NATIONAL ADVISORY COUNCIL ON INNOVATION

Innovation for a better future

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS | 2013

INNOVATION FOR
A BETTER FUTURE

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

TABLE OF CONTENTS

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

1. FOREWORD

It gives me great pleasure to introduce this South African Science and Technology Indicators booklet prepared by the Monitoring, Evaluation and Indicators project team of the National Advisory Council on Innovation (NACI). The indicators contained in this booklet are useful in the assessment of both the state of the national system of innovation (NSI) and the impact of key NSI policies and strategies. Reference to key indicators is a vital contributor to various debates in policy formulation and thereby to the promotion of evidence-based policy decisions.

The indicators cover a ten-year period spanning 2003 to 2012. This is a very important period for the NSI, following the inception of the National Research and Development Strategy (NRDS). Coincidentally, most of the targets of the NRDS were set for 2012. The indicators contained in this booklet are therefore critical in assessing the impact of this strategy on South African knowledge generation capacity and the progress achieved in positioning science-based technology to improve quality of life and economic growth. In addition, it is important to monitor these indicators as we are halfway through the Ten Year Innovation Plan (TYIP), which is key in positioning South Africa as a knowledge-based economy.

Additions to this booklet include a brief background on relevant innovation policies and strategies as well as commentary on data. In order to give the indicators some scale of comparison, we benchmark the South African NSI against the BRICS countries and Japan, the United Kingdom and the United States. BRICS countries are useful for the comparison of scale-adjusted science, engineering and innovation indicators as these countries share economic and social challenges associated with emerging economies. The three developed countries serve as a benchmark for well-organised innovation systems.

NACI makes use of these indicators together with other evidence-based studies to develop policy advice for the Minister of Science and Technology as required by the NACI Act. The indicators empower NACI to fulfil its functions, such as advising on the coordination of science and technology policy and strategies with those in other environments, the coordination and implementation of the NSI, science and technology system funding, development and maintenance of science, engineering and technology human resources and the identification of research and development (R&D) priorities.

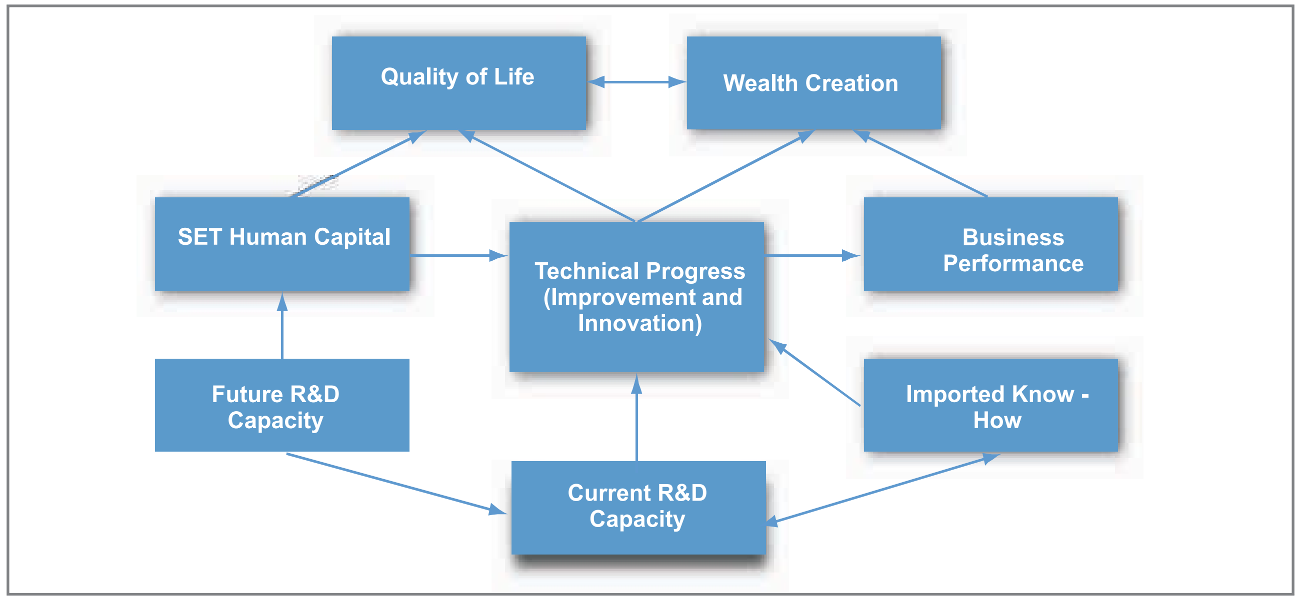
I hope you will find this 2013 South African Science and Indicators booklet very useful.

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

2. POLICY CONTEXT

The conceptual framework used by NACI in the 2013 assessment of South Africa's national system of innovation (NSI) is based on the logical indicator framework contained within the NRDS. Figure 1 shows the key components of the NSI and the links between them. All the actors within the South African innovation system (government, science councils, business, higher education institutions and NGOs) play a significant role in achieving the ultimate outcomes – quality of life and wealth creation.

Figure 1: Key Components Identified by the National R&D Strategy



Source: *Department of Science and Technology "National Research and Development Strategy, 2002"*

The NSI indicators listed in table 1 are classified according to three groups, viz. primary, intermediate and high-level indicators. The primary indicators comprise mainly inputs and current research and development activities. The main objective at this level is to ensure that the NSI is fully resourced and that knowledge generation is taking place. **Future R&D Capacity** determines the progress in the **SET Human Capital** pipeline and good progress in this component has an impact on the progress of knowledge generation under the **Current R&D Capacity**. R&D intensity is important for the absorption of **Imported Know-How**, while the imported know-how contributes to the stimulation of R&D and innovation which leads to **Technical Progress**.

Improvements in **SET Human Capital**, **Technical Progress** as well as **Business Performance** are the intermediate level objectives of the NSI. It is through high quality patents, technological demonstrations, success in key industrial sectors and technology missions, in tandem with a knowledge-driven workforce, that the vision of accelerated economic growth (**Wealth Creation**) and a better standard of living (**Quality of Life**) can be achieved. A summary of these key indicators is presented in table 1.

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

Table 1: Key Indicators of the Performance of the S&T System at Macro Level

Level	Area	Indicator
Primary	Future R&D capacity	SET proportion of higher education (HE) enrol-ments Matriculants with mathematics
	Current R&D capacity	Publications Global share of publications R&D intensity
	Imported know-how	Technology payments High-technology manufacturing imports
Intermediate	Science, engineering and technology human capital	SET graduations Researchers per thousand workforce
	Technical progress (improvement and innovation)	Patents, high-technology start-ups Business innovation investment Key technology missions
	Business performance	Technology trade mix Proportion of high-technology firms Sectoral performance
High	Quality of life	Real growth in GDP per capita Human Development Index
	Wealth creation	Technology-based growth

Since the initiation of the NRDS, the NSI measurement system has been strengthened considerably and new indicators have been introduced to provide greater insight into the performance of the NSI. The role of NACI is to diagnose problems and to propose actions to further develop this measurement system. The recent project in partnership with the Academy of Science of South Africa (ASSAf) investigated the gaps in South African science, technology and innovation indicators. The indicators proposed by this study are listed in Appendix A.

