	20,6	25,0	24,7	27,5	27,3	29,0	30,2	31,1
% White Male Staff with PhD	35,0	41,2	38,6	41,6	42,9	42,9	43,9	44,1
% Staff Aged 20 - 29 with PhD	3,1	3,0	3,2	3,4	3,4	3,7	3,7	2,9
% Staff Aged 30 - 39 with PhD	14,1	17,5	18,0	19,9	20,5	22,5	23,9	23,9
% Staff Aged 40 - 49 with PhD	27,1	31,7	30,8	32,4	33,5	33,6	35,1	36,2
% Staff Aged 50 - 59 with PhD	37,8	42,3	39,6	42,2	43,5	42,9	44,1	44,7
% Staff Aged 60+ with PhD	41,0	46,2	43,6	45,7	46,7	46,8	47,0	49,8

≥40% <40% & ≥35% <35% & ≥30% <30% & ≥20% <20% & ≥10% <10%

Source: DST "Research Information Management System (RIMS) database"

Figure 4.2 shows the inbound and outbound mobility of researchers for South Africa. The terminology on researchers' mobility model is described in **Box 2**.

BRAIN INFLOW	**TRANSITORY BRAIN MOBILITY**	**BRAIN OUTFLOW**
Researchers: 8,9%	Researchers: 49,1%	Researchers: 8,0%
Relative Productivity: 0,96	Relative Productivity: 1,27	Relative Productivity: 0,88
Relative Age: 1,14	Relative Age: 1,10	Relative Age: 1,18
FWCI: 1,60	FWCI: 1,91	FWCI: 1,63
Inflow	**Transitory (mainly South Africa)**	**Outflow**
Researchers: 6,5%	Researchers: 13,6%	Researchers: 4,9%
Relative Productivity: 0,89	Relative Productivity: 0,57	Relative Productivity: 0,77
Relative Age: 1,11	Relative Age: 0,98	Relative Age: 1,16
FWCI: 1,57	FWCI: 1,28	FWCI: 1,57
Returnee Inflow	**Transitory (mainly South Africa)**	**Returnee Outflow**
Researchers: 2,4%	Researchers: 35,5%	Researchers: 3,1%
Relative Productivity: 1,13	Relative Productivity: 1,44	Relative Productivity: 1,05
Relative Age: 1,23	Relative Age: 1,14	Relative Age: 1,31
FWCI: 1,71	FWCI: 2,02	FWCI: 1,70
	SEDENTARY	
	Researchers: 34,0%	
	Relative Productivity: 0,50	
	Relative Age: 0,78	
	FWCI: 1,04	

Figure 4.2: International Mobility of South African Researchers (1996 – 2013)

Source: The World Bank and Elsevier "A Decadal of Development in Sub-Saharan African Science, Technology, Engineering and Mathematics Research"

Box 2: Researchers Mobility Terminology

Category	Description
Sedentary	Researchers who have only published with affiliations to institutions within a country. This include researchers who move between institutions within the same country.
Inflow	Researchers who come to the country
Outflow	Researchers who leave the country
Returnees (Inflow)	Researchers who first publish while at an institution within the country, leave and publish with an affiliation to an institution outside of the country for two or more years, and ultimately return to the country. The institutional affiliation of their return destination need to be the same as their "original institution".
Returnees (Outflow)	Researchers who first publish elsewhere, come and stay in the country for two or more years, and then leave to publish elsewhere.
Transitory	Researchers that spend less than two years at an institution in the country or an institution outside the country at any given time.

Indicator	Description
Relative Productivity	The number of papers published per year since the first appearance of each researcher as an author in the database during the period 1996 – 2013, relative to all researchers in the country for the same rticles, not just those articles with a country affiliation. Relative productivity somewhat normalises for career length, enabling comparisons of productivity across different groups (e.g. those comprising mostly early career researchers versus those comprising mostly more senior researchers). For instance, a group that has a relative productivity of 1,28 produces 28% more papers published per year than that institution's overall average papers published annually.

Relative Age	The number of years since the first appearance of each researcher as an author in the database relative to all researchers in the country in the same period. The analysis calculates relative age for the author's entire output in publications (e.g. not just those with a country affiliation). Since the dataset goes as far back as 1996, reporting on relative age is right-censored (e.g. the time since a researcher's first appearance as an author has an upper limit of 17 years).
FWCI	Field-Weighted Citation Impact is an indicator of mean citation impact for all the researcher's publications (regardless of country affiliation) and it compares to the actual number of citations received by a paper with the expected number of citations for papers of the same document type (article review or conference proceeding papers), publication year and subject field.

Source: The World Bank and Elsevier "A Decadal of Development in Sub-Saharan African Science, Technology, Engineering and Mathematics Research"

Between 1996 and 2013, South Africa experienced a net inflow of researchers as inbound mobility was 8,9% of the total number of South African researchers published during this period, whereas the outbound mobility was 8,0%. About half of South African researchers during this period were in transitory mobility which is in line with a high R&D collaboration that South Africa has with other countries. The inbound mobility is made up of 2,4% of the returnees and 6,5% of the researchers from other countries. The returnees are more senior and productive than the inbound researchers from other countries.

The returnees outflow to the researchers' countries of origin is about 3,1% and the outflow of South African researchers is 4,9%. In a pattern similar to the inbound mobility, the outflow returnees are more senior and productive relative to their younger South African counterparts who are moving to other countries.

About 34,0% of South African researchers are not collaborating with any other researchers outside of South Africa and their relative productivity is half that of the country's average and they are 20% younger than the average age of researchers within the country. These are possibly the entry level and emerging researchers. According to the NDP, international exchange partnerships on research should be pursued and encouraged hence these sedentary type researchers need to be fully supported through various researchers' mobility grants.

4.2 SET Graduations

Following declines in total SET graduations as a percentage of total graduations in 2009 and 2010, this increased between 2011 and 2013 **(Table 4.5)**. SET graduations in 2013 were at 29,4% of the total, an increase of 1,5% from the 2010 level of 27,9%. There is a higher proportion of SET graduations within total graduations at undergraduate level (30,1% in 2013) compared to postgraduate level (27,7%).

SET graduations are low in comparison to SET enrolments although this ratio has been improving recently (from 17,4% in 2011 to 18,7% in 2013). Some slight improvements in SET graduations are also taking place for females and the previously disadvantaged individuals (PDIs). In 2013, 72,8% of SET graduations were from the previously disadvantaged category students and 50% of SET graduations were females.

Table 4.4: Higher Education SET Graduations

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of Total SET Graduations	31 483	33 506	35 542	36 429	39 306	41 511	42 760	46 099	48 848	53 176
% Undergraduate SET Graduations	28,6	28,9	29,3	29,5	29,9	28,7	27,6	28,6	29,6	30,1
% Postgraduate SET Graduations	22,4	24,9	26,1	26,4	27,6	29,4	28,7	28,9	29,1	27,7
% Total SET Graduations	26,9	27,8	28,5	28,8	29,4	28,9	27,9	28,7	29,4	29,4
SET Graduations to Enrolments (%)	15,5	15,9	16,8	17,0	17,5	17,5	17,0	17,4	17,9	18,7
% PDIs Total SET Graduations	60,9	61,2	62,8	64,1	66,4	67,7	69,2	70,1	71,5	72,8
% Female Total SET Graduations	49,0	48,9	48,7	49,2	49,3	49,5	49,1	49,4	49,4	50,0

Source: DHET "Higher Education Information Management System"

It can be deduced from **Table 4.5** and **Figure 4.3** that between 2004 and 2013, doctoral SET graduations at South Africa's public universities have been growing at a rate of 9,3% per annum, which is higher than the annual rate of growth for all doctoral graduations (7,5%). As a result, the proportion of SET PhD degrees awarded has increased from 45,2% in 2005 of all the PhDs awarded and 48,6% in 2008, to 54,2% in 2011; however, it decreased slightly in 2012 (52,4%). In 2013, the proportion of SET PhDs was 52,5%.

Table 4.5: Doctoral Degrees Awarded by South African Universities

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
SET PhDs	499	561	522	590	575	704	730	854	985	1 076
Total PhDs	1 105	1 189	1 100	1 274	1 182	1 380	1 421	1 576	1 878	2 051

Source: DHET "Higher Education Information Management System"

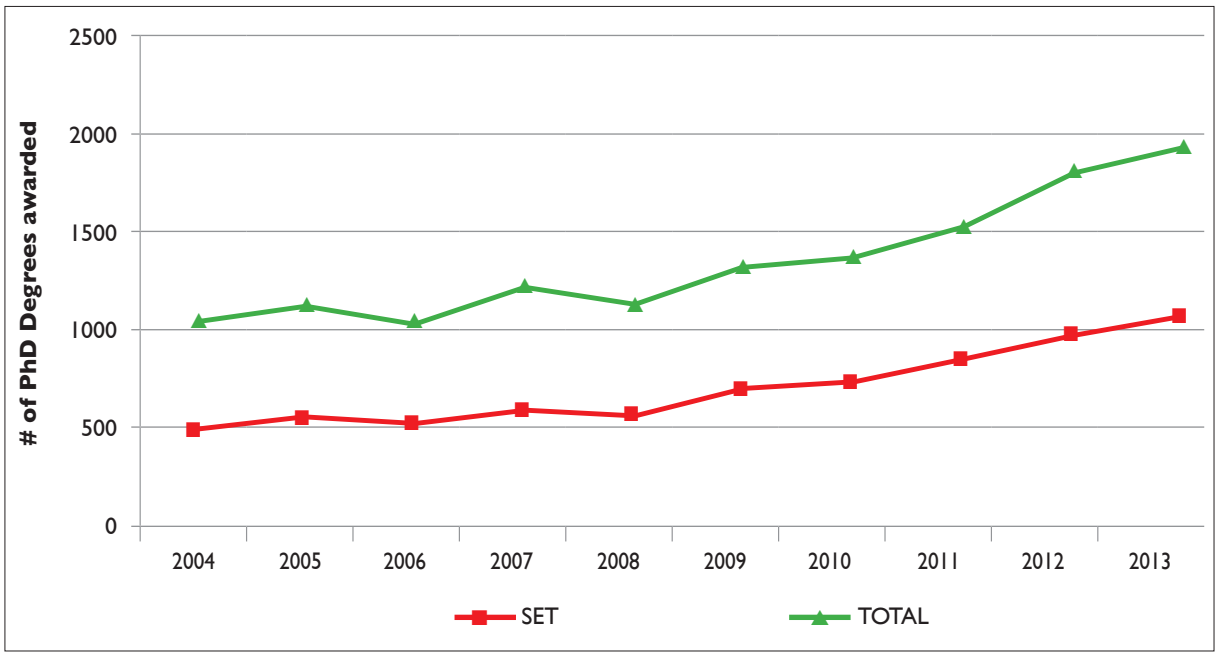


Figure 4.3: Trend in Doctoral Degrees Awarded by South African Universities

The number of females being awarded doctoral qualifications is low compared to that of their male counterparts **(Table 4.6)**. In 2013, 446 females qualified with PhD degrees while the number for males was 630. An average annual growth rate on PhD attainment is high for females (10,2% between 2004 and 2013) compared with that of males during the same period of 8,7%.