Quality of Life

Wealth Creation

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

3. KEY INDICATORS

Table 2: Key Indicators – Trends

	2008	2009	2010	2011	2012	% change 2011 to 2012 or recent years
Future R&D Capacity						
SET Enrolments as Percentage of Total HEI Enrolments	28.1	28.3	28.1	28.2	28.7	2
Mathematics Passes as Percentage of Total Matric Passes	18.1	15.6	13.8	11.9	13.6	1.7
Current R&D Capacity						
Number of ISI Publications	6 949	7 629	8 155	9 437	9 793	3.8
World Share in ISI Publications (percentage)	0.62	0.65	0.67	0.73	0.73	0
R&D Expenditure as Percentage of GDP	0.92	0.87	0.76	-	-	-0.11
SET Human Capital						
SET Graduations as Percentage of Total HEI Graduations	29.4	28.5	27.9	28.7	29.4	2
SET PhDs Awarded	575	704	730	854	985	15
FTE Researchers per Thousand Employed	40	40.8	37.9	-	-	-2.9
Imported Know-how						
Technology Balance of Payments: Receipts minus Payments (million current $)	-1 622	-1 610	-1 882	-2 052	-1 949	5
High-Technology Manufacturing Industry Trade Deficit (million current $)	11 294	9 329	12 311	13 861		12.6
Technical Progress						
SA Patents Granted in USPTO	91	93	116	123		6
Business Performance						
Manufacturing Value Added (% of GDP)	16.8	15.2	14.2	12.8	12.4	-0.4
Quality of Life						
Real GDP per Capita Growth (constant 2000 prices)	2.5	-2.6	1.7	2.2	1.3	-0.9

As shown in table 2, the notable achievements of the South African NSI are the considerable increase in SET PhDs awarded (15% increase from 2011 to 2012), the increased number of South African patents granted at the United States Patent and Trademark Office (6% increase from 2010 to 2011), the recent increase in technology balance of payments (5% from 2010 to 2011), the increasing number of high impact publications (3.8% increase from 2011 to 2012) and the increased proportion of higher education SET enrolments as well as SET graduations (both increased with 2% from 2011 to 2012). Some challenges within the NSI include the rapid increase in manufacturing trade deficit (12.6% from 2010 to 2011) and the recent decline in FTE researchers per thousand employed (-2.9% from 2009 to 2010). This negative trend in FTE researchers is expected to reverse as a result of the significant increase in SET PhD graduations.

South African knowledge generation efficiency compared to BRICS countries and to Japan, the United Kingdom and the United States is reflected in table 3. The main challenges are posed by knowledge absorption capacity, patents efficiency compared to publications and relatively low quality of life (high rates of HIV prevalence and unemployment raise most concern).

Table 3: Benchmarking of the South African National System of Innovation (Most Recent Year)

	South Africa	Brazil	China	India	Russia	Japan	United Kingdom	United States
Tertiary, Gross Enrolment Ratio	18	26	24	23	75	60	61	95
Publications per 100 Researchers FTE	52	28	14	32	6	12	40	26
Publications per 100 Million $ PPP R&D Expenditure	244	147	198	105	84	55	262	90
GERD as % of GDP	0.76	1.16	1.84	-	1.09	3.39	1.77	2.77
Technology Payments to GERD (%)	50	14	10	12	23	14	21	10
Researchers per 1 000 FTE Employed	1.4	-	1.6	-	6.3	10.2	8.2	-
Patents Applications per 100 Researchers FTE	9	5	36	11	7	72	20	31
Patents Published per 100 Million $ PPP R&D Expenditure	44	25	245	65	94	340	128	108
Manufacturing Value Added (% of GDP)	12	13	30	14	16	19	11	13
Life Expectancy at Birth (Years)	59	73	75	66	69	83	81	79
Unemployment Rate (%)	24.7	8.3	4.1	3.5	6.6	4.5	7.8	8.9
GDP per Capita ($ PPP)	11 440	11 909	9 233	3 876	23 504	35 178	36 901	49 965

4. FUTURE R&D CAPACITY

Human capital is fundamental to securing improved science and technology performance in the future. The NDP cites foundation skills in mathematics and science as essential elements of a successful education system. This section therefore highlights the trends in higher education SET enrolments and matric mathematics.

4.1 SET enrolments

The SET enrolment ratio is the proportion of students enrolled in tertiary education who follow careers in the fields of science, engineering and technology. An increase in SET enrolments will generally result in an increase in the number of students graduating with SET qualifications.

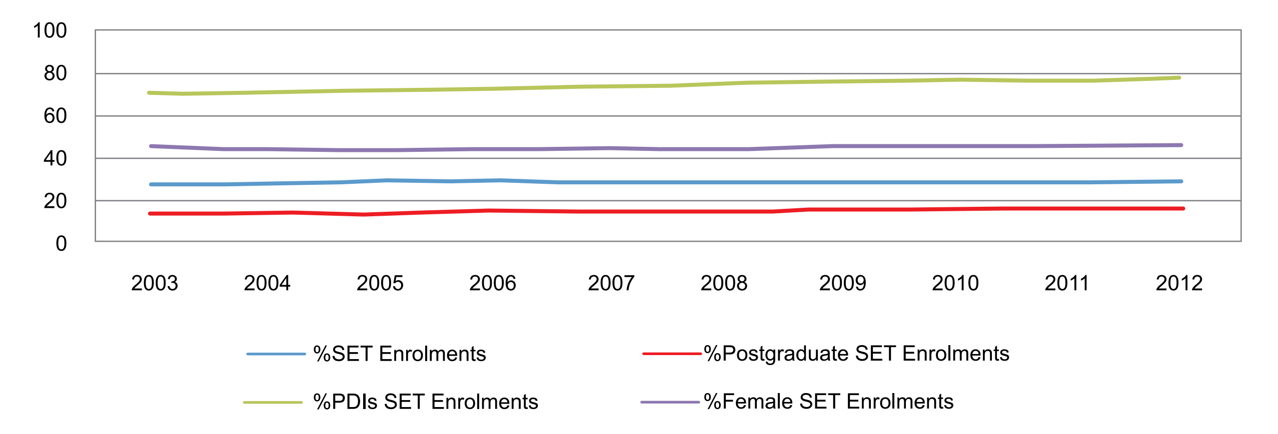
As shown in table 4 and also in figure 2, South Africa's percentage SET enrolments at public higher education institutions has been fairly constant, fluctuating in the range of 27% and 29%. This must change radically if the SET graduation target is to be met. The increase in SET enrolments is greater for high end skills, as reflected by the positive trend in postgraduate SET enrolments since 2006. A similar trend is observed for previously disadvantaged individuals (PDIs) although female SET enrolment remained almost constant in the 2003 – 2012 period.

Table 4: Higher Education SET Enrolments

Year	Total Enrolments	% SET Enrolments	% Postgraduate SET Enrolments	% PDIs SET Enrolments	% Female SET Enrolments
2003	705 255	27.5	13.7	70.0	44.9
2004	744 478	27.2	14.2	70.6	44.7
2005	735 073	28.7	14.0	71.3	43.5
2006	741 380	28.5	14.2	72.3	43.8
2007	760 889	28.2	14.5	73.1	44.1
2008	799 490	28.1	14.9	74.6	44.6
2009	837 775	28.3	15.4	75.4	45.1
2010	892 936	28.1	15.8	76.2	44.9
2011	938 200	28.2	15.9	76.9	44.8
2012	953 373	28.7	16.3	77.4	45.2

Source: *Department of Higher Education and Training "HEMIS"*

Figure 2: Trends in Higher Education SET Enrolments



Explanatory note: Higher education enrolments data include all public higher education institutions. SET includes the Classification of Educational Subject Matter (CESM) 2008 categories: Agriculture; Agricultural Operations and Related Sciences; Architecture and the Built Environment; Computer and Information Sciences; Engineering; Health Professions and Related Clinical Sciences; Family Ecology and Consumer Sciences; Life Sciences; Physical Sciences; Mathematics and Statistics; and Military Sciences.

Table 5 shows the percentage gross enrolment ratio for South Africa and selected countries. Although South Africa's gross tertiary enrolment ratio is not reflected in the 2013 Global Innovation Index (GII), if one extrapolates its value on this ranking of 134 countries, the gross tertiary enrolment ratio for South Africa will be ranked at position 96 which is lower than the other BRICS countries. The rankings for Russia, China, Brazil and India are 13th, 80th, 82nd and 94th respectively. The United States, United Kingdom and Japan are ranked 2nd, 35th and 36th respectively.

Table 5: % Gross Enrolment Ratios in Higher Education (Most Recent Year)

Country	Total, Gross Enrolment Ratio	Male, Gross Enrolment Ratio	Female, Gross Enrolment Ratio
South Africa	18	15	20
Brazil	26	22	29
China	24	23	26
India	23	26	20
Russia	75	65	87
Japan	60	63	57
United Kingdom	61	52	71
United States	95	80	111

Sources: *UNESCO Institute for Statistics "World Education Indicators"; South African data estimated by NACI from the 2011 public HEI enrolments and statsSA "Census 2011" (18-22 years population)*

As can be deduced from table 4, in the period 2002 – 2003 South Africa's tertiary education enrolment increased at an average annual rate of 3.9%, reflecting capacity constraints at South Africa's public higher education institutions. The NDP aims to increase the participation rate in higher education to over 30 percent by 2030. Table 5 shows that in terms of gender, tertiary enrolment of males is low when compared to that of females.

4.2 Matric mathematics

Table 6 shows a decline in the number of students passing matric with mathematics, although there was a slight increase in 2012.

Table 6: Matriculants with Mathematics

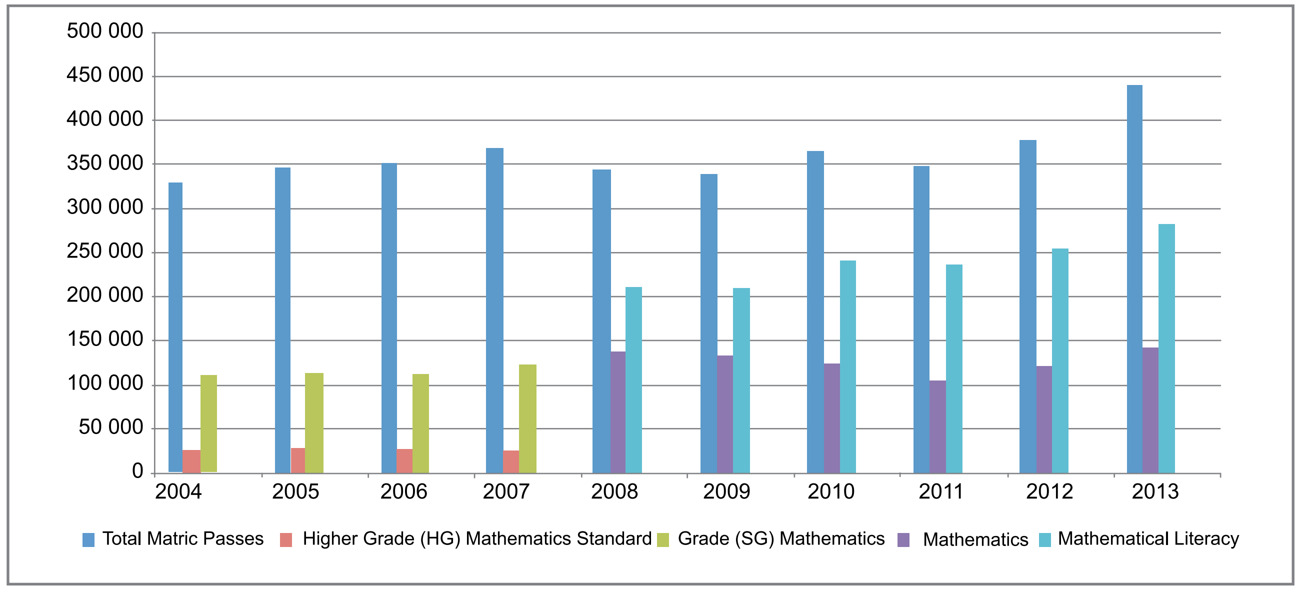
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Matric Passes	330 717	347 184	351 217	368 217	344 794	339 114	364 513	348 117	377 829	439 779
Higher Grade (HG) Mathematics	24 143	26 383	25 217	25 415	-	-	-	-	-	-
Standard Grade (SG) Mathematics	109 664	112 279	110 452	123 813	-	-	-	-	-	-
Mathematical Literacy (> 30%)	-	-	-	-	210 134	209 053	241 576	236 548	254 611	282 270
Mathematical Literacy (> 40%)	-	-	-	-	146 735	142 513	182 475	179 310	178 763	202 259
Mathematical Literacy (> 50%)	-	-	-	-	100 186	86 156	114 044	111 877	104 176	115 194
Mathematical Literacy (> 60%)	-	-	-	-	64 405	47 861	62 335	58 916	52 307	53 861
Mathematics (> 30%)	-	-	-	-	136 184	133 789	124 749	104 033	121 970	142 666
Mathematics (> 40%)	-	-	-	-	89 186	85 491	81 473	67 592	80 707	97 786
Mathematics (> 50%)	-	-	-	-	62 388	52 866	50 195	41 586	51 231	63 151
Mathematics (> 60%)	-	-	-	-	41 667	31 786	30 543	24 577	30 355	37 782

Source: *Department of Basic Education*

Most science and engineering degree programmes at universities demand a 50% or 60% pass in mathematics. On this basis, only 63 151 (14.4%) students who passed matric in 2013 can be considered as being in the pipeline for science and engineering degrees. The NRDS set a target of 7.5% by 2012 for matriculants passing with university exemption in mathematics and science. A mathematics pass of 60% or higher is one of the SET pipeline indicators suggested by the Human Resource Development Strategy of South Africa (HRDSA), although no specific target is set.

The overall SET pipeline in 2013 was 300 045 (68.2%), which is the sum of students who passed either mathematics or mathematical literacy with 40% or above in 2013. This pipeline of students with mathematics and mathematical literacy may also join other streams such as business and commercial studies.

Figure 3: Matriculants with Mathematics



Explanatory note: A new Mathematics curriculum was introduced in 2008 with the effect that Mathematics is offered on one level only (i.e. no more Standard Grade (SG) or Higher Grade (HG)), and Mathematical Literacy was introduced.

5. CURRENT R&D CAPACITY

Knowledge generation is fundamental to driving a country towards a knowledge-based economy. Many different knowledge generation indicators exist in countries' innovation systems; these include the writing of a book or chapter in a book, presenting a conference paper, the writing of journal articles, etc. The high impact Web of Science journal publications are useful as they constitute an indicator that can be easily compared across countries. R&D expenditure and R&D incentives are useful as indicators of financial commitment to knowledge generation and exploitation, the key indicator being R&D expenditure as a percentage of GDP.

5.1 Publications

The number of high impact journal publications by South Africans increased at an average of 10% per year over the 2003 – 2012 period, representing an average growth of around 624 publications per year. This growth is much more rapid than the world average, resulting in a steady increase in percentage share of world journal publications from 0.49% in 2003 to 0.73% in 2012. The world share of publications represents the 2012 target set by the NRDS.