Table 4.6: SET Doctoral Degrees Awarded by South African Universities by Gender

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Female	191	225	220	225	227	281	292	349	402	446
Male	309	336	302	365	348	423	439	505	580	630

Source: DHET "Higher Education Information Management System"

In terms of race, for the first time in 2013, the number of African students graduating with SET doctoral degrees exceeded that of white students (**Table 4.7** and **Figure 4.4**). This transition point is important as the NDP seeks to increase the number of African and female postgraduates, especially at the PhD level, to improve research and innovation capacity and to cater for a more representative university staff.

SET HUMAN CAPITAL (CONTINUED)

Table 4.7: Distribution of SET Doctoral Degrees Awarded by South African Universities by Race

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
African	120	172	156	164	193	254	275	326	410	461
Coloured	23	28	16	36	32	41	41	41	49	53
Indian	41	43	40	43	52	48	55	72	80	88
White	315	317	309	345	296	357	354	408	436	452

Source: DHET "Higher Education Information Management System"

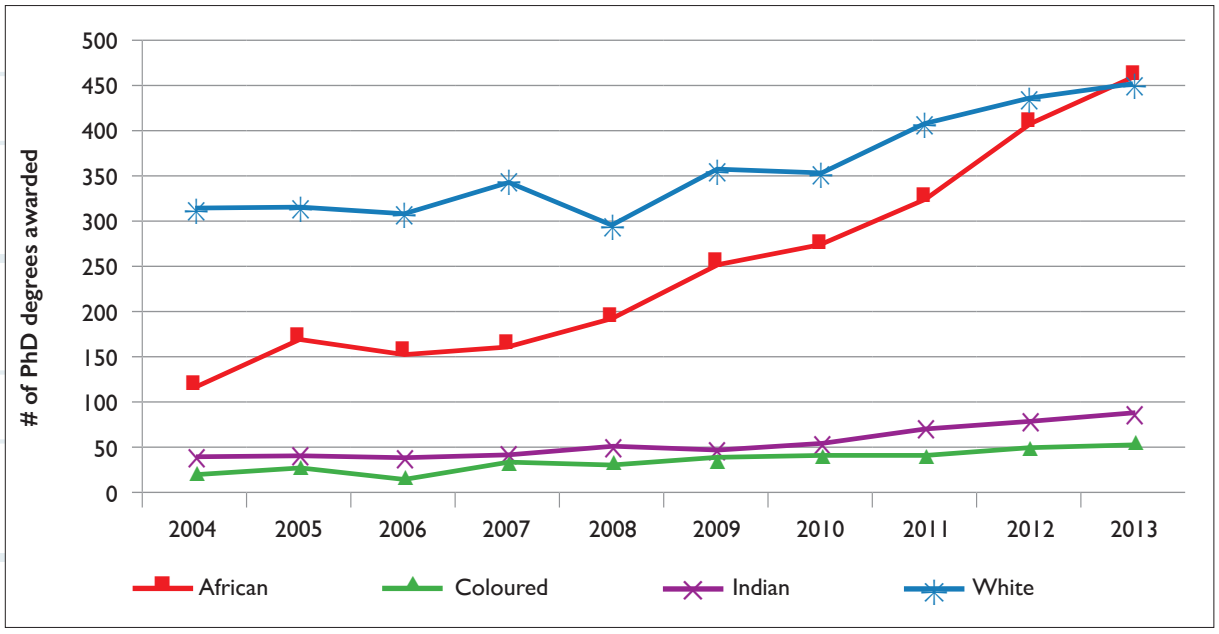
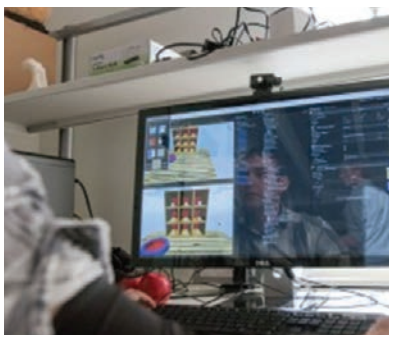


Figure 4.4: Trend in Doctoral Degrees Awards by South African Universities by Race



5 TECHNICAL PROGRESS (IMPROVEMENT AND INNOVATION)

As stated by the National Research and Development Strategy (NRDS), economic growth and wealth creation are driven by technological innovation within the country. The NRDS further stated that in developed countries, more than 50% of economic growth is attributable to technical progress. In this chapter the proxy indicators of patents, industrial designs and trademarks are used to track South Africa's technical progress.

5.1 Intellectual Property Protection

5.1.1 Patents

A patents family is a group of patents filed at different intellectual property filing offices for the same invention by the same patent owner (s)/ inventor (s). As **Figure 5.1** shows, there has been a sharp decrease in the number of patent family applications since 2008, a trend that was still continuing in 2012. This decrease in patent family applications contrasts with the positive growth the country is experiencing in scientific publications. A possible lag in processing and publishing data on patents family applications needs to be taken into account in interpreting this data.

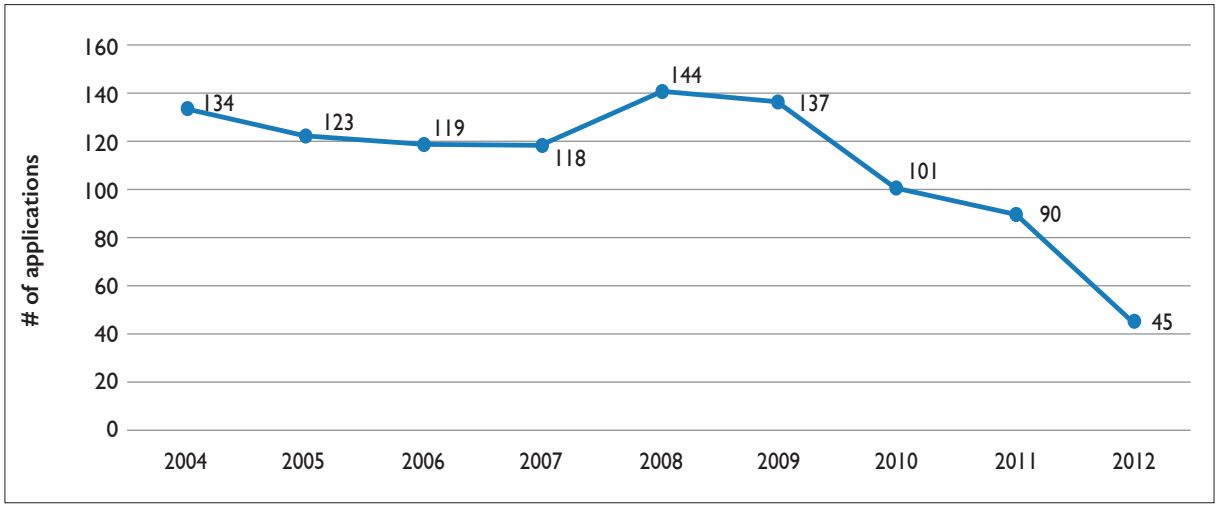


Figure 5.1: Trends in Number of South African Patent Family Applications
Source: WIPO "IP Statistics Data Center"

As shown in **Table 5.1** and **Figure 5.2**, the destination for most of South Africa's patent family applications is the United States (32,3% share during 2009 – 2012) followed by the United Kingdom (21,0%). During the same period, only 15,6% of the patents family were filed locally in the South African patent filing office.

TECHNICAL PROGRESS
(IMPROVEMENT AND INNOVATION (CONTINUED)

Table 5.1: South African Patent Family Application at Various Patent Offices

	Number of Patent Family Applications				% Share of South African Patent Family Applications			
	1994 - 1998	1999 - 2003	2004 - 2008	2009 - 2012	1994 - 1998	1999 - 2003	2004 - 2008	2009 - 2012
South Africa	133	191	225	58	28,6	36,8	35,8	15,6
US	76	110	133	120	16,3	21,2	21,2	32,3
UK	74	60	60	78	15,9	11,6	9,6	21,0
International Bureau (WIPO)	0	50	99	204	0,0	9,6	15,8	14,8
China	24	12	24	14	5,2	2,3	3,8	3,8
European Patent Office	17	9	11	4	3,7	1,7	1,8	1,1
Australia	9	10	8	10	1,9	1,9	1,3	2,7
Canada	21	9	3	0	4,5	1,7	0,5	0,0
Argentina	1	6	10	4	0,2	1,2	1,6	1,1
India	21	0	0	0	4,5	0,0	0,0	0,0
Other Patent Offices	89	62	55	28	19,1	12,0	8,8	7,6
Total	**465**	**519**	**628**	**371**	**100**	**100**	**100**	**100**

Source: WIPO "IP Statistics Data Center"

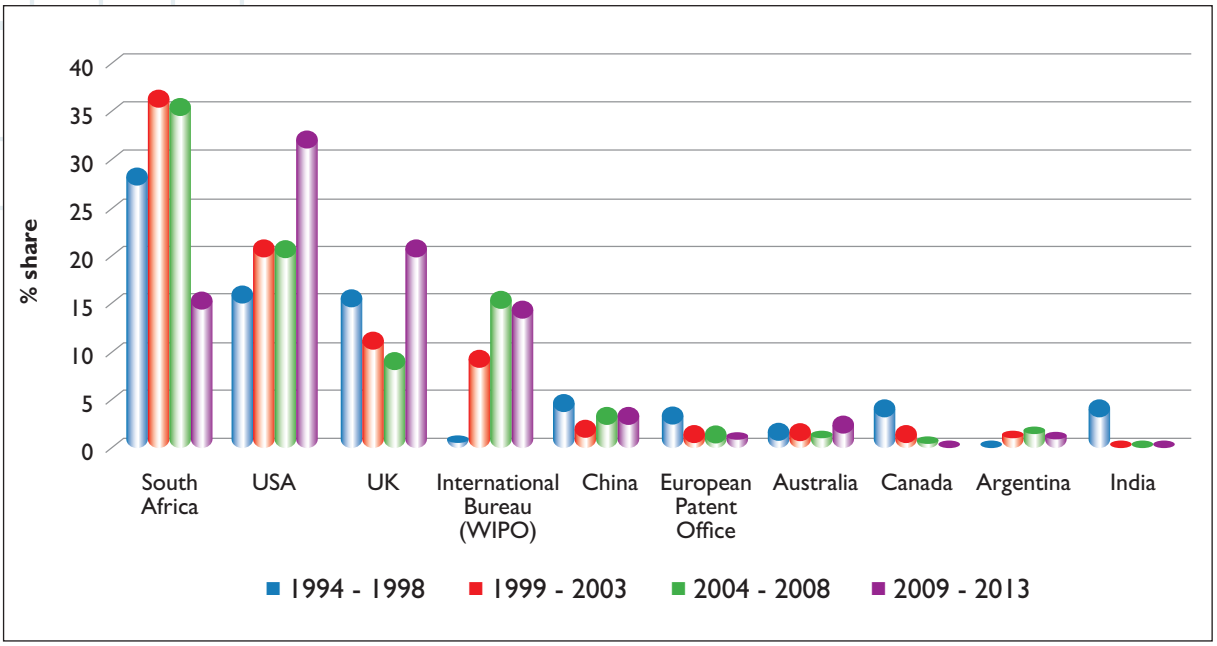


Figure 5.2: Percentage Share of South African Patent Family Applications at Various Patent Offices

As shown in **Table 5.2**, a high share of South Africa's worldwide patents published on selected technologies at the United States Patent and Trademark Office (USPTO) were in respect of medical technology (31,9% in 2012) followed by pharmaceuticals (24,3%). Most of the country's patents on civil engineering are filed at the International Bureau (WIPO) filing office (27,3%) followed by the US (18,0%) and locally in South Africa (13,8%). A large proportion of South African technologies filed in China are in materials/metallurgy (11,4%) as well as basic materials chemistry (10,4%) which is in line with the mix of South Africa's export basket to China. Second to WIPO, a large proportion of electrical machinery patents are filed in the United States (16,5%).

Table 5.2: Destination of South African Patent Publications on Selected Technologies, % (2012)

	Materials/ Metallurgy	Civil Engineering	Basic Materials Chemistry	Chemical Engineering	Medical Technology	Electrical Machinery	Pharma-ceuticals
South Africa	3,3	13,8	6,1	2,3	8,1	11,5	4,3
United States	10,5	18,0	19,6	19,0	31,9	16,5	24,3
Canada	5,7	4,8	5,4	5,4	1,2	5,0	4,3
Australia	5,4	6,1	6,1	7,0	4,0	6,5	4,3
International Bureau (WIPO)	13,2	27,3	11,8	14,7	23,4	23,0	24,9
European Patent Office	11,1	8,4	7,9	9,7	10,5	9,5	14,6
Japan	7,8	1,9	6,4	4,7	3,6	4,0	6,0
China	11,4	3,2	10,4	9,7	4,8	7,5	7,6
Brazil	2,4	1,6	2,1	2,7	1,6	1,0	2,2
India	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
Russia	4,5	1,0	2,9	4,7	0,8	2,0	<0,1
African Regional Intellectual Property Organization	3,0	4,5	4,6	4,3	1,2	3,5	2,2
Egypt	0,6	<0,1	0,7	<0,1	<0,1	<0,1	0,5
Other Offices	21,1	9,4	16	15,8	8,9	10	4,8

≥25% <25% & ≥20% <20% & ≥15% <15% & ≥10% <10% & ≥25% <5% & ≥0,1%

Source: WIPO "IP Statistics Data Center"

5.1.2 Industrial Designs

In the case of industrial designs, the majority are filed at the South African filing office as shown in **Tables 5.3** and **5.4**. During the period 2009 – 2013, the proportion of industrial designs filed locally was 85,3%, a decrease from 2004 – 2008 (88,8%) and 1999 – 2003 (90,8%). The United States is in distant second place with 3,4% of South African industrial designs filed there during 2009 – 2013. This is followed by the European Union's Office for Harmonization in the Internal Market (3,0%), Australia (1,8%), China (1,2%), etc.

TECHNICAL PROGRESS
(IMPROVEMENT AND INNOVATION (CONTINUED)

Table 5.3: Number of Industrial Design Applications at Selected Offices

	1994-1998	1999-2003	2004-2008	2009-2013
South Africa	2 474	3 475	4 781	3 834
United States of America	67	67	170	151
Office for Harmonization in the Internal Market	0	11	132	136
Australia	38	43	82	81
China	7	11	15	52
African Regional Intellectual Property Organization	4	0	0	40
India	4	21	17	21
Brazil	6	10	24	19
Canada	15	2	30	19
Japan	10	4	18	14
Other Offices	205	185	113	126
Total	**2 830**	**3 829**	**5 382**	**4 493**

Source: WIPO "IP Statistics Data Center"

Table 5.4: Percentage Distribution of Industrial Design Applications at Selected Offices

	1994-1998	1999-2003	2004-2008	2009-2013
South Africa	87,4	90,8	88,8	85,3
United States of America	2,4	1,7	3,2	3,4
Office for Harmonization in the Internal Market	0,0	0,3	2,5	3,0
Australia	1,3	1,1	1,5	1,8
China	0,2	0,3	0,3	1,2
African Regional Intellectual Property Organization	0,1	0,0	0,0	0,9
India	0,1	0,5	0,3	0,5
Brazil	0,2	0,3	0,4	0,4
Canada	0,5	0,1	0,6	0,4
Japan	0,4	0,1	0,3	0,3
Other Offices	7,2	4,8	2,1	2,8

Source: WIPO "IP Statistics Data Center"

5.1.3 Trademarks

As **Table 5.5** and **Table 5.6** show, in contrast with the high number of patents filed abroad, most of South Africa's trademarks are filed locally (93,2% during 2009 – 2012), a pattern similar for industrial designs. A major difference in this case is China being in second place (1,5%) and followed jointly by the European Union and the United States (0,9% each). The number of trademarks filed in Australia used to contribute 0,8% of total South African trademark applications during 1994 – 1998 and 1999 - 2003, but this has declined to just 0.5% in 2009 – 2012.

Table 5.5: Number of South African Trademark Applications at Selected Offices

	1994 - 1998	1999 - 2003	2004 - 2008	2009 - 2012
South Africa	52 867	67 832	85 096	74 195
China	240	210	878	1 199
Office for Harmonization in the Internal Market	143	679	828	720
United States of America	581	753	889	685
Australia	457	561	502	378
Brazil	102	52	230	261
India	0	14	0	198
Canada	182	227	213	185
Hong Kong	168	402	150	153
New Zealand	293	262	160	127
Other Offices	5 710	2 511	1 924	1 483
Total	**60 743**	**73 503**	**90 870**	**79 584**

Source: WIPO "IP Statistics Data Center"

Table 5.6: Percentage Distribution of Trademark Applications at Selected Offices

	1994-1998	1999-2003	2004-2008	2009-2012
South Africa	87,0	92,3	93,6	93,2
China	0,4	0,3	1,0	1,5
Office for Harmonization in the Internal Market	0,2	0,9	0,9	0,9
United States of America	1,0	1,0	1,0	0,9
Australia	0,8	0,8	0,6	0,5
Brazil	0,2	0,1	0,3	0,3
India	0,0	0,0	0,0	0,2
Canada	0,3	0,3	0,2	0,2
Hong Kong	0,3	0,5	0,2	0,2
New Zealand	0,5	0,4	0,2	0,2
Other Offices	9,4	3,4	2,1	1,9

Source: WIPO "IP Statistics Data Center"

6 BUSINESS PERFORMANCE AND KEY INDUSTRIAL SECTORS

6.1 Export of Goods and Services

As shown in **Table 6.1** and **Figure 6.1**, South Africa's trade as a percentage of GDP reached a peak in 2008 (at 74,8%) and experienced a decline in 2009 to 55,5%, potentially due to a global economic recession. The trade component of GDP has since then increased gradually and the 2013 proportion (65,1%) is nearly equal to the 2007 pre-recession performance (65,7%), and significantly higher than the trade contribution to GDP back in 2004 (53,1%).

Table 6.1: Contribution to South African Exports by Various Key Economic Sectors

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Trade (as % of GDP)	53,1	55,2	62,5	65,7	74,8	55,5	56,1	60,8	61,8	65,1
Exports of Goods and Services (as % of GDP)	26,4	27,4	30,0	31,5	35,9	27,3	28,4	30,6	29,9	31,1
Food Exports (as % of merchandise exports)	8,8	8,5	7,1	6,6	7,3	10,2	10,0	9,2	9,7	10,5
Fuel Exports (as % of merchandise exports)	9,1	10,3	9,4	10,4	9,5	11,1	10,6	11,6	12,8	11,4
Ores and Metals Exports (% of merchandise exports)	22,2	22,4	28,6	29,5	29,1	29,3	28,3	31,0	27,6	29,8
Manufacturers Exports (as % of merchandise exports)	57,6	56,7	52,9	51,6	52,2	47,5	48,7	45,7	47,6	45,9
High Technology Exports (as % of manufactured exports)	5,5	6,7	6,5	5,6	5,1	5,4	4,3	5,1	5,5	-

Source: The World Bank "World Development Indicators"

Exports of goods and services represent just less than half of the trading activities. In 2013, the value of goods and services exported as a percentage of GDP was 31,1%; 35,9% during a peak level in 2008 and 26,4% in 2004. The actual values of South African merchandise exports are shown in **Figure 6.2** whereas **Figure 6.3** shows a trend in sectoral contribution of these merchandise exports. As it has been the case for most of the 2004 to 2013 period, most of the merchandise exports in 2013 were in manufacturing (45,9%); followed by ores and metals (29,8%), fuels (11,4%) and food (10,5%).