Table 7: Number of Web of Science Journal Publications by South Africans

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of Publications	4 173	4 526	4 799	5 446	6 117	6 949	7 629	8 155	9 437	9 793
% of World Share	0.49	0.50	0.51	0.55	0.58	0.62	0.65	0.67	0.73	0.73

Source: *Thomson Reuters "InCites"*

Figure 4: SA Scientific Publications in We

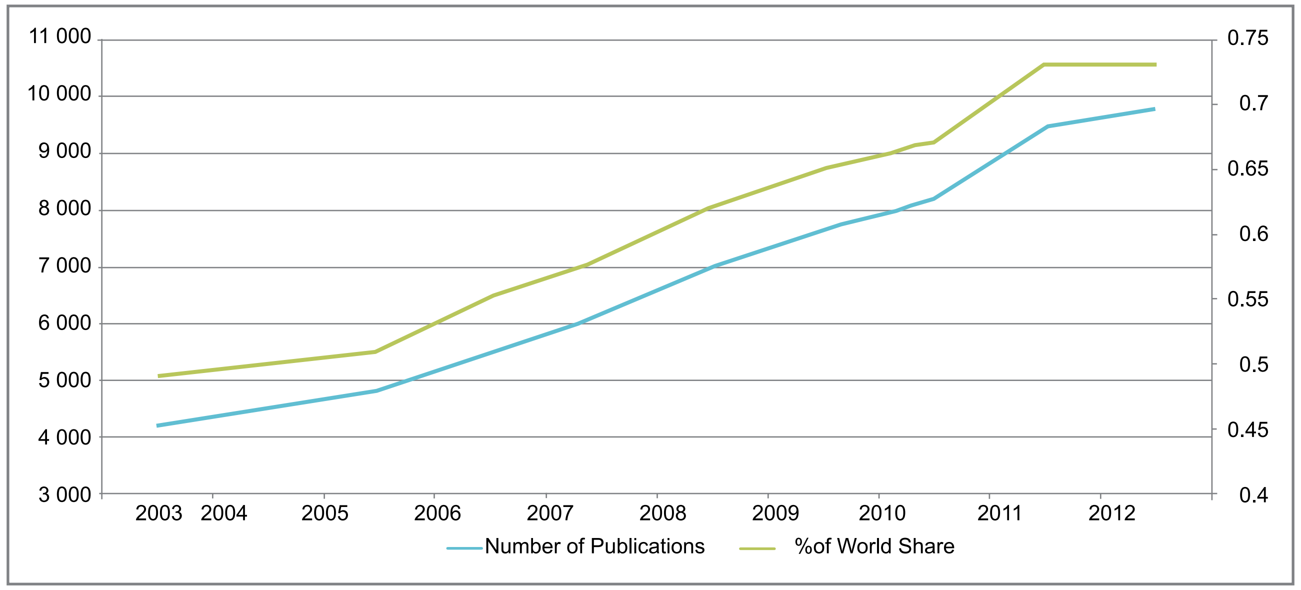


Table 8 benchmarks South African publications efficiency against BRICS countries and Japan, the United Kingdom and the United States. The country is competitive in terms of publications per million capita despite a stagnating and relatively low number of researchers per 1 000 workforce.

South African researchers produce more publications per 100 researchers FTE than all other countries selected for comparison, including the three developed nations. This superiority in journal publications is mirrored by high impact journal citations per 100 researchers FTE. Only the United Kingdom exceeds South Africa in terms of journal publications and citations per R&D expenditure.

Table 8: Summarised Publications Efficiency for South Africa and Selected Countries (Most Recent Year)

	South Africa	Brazil	China	India	Russia	Japan	United Kingdom	United States
ISI Journal Publications	9 793	37 346	186 577	48 151	28 050	77 125	103 528	369 258
Number of Citations	6 442	14 315	88 164	19 045	11 863	43 166	86 794	282 590
Publications per Million Capita (pmc)	192	192	138	38	196	604	1 638	1 176
% Share of the World	0.73	2.78	13.90	3.59	2.09	5.75	7.71	27.51
Publications per 100 Researchers FTE	52	28	14	32	6	12	40	26
Citations per 100 Researchers FTE	34	11	7	13	3	7	34	20
Publications per 100 Million $ PPP R&D Expenditure	244	147	105	198	84	55	262	90
Citations per 100 Million $ PPP R&D Expenditure	161	56	49	78	35	31	220	69

Sources: *Citations data from Thomson Reuters "InCites"; 2012 population data from Population Reference Bureau; 2010/11 R&D expenditure and FTE researchers from OECD "Main Science and Technology Indicators"; South Africa's R&D expenditure and FTE researchers from DST "National Survey of Research and Experimental Development", 2010/11; R&D expenditure and FTE researchers data for Brazil and India from UNESCO "2010 Science Report"*

Table 9 represents a tabulation of activity versus impact on scientific fields as classified by Brazil's FAPESP (a Sắo Paulo based Research Foundation). The high impact and high activity publications are mainly in fields where South Africa has obvious geographical advantages (e.g. astronomy, ecology, anthropology and archaeology).

Table 9: Activity versus Impact on Scientific Fields Classified According to Brazil FAPESP (2008-2012)

	Low Activity (bottom 25%)	Moderate Activity (middle 50%)	High Activity (top 25%)
High Impact (top 25%)	Agricultural Engineering; Medicine; Nursing	Physiotherapy and Occupational Therapy; Oceanography; Microbiology; Veterinary Medicine; General Biology; Fish Resources and Fishing Engineering; Physical Education; Multidisciplinary Humanities; Arts; Multidisciplinary Physics	Archaeology; Anthropology; Immunology; Collective Health; Astronomy; Ecology
Moderate Impact (middle 50%)	Multidisciplinary Engineering; Mechanical Engineering; Air and Space Engineering; Physics; Biochemistry; Computer Science; Dentistry; Biomedical Engineering; Electrical Engineering; Biophysics	Zootechny; Multidisciplinary Geosciences; Economics; Agronomy; Geosciences; Languages and Literary Studies; Social Services; Multidisciplinary Agriculture; Philosophy; Chemical Engineering; Psychology; Food Science and Technology; Political Science; History; Mathematics; Nutrition; Pharmacology; Genetics; Nuclear Engineering; Chemistry; Probability Statistics; Civil Engineering; Physiology	Urban and Regional Planning; Geography; Zoology; Botany; Parasitology; Demography; Sociology; Forestry Resources and Forestry Engineering
Low Impact (bottom 25%)	Materials and Metallurgical Engineering; Multidisciplinary Chemistry; Architecture and Urbanism; Multidisciplinary Materials Science; Transportation Engineering; Nanoscience and Nanotechnology	Sanitary Engineering; Information Science; Law; Morphology; Administration; Industrial Engineering; Communications; Tourism	Theology; Mining Engineering; Multidisciplinary Psychology; Linguistics; Education; Multidisciplinary Sciences

Source: *Thomson Reuters "InCites"*

Explanatory note: The activity index characterises the relative research effort a country devotes to a given subject field. The relative impact indicates the citations attracted by the country's publications in a particular field in comparison to the citation impact of the field as a whole worldwide.

The Air and Space Engineering field shows low activity and moderate impact while Astronomy is one of the highly cited and published scientific fields in South Africa. The biotechnology scientific field has moderate impact with low activity. Immunology has high impact and high activity. Human and social sciences publications have high activity although their influence on the world scientific community is slighter (low relative impact).

Table 10 shows the contribution to high impact journal publications by South African higher education institutions over a five-year period (2008 – 2012). The research infrastructure available per institution (indicated by finances and researchers) is also reflected for purposes of efficiency evaluation and transformation. Five universities (University of Cape Town, Wits University, Stellenbosch University, Pretoria University and UKZN) contribute 68.5% of all higher education Web of Science documents.