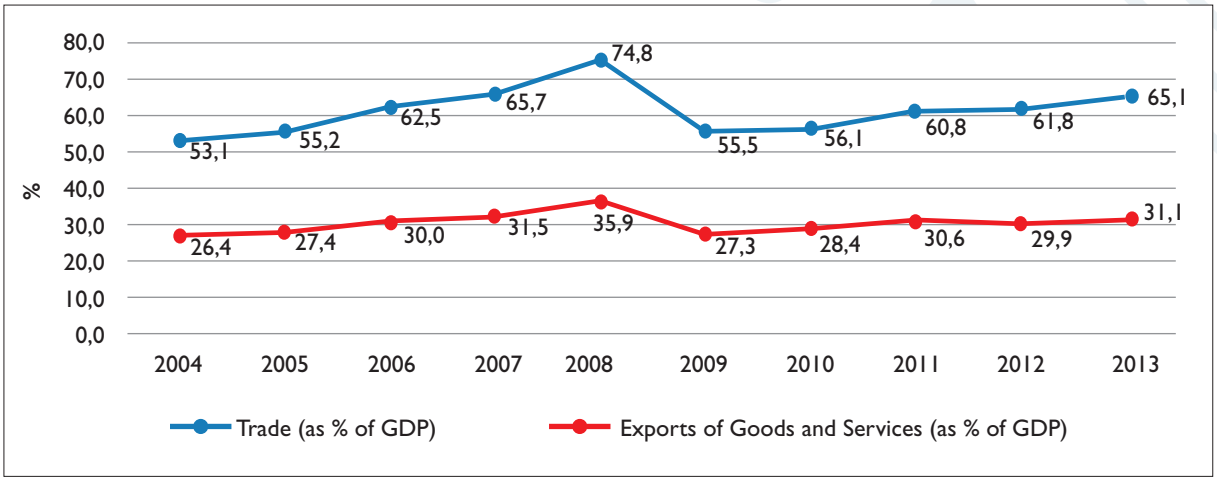


Figure 6.1: Trends in Trade and Exports as Percentage of GDP

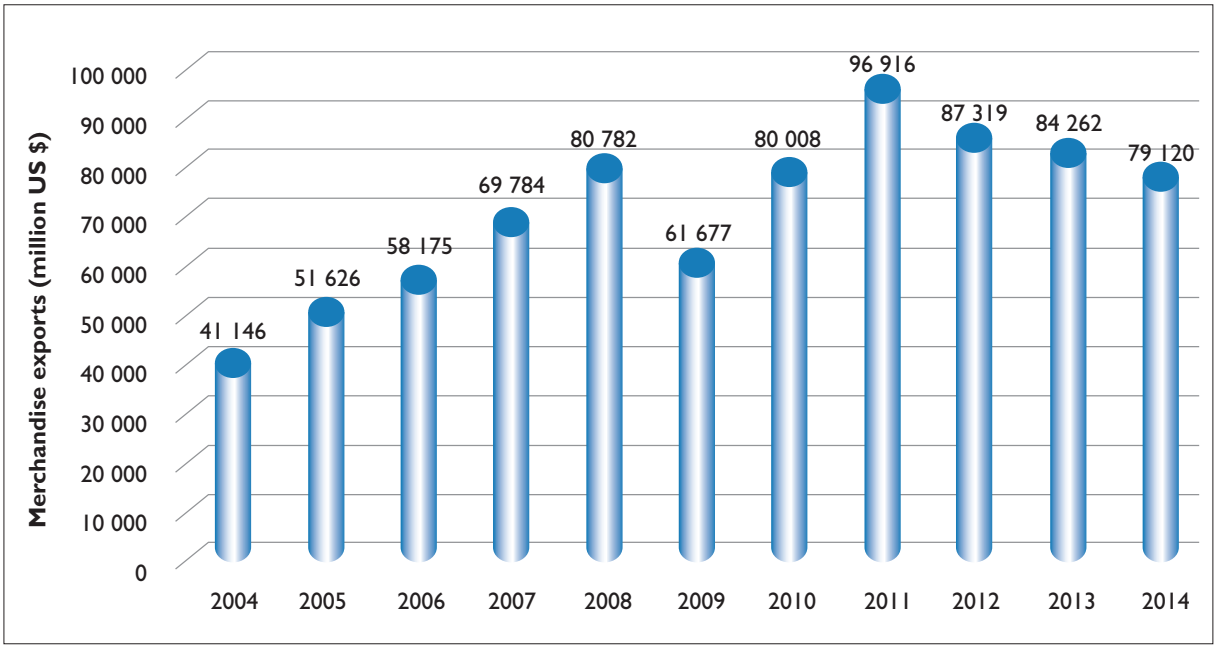


Figure 6.2: Trend in South African Total Merchandise Exports (million US $)
Source: Econometrix

According to the Industrial Development Corporation (IDC)[iv], motor vehicles are a leading manufacturing export category (7,6% of total merchandise exports in 2012) followed by basic iron and steel (7,3%); parts and accessories for motor vehicles (3,7%); and basic chemicals (3%). Although there was a persistent decline in the contribution of manufacturing to total merchandise exports, this negative trend has started to reverse in 2012 and 2013 as shown in **Figure 6.3**. However, this can be explained not as much by a stellar performance by manufacturing exports as by the fact that mineral exports declined due to lower production resulting from weak commodity prices and industrial action.

The NDP has a vision of growing South Africa's exports through diversification of trade in a manner that helps drive growth of non-mineral manufacturing and services. The share of high-technology manufacturing exports to total manufacturing exports has been stagnant at around 5.5% **(Table 6.1**).

BUSINESS PERFORMANCE AND KEY INDUSTRIAL SECTORS

As stipulated by the NDP, an upscaling of the advanced manufacturing sector can be achieved through a substantial investment in R&D and commercialisation of South African innovations.

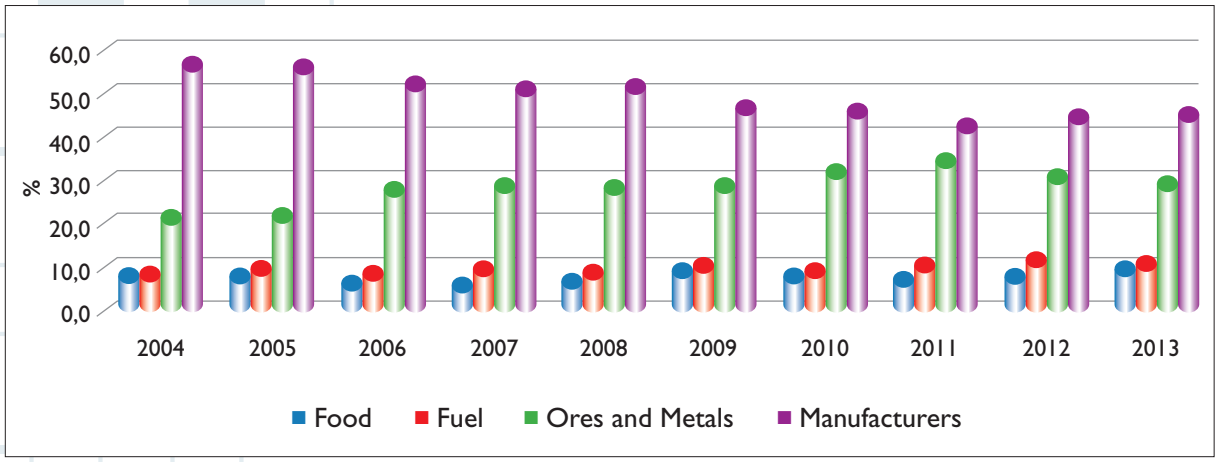


Figure 6.3: Trend in Sectoral Export Contribution to Total Merchandise Exports (%)

Although most of merchandise exports in 2004 were destined to high-income economies (66,4%), the direction of South African trade has changed significantly. In 2013, the share of South Africa's merchandise exports to high-income economies had fallen to 36,1%. Also in 2013, the merchandise to the developing countries outside of SADC for the first time during the period under review, overtook that directed towards the developed countries (**Table 6.2** and **Figure 6.4**). According to the IDC[iv], there has been a significant reduction in exports to the UK, Japan and Switzerland and to a lesser extent to the US and proportionately to Germany as well. In 2012, the main markets for South Africa's non-gold merchandise exports were China (12,9%), the US (9,8%), Japan (7,0%), Germany (6,0%), India (4,8%) and the UK (4,3%).

Table 6.2: Merchandise Exports to Various Economies as a Percentage of Total Merchandise Exports

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Arab World	2,0	1,9	2,9	3,0	2,9	3,5	2,6	2,4	3,6	2,9
High-Income Economies	66,4	66,9	74,3	70,8	67,8	60,3	59,0	51,1	49,5	36,1
Developing Economies Outside Region	8,1	10,0	11,8	15,0	15,7	20,9	27,2	22,8	23,5	43,0
Developing economies in East Asia & Pacific	4,3	4,5	5,9	8,6	8,2	13,1	15,4	15,3	14,8	34,9
Developing economies in Europe & Central Asia	*0,5*	*0,6*	*0,9*	*0,9*	*1,3*	*0,8*	*1,3*	*0,8*	*1,0*	*1,4*
Developing economies in Latin America & the Caribbean	*1,2*	*1,3*	*1,7*	*1,7*	*1,6*	*1,3*	*1,3*	*2,1*	*2,2*	*1,1*

Developing economies in Middle East & North Africa	*0,6*	*1,0*	*1,3*	*1,3*	*1,1*	*1,5*	*1,0*	*0,8*	*0,8*	*0,6*
Developing economies in South Asia	*1,5*	*2,7*	*1,9*	*2,6*	*3,5*	*4,3*	*8,2*	*3,8*	*4,6*	*5,0*
Developing Economies in Sub-Saharan Africa	12,6	13,3	13,9	14,2	16,5	18,7	13,7	14,6	16,7	13,1

Source: The World Bank "World Development Indicators"

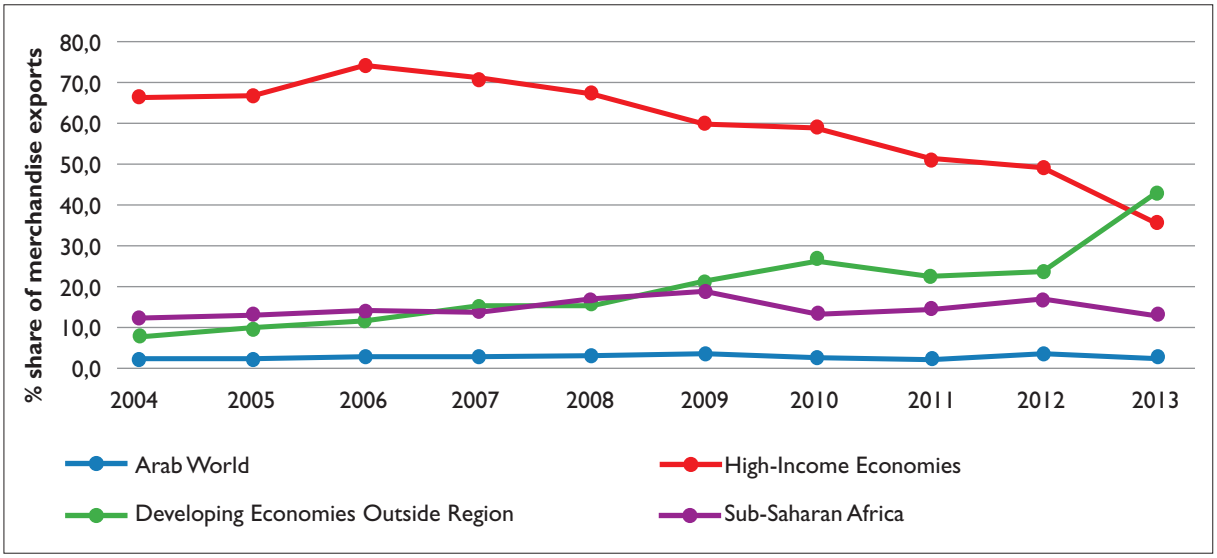


Figure 6.4: Trend in Percentage Share of Total Merchandise Exports by Various Economies

6.2 Trade Balance

The high technology manufacturing sector is increasing its world export market share gradually, although this is from a low base. In 2004, both pharmaceuticals and 'computer, electronics and optical' industries had an export market share of 0,05%. This has risen to 0,09% for pharmaceutical industry and 0,07% for computer, electronics and optics industry in 2013 (**Table 6.3** and **Figure 6.5**).