Table 10: High Impact Journal Publications versus R&D Resources at SA Higher Education Institutions

Top 10 Higher Education Institutions (HEIs)	Number of Publications (2008 – 2012)	% of Total HEI Publications	R&D Expenditure 2010/11 (R'000)	Researchers FTE 2010/11
University of Cape Town	7 551	17.9	911 811	337
University of the Witwatersrand	5 706	13.5	778 683	280
Stellenbosch University	5 301	12.7	565 240	333
Pretoria University	5 195	12.3	441 977	327
University of KwaZulu-Natal	5 102	12.1	631 414	459
University of Johannesburg	1 935	4.6	221 154	188
University of North West	1 800	4.3	243 466	318
University of Free State	1 691	4.0	213 791	50
Rhodes University	1 577	3.7	204 381	95
University of Western Cape	1 379	3.3	163 340	206
Other HEIs	4 927	11.7	1 049 345	1 021
Total	**42 244**	**100**	**5 424 602**	**3 614**

Source: *Thomson Reuters "InCites"; DST "National Survey of Research and Experimental Development", 2010/11*

Table 11 reflects the Department of Higher Education and Training's (DHET) recognised research output produced by public higher education institutions. Various experts have indicated the positive impact that the DHET's research output subsidy has had in increasing high impact journal publications.

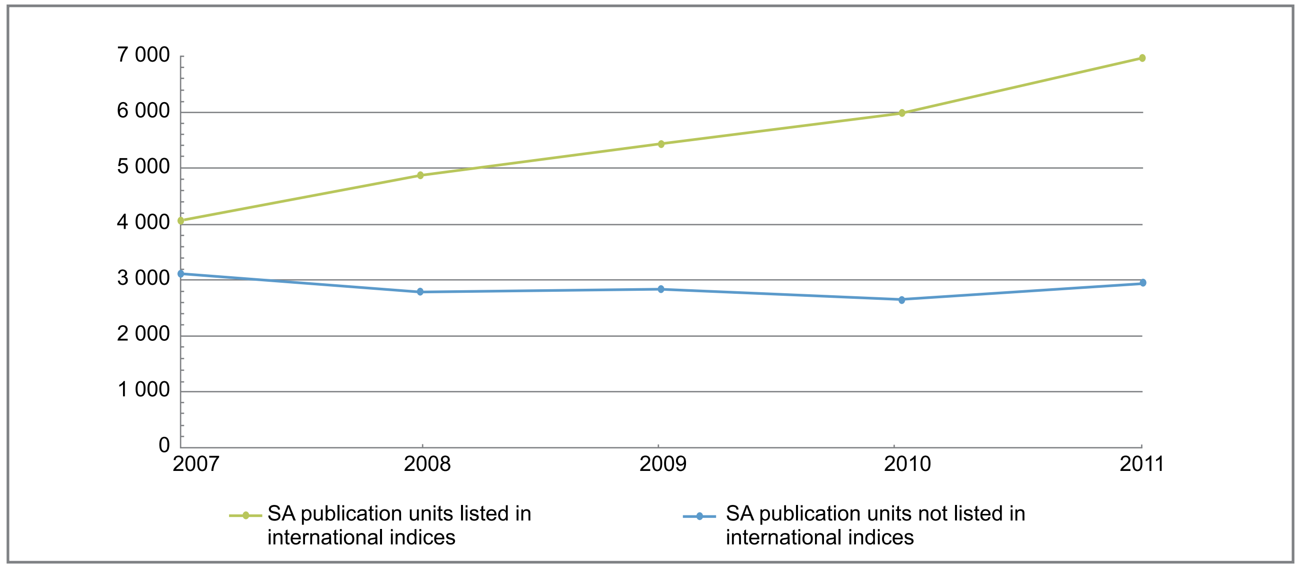
Table 11: Recognised Research Output Produced by Public Higher Education Institutions

Year	2007	2008	2009	2010	2011
SA Publication Units Listed in International Indices[1]	4 052.53	4 868.56	5 425.59	5 978.97	6 952.79
SA Publication Units not Listed in International Indices[2]	3 110.72	2 767.56	2 831.02	2 624.39	2 939.17

1. Includes publications in journals listed in Sciences Citation Index of the Institute of Scientific Information (ISI), the Social Sciences Citation Index of the ISI, the Arts and Humanities Citation Index of the ISI and the International Bibliography of Social Sciences (IBSS).
2. Includes publications in South African journals not appearing in the above indices, but whose seat of publication is in South Africa and which meet criteria set by the DHET.

Source: *Department of Higher Education and Training*

Figure 5: Recognised Research Output Produced by Public Higher Education Institutions



Explanatory note: Recognised research output, in terms of the "Policy and Procedures for the Measurement of Research Output for Public Higher Education Institutions, 2003" comprises journals, books and proceedings measured in terms of publication units. A number of one unit and half a unit is allocated to publications in journals and proceedings respectively, while a maximum of five units is allocated to books.

5.2 R&D expenditure

The highest proportion of R&D expenditure in South Africa occurs in the business sector, as illustrated in table 12. Since 2008/09, the proportion of business expenditure on R&D has declined while there has been a positive upwards trend in the high education sector. The 2013 Global Innovation Index ranks South Africa 38th out of 142 countries in terms of percentage of general expenditure on R&D (GERD) financed by the business sector. China, Brazil, India and Russia are ranked 4th, 29th, 48th and 57th respectively; Japan, the United Kingdom and the United States are ranked 2nd, 34th and 12th respectively. Business sector R&D expenditure is important as business is capable of exploiting the knowledge generated through new products and process development.

Table 12: Percentage Expenditure on R&D by Sector

	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Business	55.5	56.3	58.3	55.9	57.7	58.6	53.2	49.7
Higher Education	20.5	21.1	19.3	20.0	19.5	19.9	24.3	26.8
Government (incl. Science Councils)	21.9	20.9	20.8	22.8	21.7	20.3	21.6	22.7
Not-for-Profit	2.1	1.7	1.6	1.3	1.2	1.1	0.9	0.8

Source: *DST "National Survey of Research and Experimental Development", 2003/04 – 2010/11*

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

As a percentage of GDP, the GERD is low for South Africa and India when compared to other BRICS countries and to the three selected developed countries. This ratio has declined in most countries around the world except in the most powerful Asian countries where there has been a sustained increase in GERD as percentage of GDP. As a result, South Africa missed the 1% GERD as percentage of GDP target for 2008. Unless economic conditions improve radically, the 2% target for 2018 as set by the TYIP is also unlikely to be achieved.

Table 13: Gross Expenditure on R&D as Percentage of GDP (Selected Countries)

	Brazil	Russia	India	China	South Africa	Japan	United Kingdom	United States
2010	1.16	1.13	-	1.76	0.76	3.25	1.77	2.74
2009	1.17	1.25	-	1.70	0.87	3.36	1.82	2.82
2008	1.11	1.04	-	1.47	0.93	3.47	1.75	2.77
2007	1.10	1.12	0.76	1.39	0.92	3.46	1.75	2.63
2006	1.01	1.07	0.77	1.32	0.93	3.41	1.72	2.55

Source: *OECD "Main Science and Technology Indicators"; Brazil and India data from UNESCO Institute for Statistics*