Table 6.3: Export Percentage Market Share for High Technology Manufacturing Industries

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pharmaceuticals	0,05	0,05	0,04	0,04	0,05	0,04	0,09	0,10	0,04	0,09
Computer, Electronics and Optical	0,05	0,05	0,05	0,06	0,06	0,06	0,07	0,07	0,06	0,07
Aerospace	0,16	0,37	0,27	0,23	0,25	0,10	0,13	0,14	0,11	0,14

Source: OECD "Main Science and Technology Indicators"

According to the Department of Trade and Industry (*the dti*)[v], "pharmaceutical manufacturing contributes 1,6% to South African GDP, provides direct employment to 9 600 people (most of them professionals and skilled workers) and creates a further 11 100 indirect jobs". Furthermore, the downstream segment in this industry (logistics, warehousing, distribution and sales) provides an additional 25 000 jobs.

BUSINESS PERFORMANCE AND KEY INDUSTRIAL SECTORS

The export market share in this industry is low compared to some of the BRICS's countries (China had 2,41% market share while Russia had 0,11% in 2013). The pharmaceutical industry is key for South Africa to support an expanding public antiretroviral (ARV) programme in South Africa and other African countries where there is a high prevalence of HIV/AIDS.

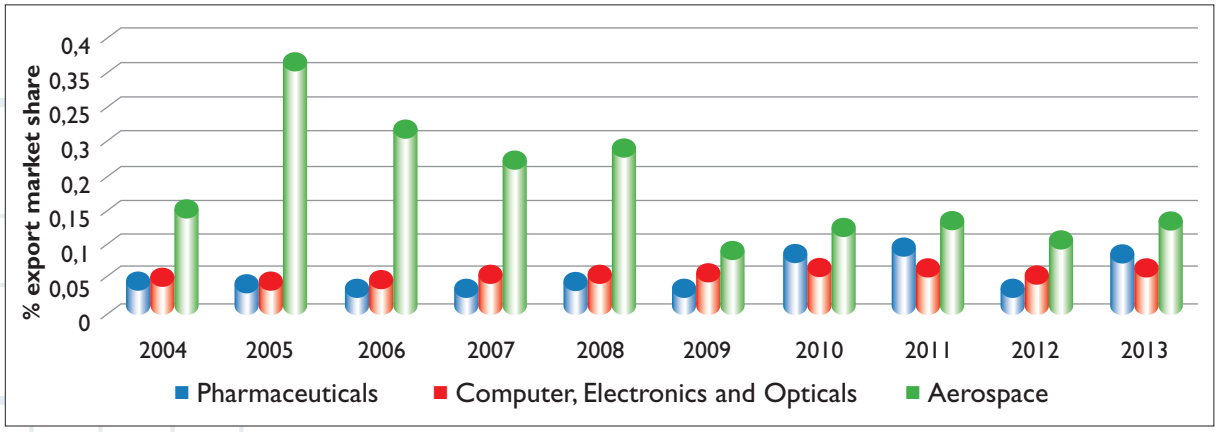


Figure 6.5: Trend in South African High Technology Manufacturing Export Market Share (%)

The trade balance has widened in the pharmaceutical sector as indicated by an increase in the ratio of imports to exports from 1,7:1 in 2005 to 4,3:1 in 2013 (**Table 6.4**). Although the computer, electronics and optical industry has the largest trade deficit in the high technology manufacturing sector (8 338 million US $ in 2013), the ratio of imports to exports has been contained. In 2013 this ratio was 6,1:1 compared with the 8,7:1 ratio of 2004. In the aerospace industry, although the import/export ratio was 1,5:1 in 2013, this was very low if compared to the ratio of 2,7:1 in 2004. However, there is a lot of fluctuation in exports and imports in this industry for the period being reviewed (2005 to 2013).

Table 6.4: Trade Balance for High Technology Manufacturing Industries (million US $)

		2005	2006	2007	2008	2009	2010	2011	2012	2013
Pharmaceuticals	Imports	1 218	1 377	1 530	1 640	1 665	2 138	2 257	2 432	2 358
	Exports	706	636	585	688	251	221	459	379	544
	Trade Balance	-1 091	-1 248	-1 375	-1 446	-1 473	-1 972	-2 066	-2 224	-1 903
Computer, Electronics and Opticals	Imports	7 331	8 408	8 263	8 283	6 689	8 850	9 895	9 215	9 967
	Exports	847	1 002	1 162	1 216	1 080	1 063	1 221	1 389	1 629
	Trade Balance	-6 484	-7 406	-7 101	-7 067	-5 609	-7 786	-8 674	-7 826	-8 338
Aerospace	Imports	1 894	1 599	1 807	2 119	1 284	1 311	1 934	1 301	833
	Exports	706	636	585	688	251	221	459	379	544
	Trade Balance	-1 188	-963	-1 221	-1 431	-1 033	-1 090	-1 475	-922	-289

Source: OECD "Main Science and Technology Indicators"

7 WEALTH CREATION

The triple challenges of poverty, unemployment and inequality can be addressed through accelerated and sustainable economic growth as envisioned by the NDP. In this section, the progress in wealth creation is reported using indicators such as value-added GDP, GDP growth and employment creation.

7.1 Gross Domestic Production

7.1.1 Value-Added

Table 7.1 shows the contribution to GDP of major economic sectors. The services sector is the most dominant (68,9% in 2014,) and is followed by industry excluding manufacturing, at 14,6%, manufacturing, at 13,9%, and agriculture at 2,6%. As shown in **Figure 7.1**, the services sector's role in South Africa's economy is expanding while the manufacturing sector's role is shrinking (down from 15,3% in 2004). According to the IDC[iv], the services sector in 2012 was composed of trade (25,2%), business services (22,8%), finance (13,4%), transport (10,6%), construction (6,7%), communication (4,8%), electricity (4,7%), catering and accommodation (1,8%) and other services (10,0%).

Table 7.1: Value-Added as Percentage of GDP in Various Sectors

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Agriculture Value-Added (as % of GDP)	2,8	2,7	2,4	2,4	2,7	2,7	2,6	2,6	2,5	2,5	2,6
Manufacturing Value-Added (as % of GDP)	15,3	15,4	15,6	15,6	15,4	14,0	14,4	14,4	14,3	14,1	13,9
Industry Value-Added, excl. Manufacturing (as % of GDP)	17,8	17,5	16,9	16,5	15,7	15,7	15,8	15,3	14,8	14,9	14,6
Services Value-Added (as % of GDP)	64,1	64,4	65,1	65,6	66,2	67,6	67,2	67,7	68,3	68,5	68,9

Source: Econometrix

The industry sector excluding manufacturing comprises value added in mining, construction, electricity, water and gas. Manufacturing is reported separately in **Table 7.1** and **Figure 7.1**. Rapidly falling gold production within the mining industry has impacted this sector negatively, with its contribution to GDP decreasing by 3,2% from 2004 to 2013. Gold's percentage share of the mining industry decreased from 67,1% in 1980 to 49,2% in 1994 and down to just 20,6% in 2012[iv]. A positive trend in the share of the mining sector has been portrayed by commodities such as platinum group metals (18,6% in 2012), coal (25,7%) and iron ore (17,1%).

WEALTH CREATION

The agricultural sector's contribution to GDP remains low and the NDP envisions the stimulation of growth in this sector through technology development in key value-adding activities such as water-saving technology. This sector is important due to its potential as a job multiplier through a well-integrated value chain from downstream farming to upstream food processing and retailing. As articulated within the IPAP 2013/14 – 2015/16, food processing is the largest sector in manufacturing in terms of employment provision. In 2011 about 183 502 workers were employed in this sector. In 2012, the dominant sectors in manufacturing were chemicals (22,7%), food processing (22,1%) and metals and machinery (20,3%)[iv].

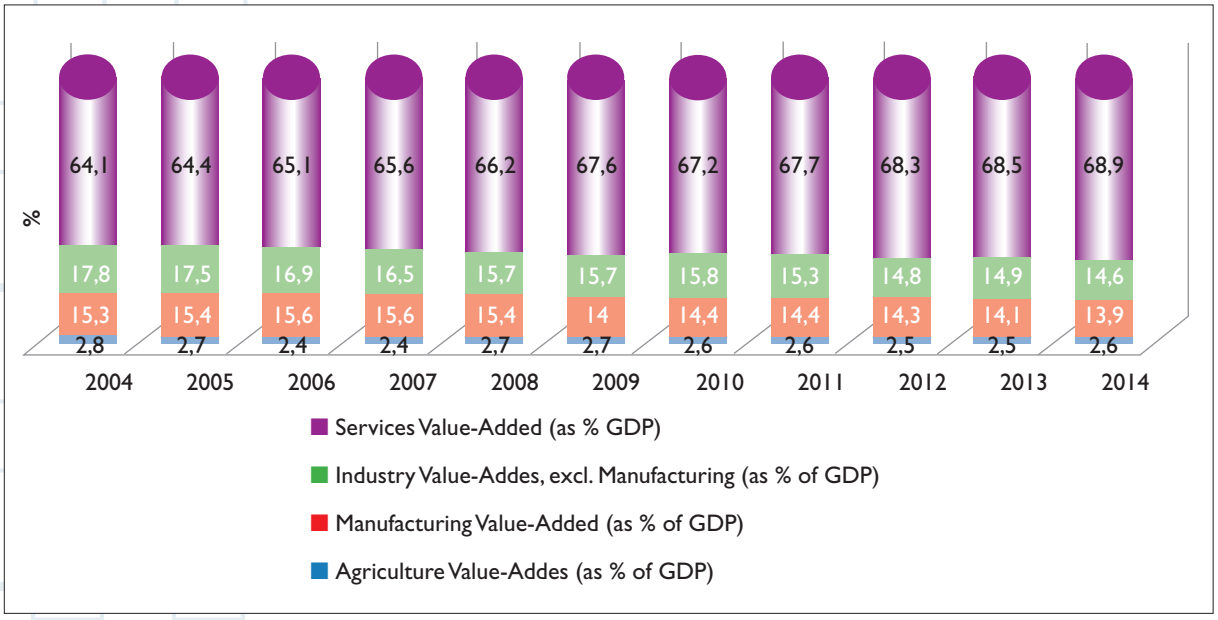


Figure 7.1: Trend in Distribution of Sectoral Value-Added as Percentage of GDP

7.1.2 GDP Growth

Although there were signs of recovery in GDP growth in 2011 (3,2%), the growth rate slowed down in 2012, 2013 and 2014 to 2,2%, 2,2% and 1,5%, respectively. This led to a reduction in real GDP per capita percentage growth to 0,1% in 2014 from a high of 4,0% in 2006 (**Table 7.2** and **Figure 7.2**). The NDP targets a GDP growth rate of about 5,4% per annum in order to reduce the high rate of unemployment of over 25% currently, to 6% by 2030. According to the IDC[v], for the period 2008 to 2012, the highest average annual GDP growth rate within the manufacturing sector was in the radio and television industry followed by transport equipment, textiles and clothing and chemicals. During the same period, a slight contraction was experienced in non-metallic mineral products, followed by metals and machinery industries.