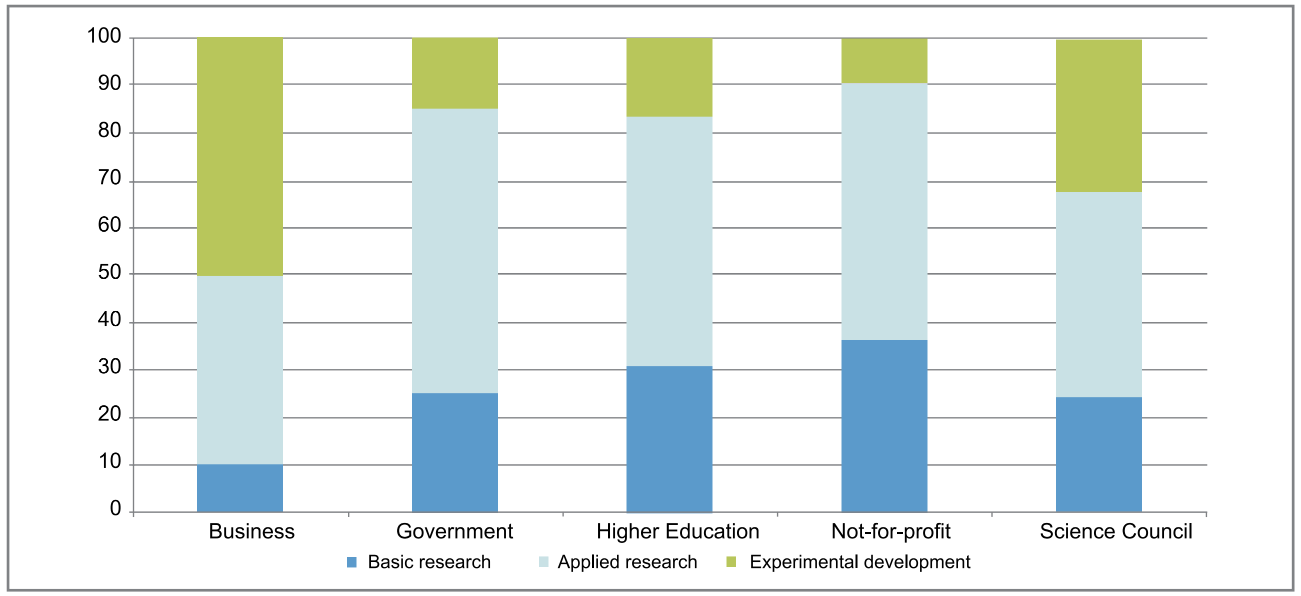
As table 14 illustrates, the business sector spends more on experimental development than on basic and applied research. The decline in R&D in this sector will have a negative impact on new product development.

Table 14: % R&D Expenditure by Type of Research (2010/11)

	Business	Government	Higher Education	Not-for-profit	Science Councils
Basic Research	10.2	25.4	48.6	36.4	24.2
Applied Research	39.3	59.3	34.8	53.7	42.6
Experimental Development	50.5	15.2	16.6	9.9	33.2

Source: *DST "National Survey of Research and Experimental Development", 2010/11*

Figure 6: Distribution of R&D Expenditure by Type of Research (2010/11)



The provincial R&D intensities reflected in table 15 serve as an indicator of the strengths of various regional innovation systems and this can help in assessing the contribution made by each province to South Africa's R&D intensity. As table 15 indicates, nearly half of South Africa's GERD in 2010/11 was contributed by Gauteng province, followed by the Western Cape (20.9 %) and KwaZulu-Natal (11.3%). The Northern Cape was the worst performing South African province in terms of R&D expenditure (1.2%), followed by Limpopo (2%) and Mpumalanga (2%).

Table 15: Distribution of R&D Intensity by Province

	GERD as % of Provincial GDP		% GERD	
	2009/10	2010/11	2009/10	2010/11
Eastern Cape	0.61	0.51	5.4	5.2
Free State	1.05	0.92	6.5	6.6
Gauteng	1.28	1.09	49.5	48.3
KwaZulu-Natal	0.56	0.54	10.3	11.3
Limpopo	0.20	0.21	1.6	2.0
Mpumalanga	0.23	0.21	1.9	2.0
North West	0.14	0.30	1.0	2.6
Northern Cape	0.98	0.41	2.6	1.2
Western Cape	1.31	1.13	21.1	20.9
Total	**0.87**	**0.76**	**100**	**100**

Sources: *Provincial distribution of GERD computed by NACI from DST "National Survey of Research and Experimental Development", 2009/10 and 2010/11; provincial GDP contribution data from StatsSA "GDP, Third Quarter 2011, P0441"*

In the 2010/11 financial year, the R&D expenditure as a percentage of provincial GDP (R&D intensity) was highest in the Western Cape (1.13%), followed by Gauteng (1.09%), Free State (0.92%), KwaZulu-Natal (0.54%) and Eastern Cape (0.51%). The provinces with an R&D intensity below 0.5% were Northern Cape (0.41%), North West (0.30%), Limpopo (0.21%) and Mpumalanga (0.21%).

Figure 7: Provincial R&D Expenditure as a Percentage of GDP

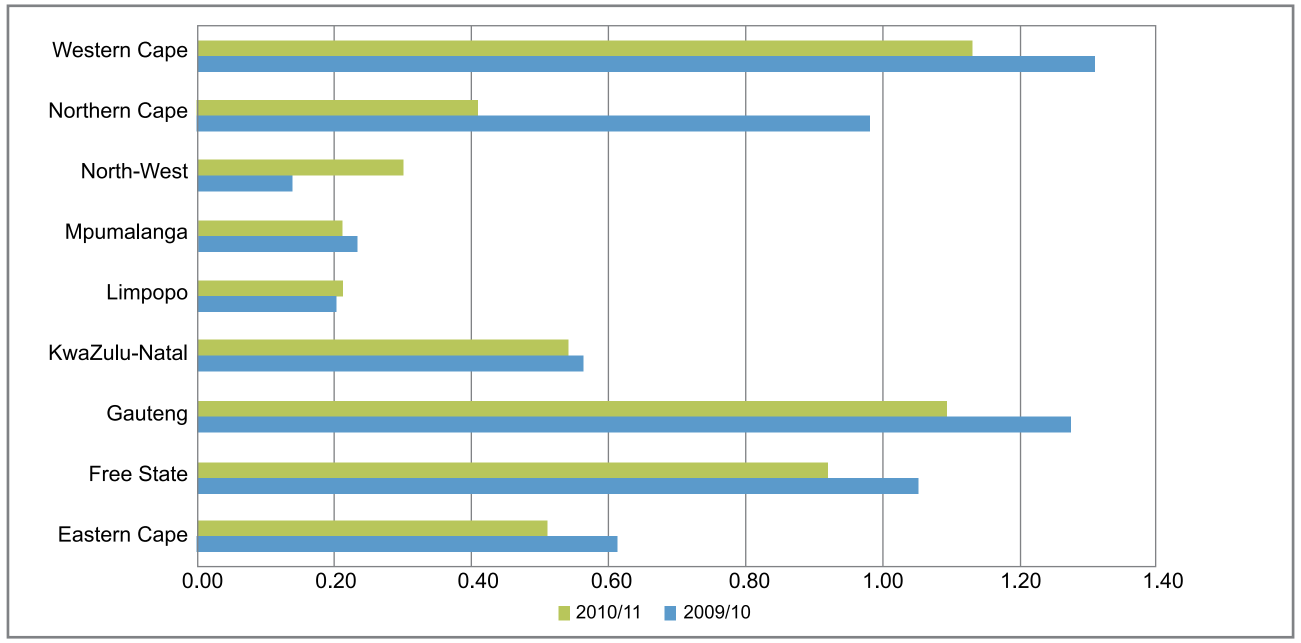


Table 16 shows research field focus in South Africa's nine provinces. Only the top three research fields per province are displayed and the relative provincial distribution of R&D expenditure is shown in brackets. Although Medical and Health Sciences is not a top research field in South Africa (in terms of publications), it features among the top three in all provinces, and is highest in the Western Cape. Engineering Sciences is the dominant research field in all provinces except Limpopo, Northern Cape and Western Cape.