Table 7.2: Percentage Annual GDP Growth

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GDP Growth (annual %)	4,6	5,3	5,6	5,4	3,2	-1,5	3,0	3,2	2,2	2,2	1,5
Real GDP per Capita Growth (annual %)	2,8	3,6	4,0	3,9	1,9	-2,7	1,9	2,1	1,1	0,9	0,1

Source: Econometrix

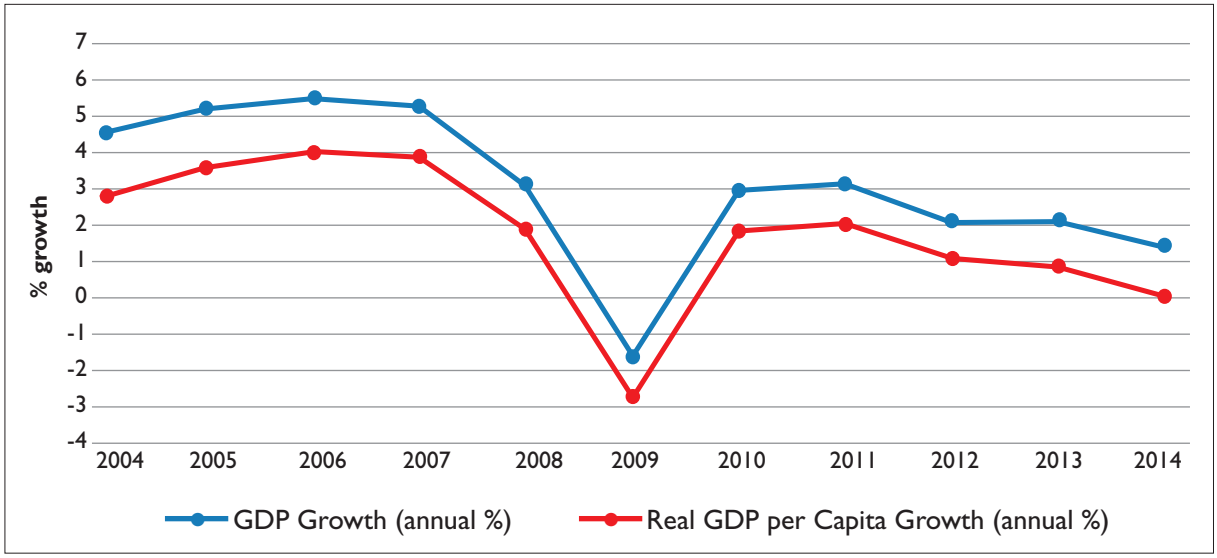


Figure 7.2: Trends in Annual GDP Growth

7.2 Employment Creation

South Africa has a clear intention to reduce unemployment and one of the radical plans of the NDP is to increase the labour force participation rate to 65% while reducing unemployment to 6% by 2030. As **Table 7.3** shows, the employment participation rate dropped by 1,8% during the recession between 2008 and 2009 but then increased gradually, reaching 57,1% in 2014. There has been a decline in the share of employment for industry and agricultural sectors between 2008 and 2014, although the service sector increased its share by 3,3% from 2008 to 2014. The NDP aims to have more jobs created in services, such as retail and personal services, from 14,7% percentage of total employment in 2010 to 20,9% by 2030. The improvement of skills is key in achieving the employment targets as it is clear that most unemployed citizens have only secondary education. Although only 10.7% of the unemployed have no more than a primary education, 79.9% have a secondary education but only 7.4% of the unemployed have tertiary education. Admittedly, this figure has risen from just 4.9% of the unemployed constituting persons who had tertiary qualifications in 2008.

WEALTH CREATION

Table 7.3: Summary of South African Selected Annual Employment Statistics

	2008	2009	2010	2011	2012	2013	2014
Labour Force Participation rate (as % of population aged 15+)	59,3	57,5	55,7	55,7	56,2	56,8	57,1
Employment in Agriculture (as % of total employment)	5,6	5,0	4,8	4,6	4,8	5,0	4,6
Employment in Industry (as % of total employment)	25,8	25,3	24,4	24,2	23,5	23,5	23,5
Employment in Services (as % of total employment)	68,6	69,7	70,7	71,2	71,7	71,5	71,9
Unemployment with Primary Education (% of unemployment)	15,5	13,8	12,9	11,7	11,5	10,2	10,7
Unemployment with Secondary Education (% of unemployment)	76,3	77,7	78,7	80,1	80,2	80,9	79,9
Unemployment with Tertiary Education (% of unemployment)	4,9	5,4	5,8	5,9	6,2	6,8	7,4

Source: The World Bank "World Development Indicators" and Econometrix

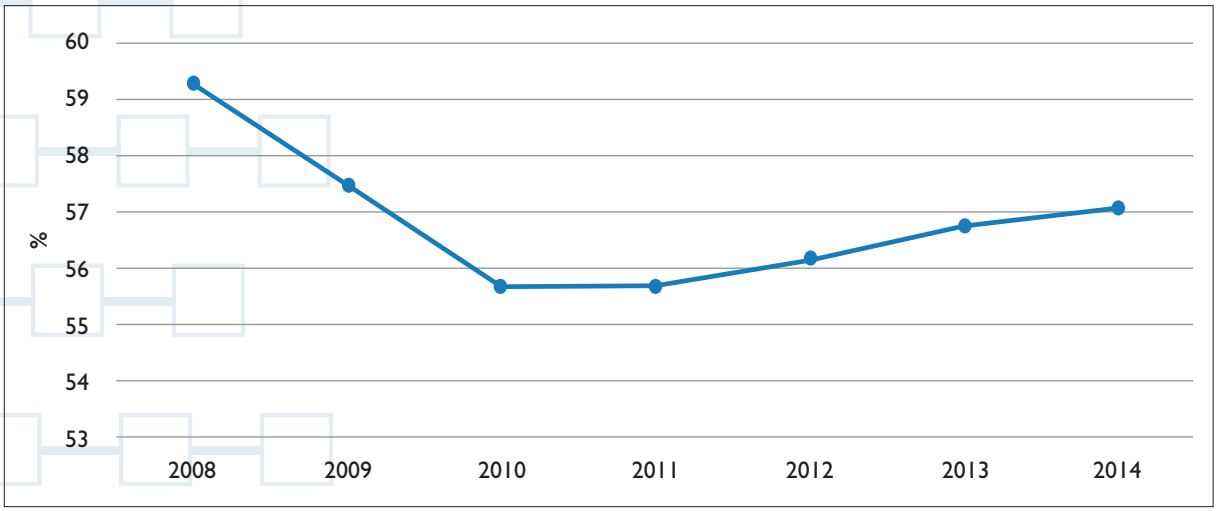


Figure 7.3: Trend in South African Labour Force Participation Rate

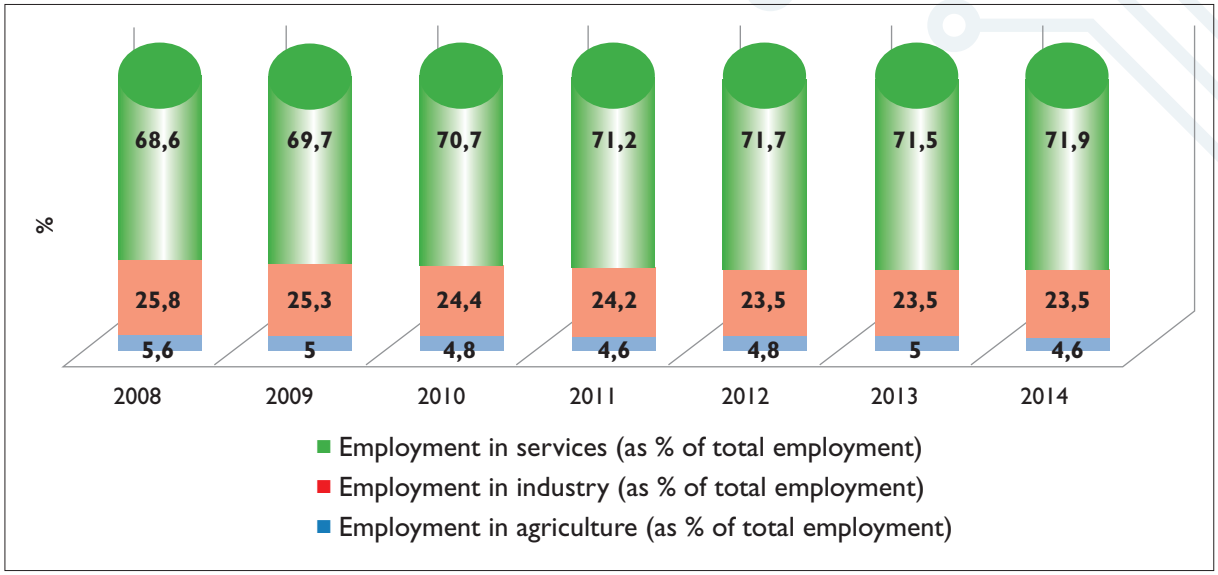


Figure 7.4: Sectoral Employment as Percentage of Total Employment

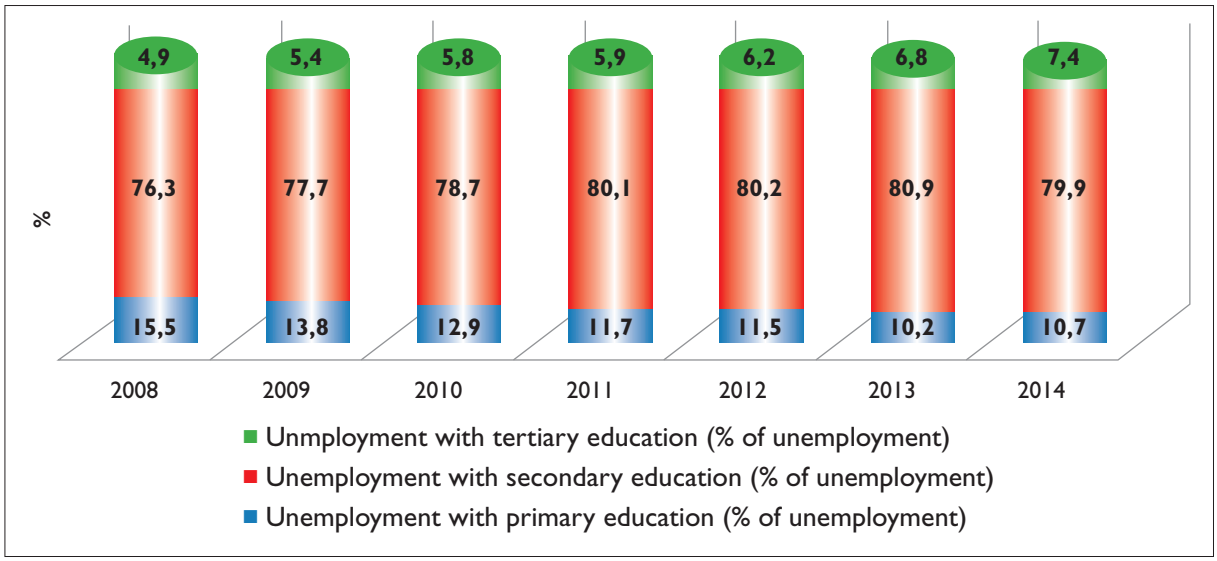


Figure 7.5: Unemployment by Level of Education as Percentage of Total Unemployment

8 QUALITY OF LIFE

In addition to wealth creation, quality of life, as defined by a consolidation of indicators such as health, education, employment, the economic growth and environmental issues, represents one of the high level impact goals prioritised in the country, through the NDP. The South African innovation system needs to be geared in a way that impacts significantly positively on societal and environmental sustainability of current and future generations.

8.1 Health

Life expectancy at birth is an important health indicator as it factors in different health challenges that confront society in different age groups. As **Table 8.1** shows, since 2006, an overall life expectancy at birth has been increasing gradually, from 52 years in 2005 to 61 years in 2014. Both females and males are experiencing an increase in life expectancy, although as is the case for most countries worldwide, female life expectancy is higher than that of males with a difference of 4,0 years in 2014 (**Figure 8.1**). The gap between male and female life expectancy is not changing much as it was 3,9 years in 2004; 3,9 in years in 2007; 4,0 years in 2011; and remained 4,0 years in 2014.

Table 8.1: Selected South African Health Indicators

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Life Expectancy at Birth (years)	52,2	52,1	53,0	54,7	56,0	57,3	58,2	58,7	59,3	60,2	61,2
Female Life Expectancy at Birth (years)	54,1	53,9	54,8	56,6	58,1	59,4	60,3	60,6	61,3	62,1	63,1
Male Life Expectancy at Birth (years)	50,2	50,2	51,0	52,7	53,8	55,1	56,1	56,6	57,3	58,2	59,1
HIV/AIDS Prevalence Rate for Adults, % (ages 15 – 49)	15,9	15,9	15,9	16,0	16,2	16,3	16,5	16,6	16,6	16,7	16,8
HIV/ AIDS Prevalence for Adult Females (ages 15 – 49)	17,0	17,1	17,3	17,5	17,7	17,9	18,0	18,2	18,3	18,4	18,5
HIV/ AIDS Prevalence for Youth, % (ages 15 – 24)	12,5	11,9	11,5	11,1	10,8	10,4	10,1	9,7	9,3	9,0	8,7
HIV/ AIDS Prevalence, % (total population)	9,2	9,3	9,4	9,5	9,7	9,8	9,9	10,0	10,1	10,1	10,2

Source: Statistics South Africa "Mid-Year Population Estimates 2014"

Technological innovations in areas such as mining and construction can lessen the burden of manual hard labour experienced by males. According to the World Health Organisation, the world average life expectancy at birth in 2012 was 70 years, ranging from 62 years in low-income countries to 79 years in high-income countries. In Africa, the average life expectancy at birth was 58 years.

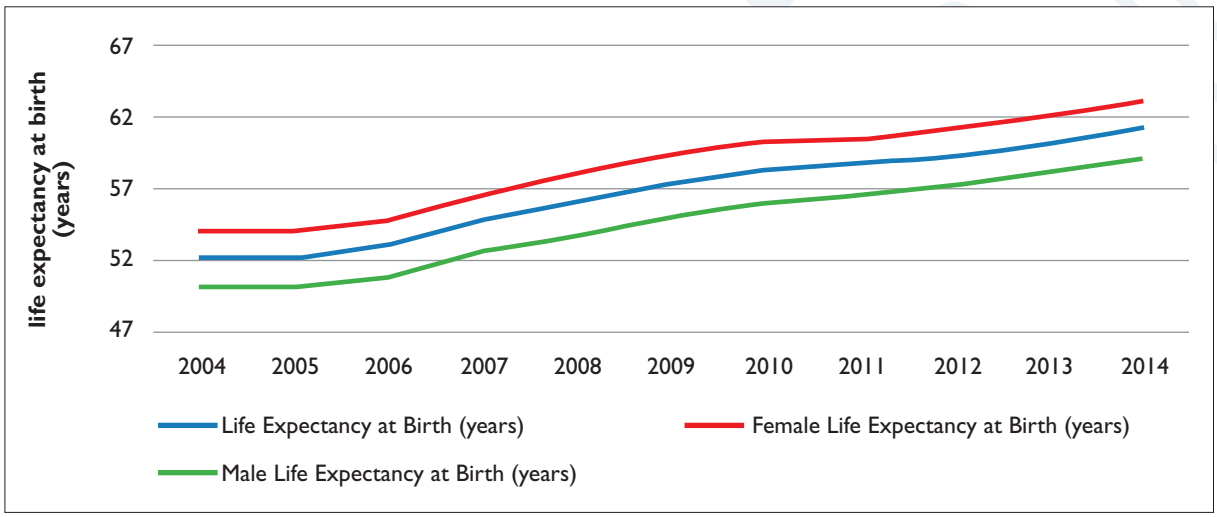


Figure 8.1: Trend in South African Life Expectancy at Birth

The NDP targets a life expectancy at birth of 70 years by 2030. One of the strategies suggested is a significant reduction in the burden of diseases such as HIV/AIDS and tuberculosis (TB). The HIV/AIDS prevalence rate is increasing very slowly among the adults (especially females), from 15,9% in 2006 to 16,8% in 2014. As **Figure 8.2** shows, the HIV/AIDS prevalence rate among youth (15 – 24 years) is declining such that in 2014 it was 8,7%, down sharply from 12.5% in 2004. The NDP seeks to ensure that the generation of under 20s is HIV free. This clearly shows the success being achieved by the free rollout of anti-retroviral drugs for much of the infected population since 2005.

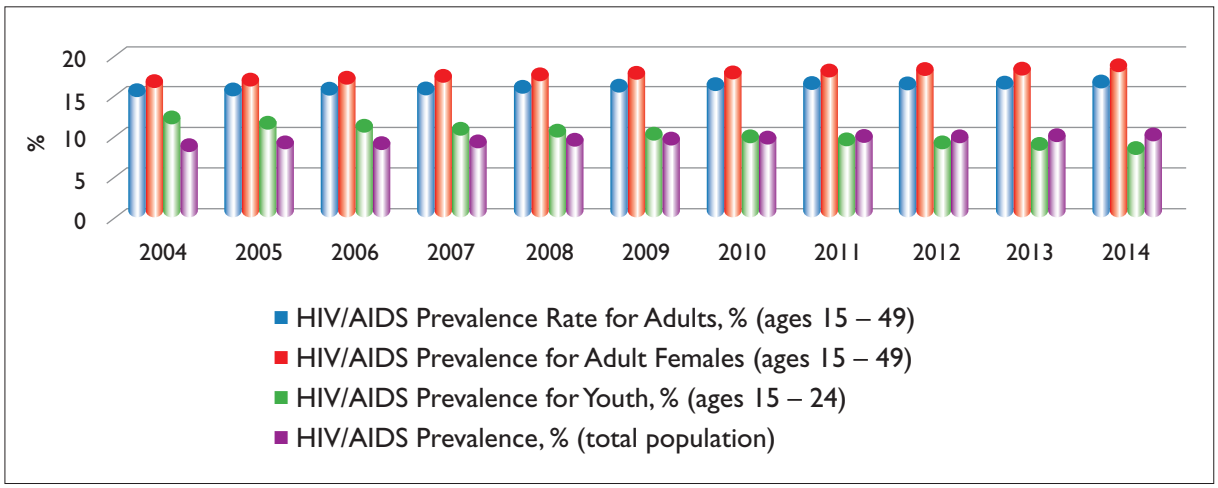


Figure 8.2: Trend in South African HIV/ AIDS Prevalence Rate

8.2 Education

As **Table 8.2** shows, the literacy rate is improving for both adults and youth. In terms of gender, the literacy rate is higher for young females (15 – 24 years) compared with young males as in 2012 it was 99,3% for females and 98,5% for males. The Millennium Development Goals (MDGs) had a target of 100% by 2015 for the youth literacy rate arrived at through mechanisms such as universal primary education.

Table 8.2: South African Adult and Youth Literacy Rate

	2007	2009	2010	2011	2012
Adult literacy rate (% of people aged 15 and above)	88,7	92,9	92,9	93,1	93,7
Youth literacy rate (% of people aged 15-24)	97,6	98,4	98,6	98,8	98,9
Female youth literacy rate (% of females aged 15-24)	98,1	98,8	98,9	99,2	99,3
Male youth literacy rate (% of males aged 15-24)	97,0	97,9	98,4	98,4	98,5

Source: The World Bank "World Development Indicators"

8.3 Employment and Economy

Following the deterioration in the global economy in mid-2008, the South African official unemployment rate has been rising. It has risen from a low of 22,3% in 2007 and 24,9% in 2010 to 25.1% in 2014 (**Table 8.3** and **Figure 8.3**). The NDP aims to cut this unemployment rate to 20% by 2015, 14% by 2020 and 6% by 2030. The strategy to reach this steep target is by achieving a GDP growth rate of more than 5,4% per year. The unemployment rate is higher among females at 27,2% in 2014, than in males (23,3%). This unemployment gap between males and females is narrowing. In 2004, it was 7,5%, it then fell to 6,7% in 2008, 5,1% in 2012 and 3,9% in 2014. On the positive side, GDP per capita has been increasing both in nominal and real terms. There was a slight decline in GDP per capita in 2009 of 2,1%, but it rebounded back to its prerecession level in 2010, and there has been a constant increase through to 2014, such that the Dollar value of GDP per capita in 2014 was 44.4% higher than a decade earlier and 14.8% higher than the 2009 recessionary lowpoint.