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

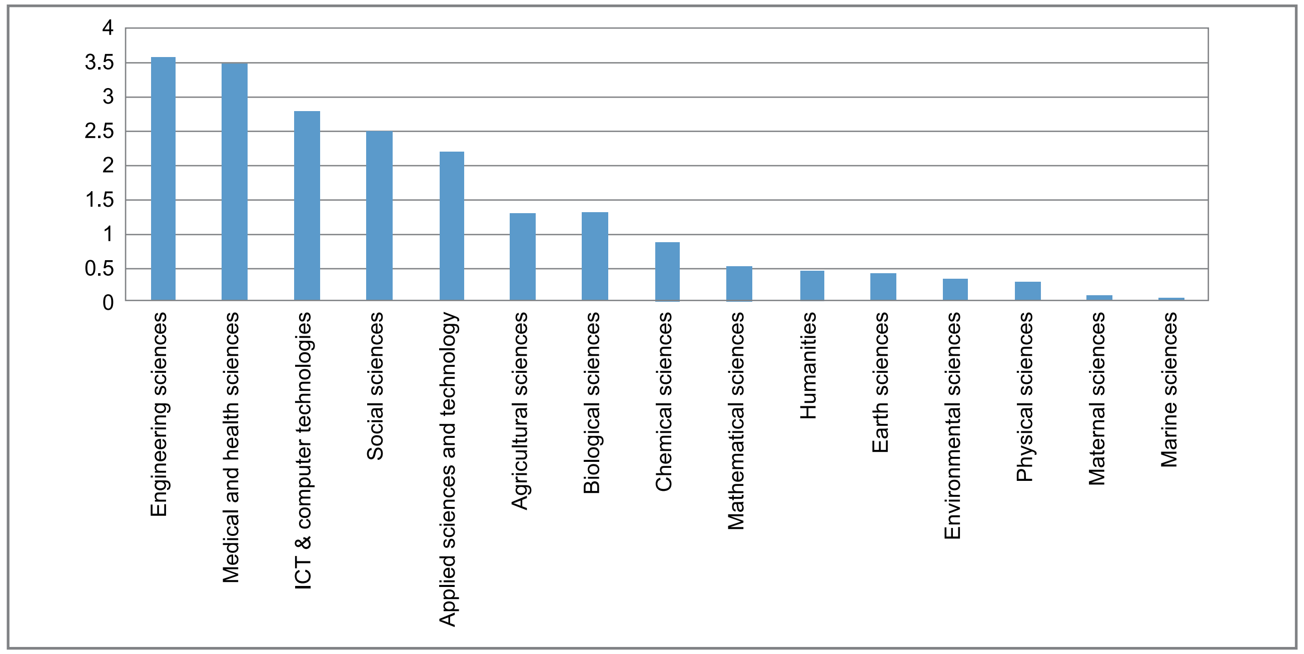
Table 16: Provincial R&D Expenditure Percentage Distribution by Top Research Fields

Eastern Cape	Free State	Gauteng	KwaZulu-Natal	Limpopo	Mpumalanga	North West	Northern Cape	Western Cape
Social Sciences (17%)	Engineering Sciences (35%)	Engineering Sciences (26%)	ICT & Computer Technologies (23%)	Agricultural Sciences (25%)	Agricultural Sciences (25%)	Engineering Sciences (24%)	Agricultural Sciences (32%)	Medical & Health Sciences (19%)
Engineering Sciences (16%)	Chemical Sciences (24%)	ICT & Computer Technologies (19%)	Medical & Health Sciences (19%)	Medical & Health Sciences (23%)	Engineering Sciences (15%)	Medical & Health Sciences (12%)	Social Sciences (17%)	ICT & Computer Technologies (15%)
Medical & Health Sciences (14%)	Medical & Health Sciences (16%)	Medical & Health Sciences (16%)	Engineering Sciences (16%)	Social Sciences (14%)	Medical & Health Sciences (14%)	Applied Sciences & Technology (10%)	Medical & Health Sciences (16%)	Social Sciences (15%)

Source: *Tabulated for NACI by CESTII from DST "National Survey of Research and Experimental Development", 2009/10*

As figure 8 indicates, Engineering Sciences is the top research field in South Africa in terms of R&D expenditure, followed by Medical and Health Sciences and ICT and Computer Technologies. The latter is not necessarily dominant in all provinces, but the ICT and Computer Technologies field is among the top research fields in provinces with high R&D expenditure (Gauteng, Western Cape and KwaZulu-Natal). Agricultural Sciences is the top research field in provinces with low R&D intensity such as Limpopo, Mpumalanga and Northern Cape, although not in North West where Engineering Sciences is a top research field owing to the high concentration of mining and mineral processing activities in this province.

Figure 8: R&D Expenditure by Research Field (2010/11) (Billion Rand)



Source: *DST "National Survey of Research and Experimental Development", 2010/11*

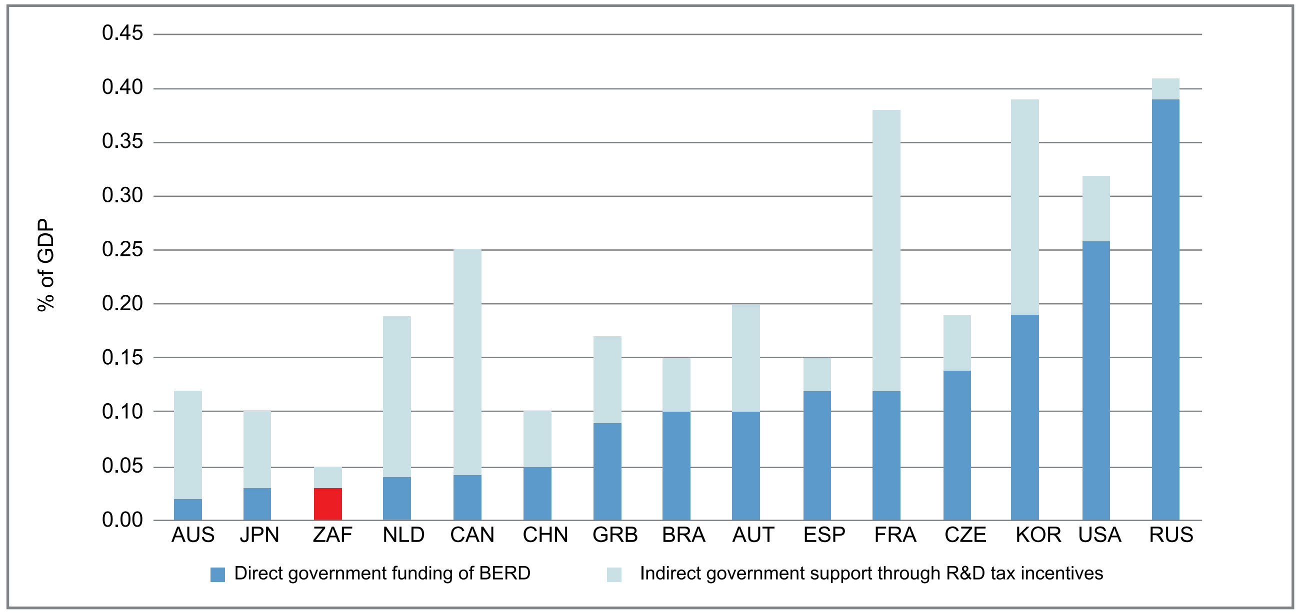
Explanatory note: SA's R&D effort was classified according to 15 broad fields of research and based on recognised academic disciplines and emerging areas of study.

5.3 R&D incentives

Fiscal incentives are widely used by governments to encourage expenditure on R&D. There are two forms of such incentives, viz. direct government grants and indirect R&D tax incentives. The direct grant system allows a government to influence the nature of R&D programmes that can be incentivised, allowing direct state control of private sector research and innovation prioritisation. Indirect R&D tax incentives, on the other hand, give companies the power to decide on the nature of their R&D programmes, based on prevailing market dynamics. The most important consideration in evaluating the performance of R&D incentives is the social rate of return as compared to the private rate of return. A desirable policy outcome occurs when there is a higher social rate of return, justifying the diversion of public funds to the private sector.