Table 8.3: Selected Employment and Economy Indicators

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unemployment Rate (%)	24,7	23,8	22,6	22,3	22,5	23,7	24,9	24,8	24,9	24,1	25,1
Female Unemployment Rate (%)	28,9	28,4	27,4	26,7	25,9	25,7	27,2	27,4	27,2	26,7	27,2
Male Unemployment Rate (%)	21,4	20,2	18,7	18,8	19,9	22,1	23,0	22,7	23,0	23,1	23,3
GDP per Capita (PPP US $)	8 808	9 447	10 149	10 852	11 313	11 080	11 415	11 910	12 258	12 507	12 722

Source: The World Bank "World Development Indicators"; Statistics South Africa "Quarterly Labour Force Survey"

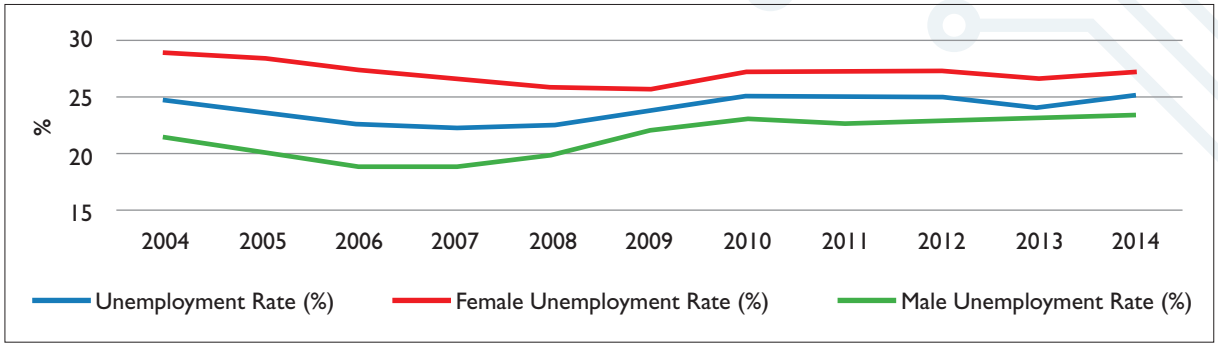


Figure 8.3: Trend in South African Unemployment Rate

8.4 Environment

Environmental quality is an important indicator of quality of life as it also affects the state of health of society. The level of carbon dioxide (CO_2) metric tons emitted per given size of population is universally used to measure the extent of air pollution within the surrounding atmosphere. CO_2 emissions (metric tons per capita) have remained nearly constant at around 9,0 between 2004 and 2010, with minor variations in different years (**Table 8.4**). The NDP aims for a low carbon economy, hence there are programmes to minimise the damage to the environment by increasing the ratio of renewable energy on the grid as a proportion of energy supply on the national grid.

In reducing the dependency on fossil fuels, the Integrated Resource Plan for Energy aims to increase the proportion of alternative and nuclear energy on the grid to 20% nuclear energy, 5% of hydro energy, 9% of renewable energy (solar and wind) and 6,3% of combustible renewables and waste energy by 2030. As **Table 8.4** and **Figure 8.4** show, the proportion of alternative and nuclear energy usage on the national grid is low (2,6% in 2012), whilst that of combustible renewables and waste energy usage is somewhat higher at 10,7% in 2012 but still low compared with other energy sources such as coal.

Table 8.4: Proportion of Nuclear and Renewable Energy on Total Energy Usage

	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 emissions (metric tons per capita)	9,1	8,3	8,8	9,1	9,4	10,0	9,0	-	-
Proportion of alternative and nuclear energy usage (%)	2,8	2,4	2,3	2,2	2,4	2,5	2,4	2,7	2,6
Proportion of combustible renewables and waste energy usage (%)	10,5	10,7	10,9	10,3	9,7	10,1	10,2	10,4	10,7

Source: CO_2 emissions data from The World Bank "World Development Indicators"; energy balance data from International Energy Agency

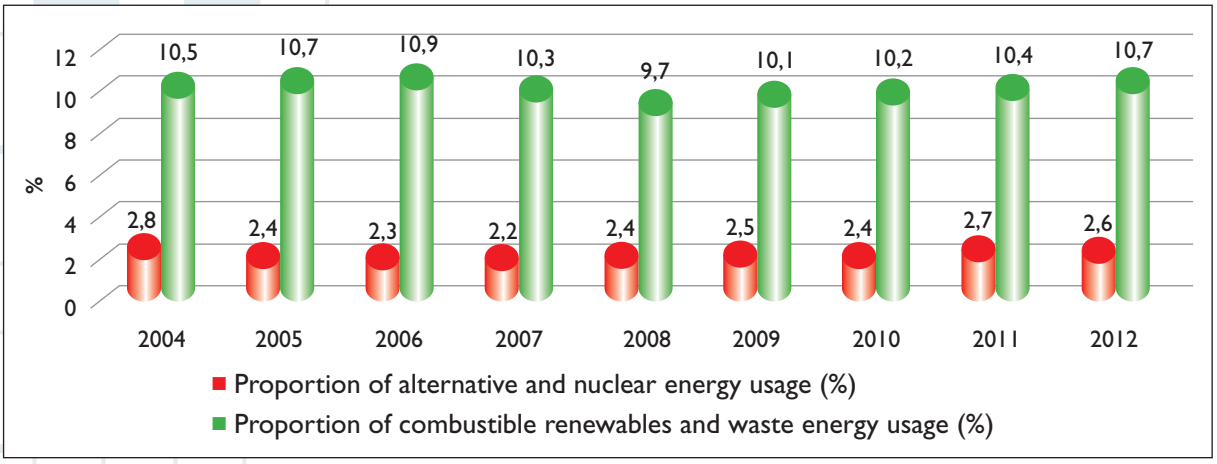


Figure 8.4: Trends in Proportion of Nuclear and Renewable Energy on Total Energy Usage

8.5 Human Development Index

The Human Development Index is a composite index of life expectancy at birth, literacy rate and GDP per capita and it is used to monitor societal development in a country. As **Table 8.5** and **Figure 8.5** show, South Africa's quality of life improved at a slow pace between 2005 and 2013. The increasing life expectancy at birth, literacy rate and GDP per capita are all contributing to the human development index.

Table 8.5: South African Human Development Index

	2005	2006	2007	2008	2009	2010	2011	2012	2013
SA Human Development Index	0,61	0,61	0,62	0,62	0,63	0,64	0,65	0,65	0,66

Source: The World Bank "World Development Indicators"

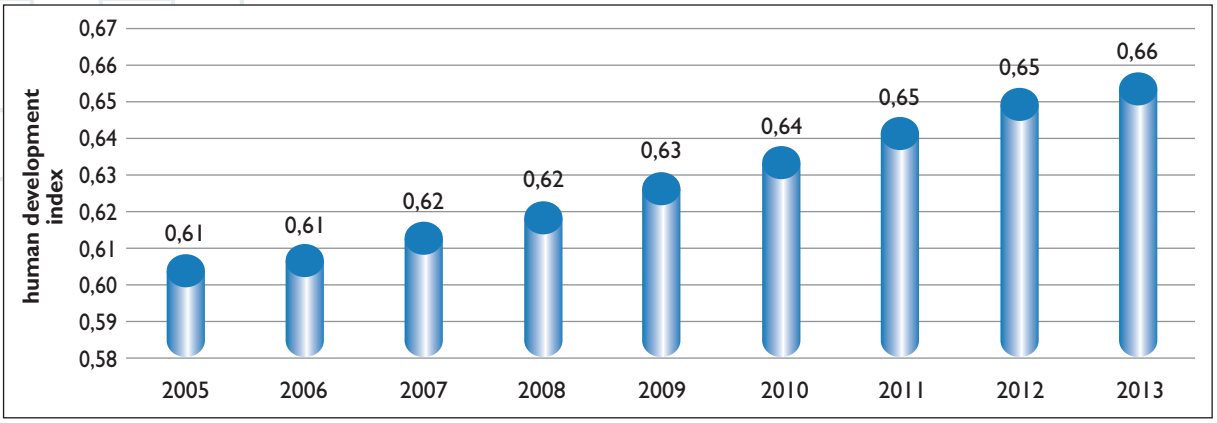


Figure 8.5: Trend in South African Human Development Index

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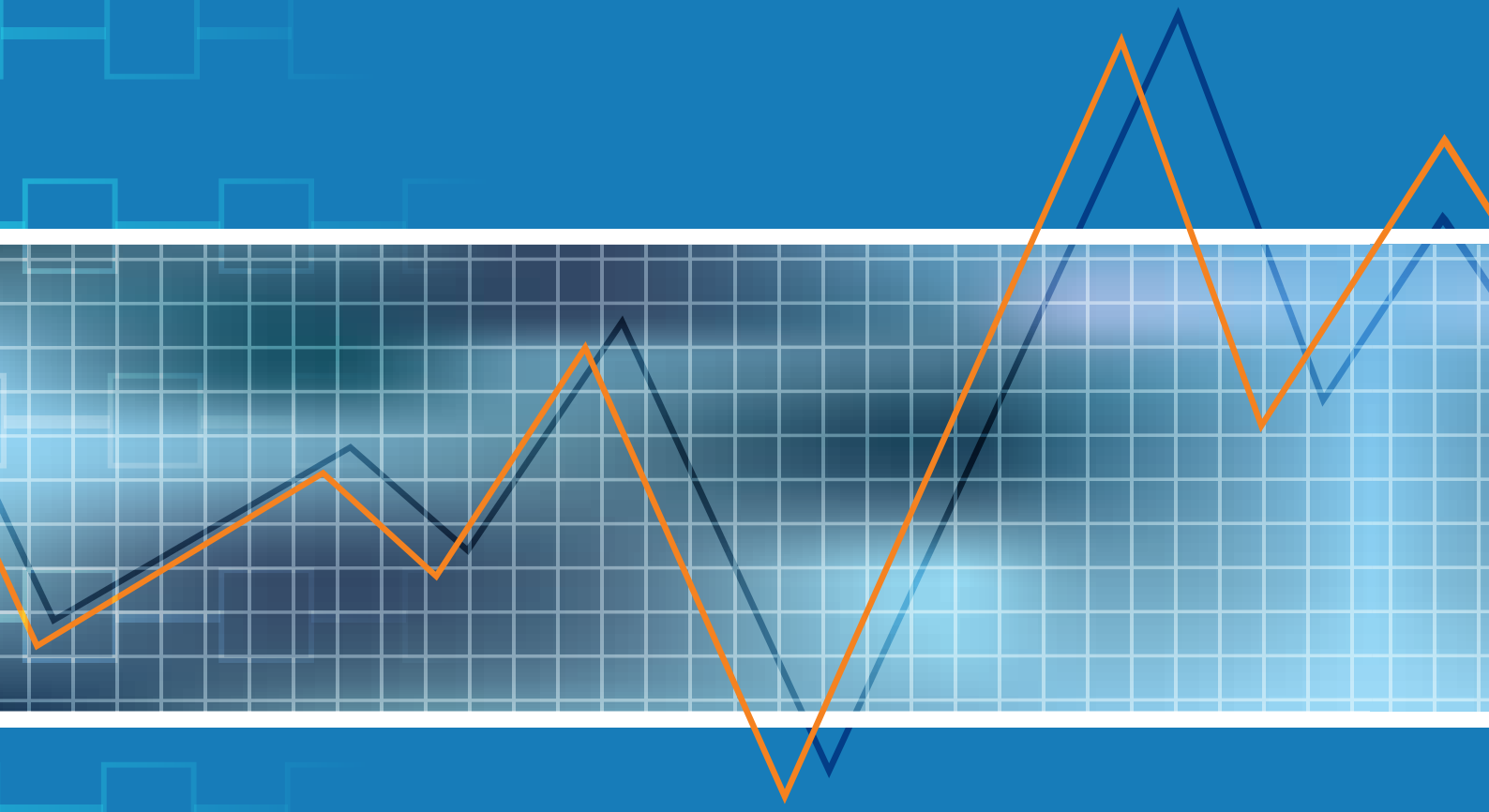

Contacts:
Tel: 012 844 0252
Email: naci@dst.gov.za

www.naci.org.za