Figure 9 shows the ratio of direct and indirect incentives as a percentage of GDP for South Africa and other countries. In line with a low GERD as percentage of GDP in this country, the government contribution to business expenditure on R&D is only about 0.05% of GDP, which is very low when compared to Russia, Brazil and China, which have contributions of 0.41%, 0.15% and 0.10% respectively. As in countries such as Russia, the United States and Brazil, the South African government's intervention in business R&D expenditure is mainly in the form of direct funding through programmes such as THRIP, SPII and TIA.

Figure 9: Contribution of Government Incentives to R&D Expenditure as % of GDP

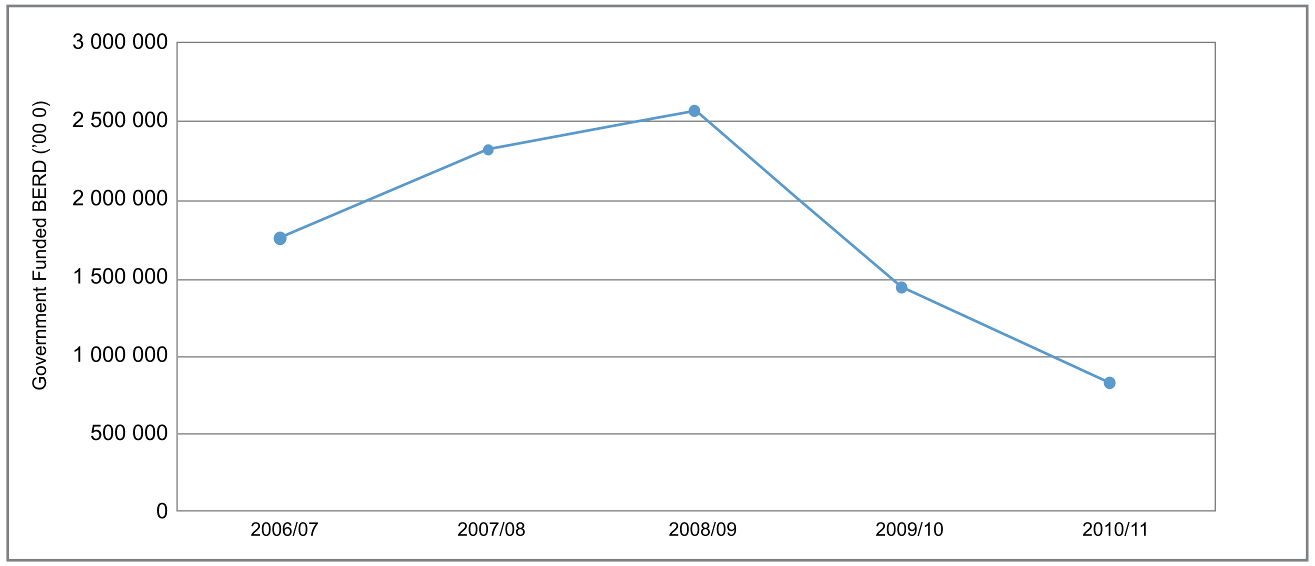


Sources: *Adapted from OECD R&D Tax Incentive Statistics (http://www.oecd.org/sti/rd-tax-stats.htm); South Africa's 2010 values computed from 2011/12 R&D Tax Incentive annual report and DST "National Survey of Research and Experimental Development", 2010/11*

Key: AUS – Australia; JPN – Japan; ZAF – South Africa; NLD – New Zealand; CAN – Canada; CHN – China; GBR – Great Britain; BRA – Brazil; AUT – Austria; ESP – Spain; FRA – France; CZE – Czech Republic; KOR – South Korea; USA – United States; RUS – Russia

Despite relatively low government funding of business R&D expenditure in South Africa, the trend is negative with a decline of 44.3% from 2008/09 to 2009/10, as shown in figure 10. From 2009/10 to 2010/11 this decline was 41.8%. This drastic decrease in government support of BERD occurred after the 2008 economic recession, although the decrease was much greater than the decrease in total business expenditure on R&D over the same period. The decline in BERD was only 9.7% for both 2008/09 to 2009/10 and 2009/10 to 2010/11. The importance of government funding for R&D is noted within the NDP, where the state is encouraged to play an active role both in funding R&D and in guiding the type of R&D programmes that private and public sectors conduct.

Figure 10: Declining Government Funding of BERD

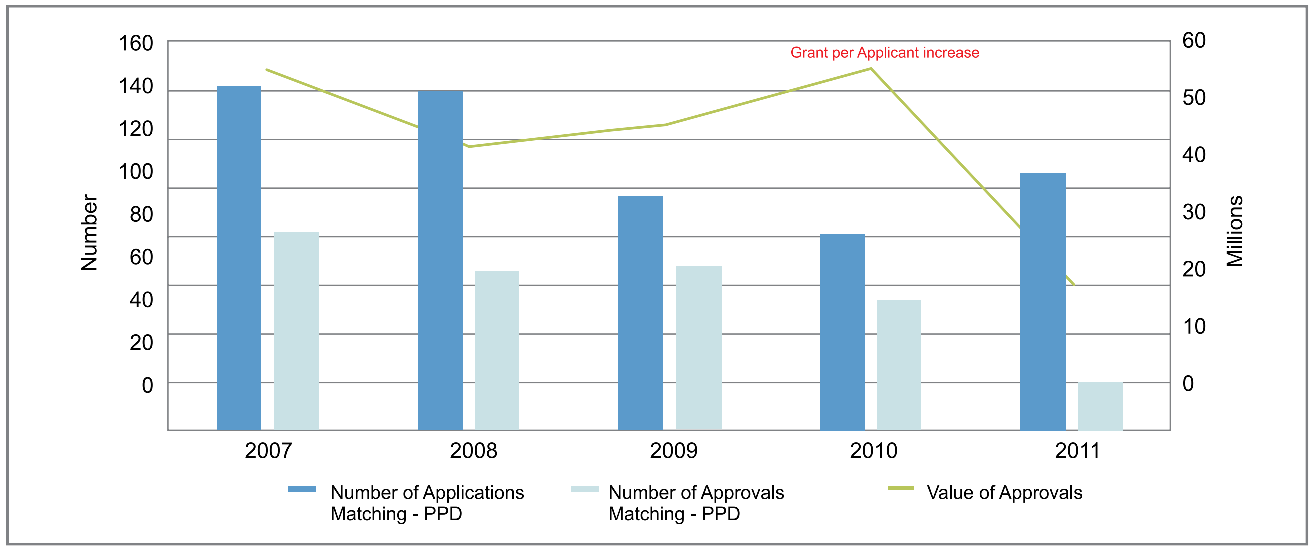


Source: *DST "National Survey of Research and Experimental Development", 2010/11*

The Support Programme for Industrial Innovation (SPII) is a government instrument under the DTI (administered by the IDC) aimed at playing a key role in the development of new technologies for South African industries. There are three funding mechanisms under this programme, viz. Product Process Development (PPD), the Matching Scheme and the Partnership Scheme. PPD is meant for small, very small and micro enterprises while the Matching Scheme is targeted at small and medium companies.

Figure 11 shows the trends in both the PPD and the Matching Scheme in terms of the number of applicants, the number of approvals and the value of these approvals. Since 2007 there has been a decline in the number of applications approved, a trend reflected in the number of applications, although there was huge growth in the number of applications in 2011. The decline in the number of approvals in 2011 was the result of an exercise to correct the number of commitments to the SPII programme (IDC, "SPII 2010/11 Annual Report").

Figure 11: Performance of SPII Matching and PPD Schemes



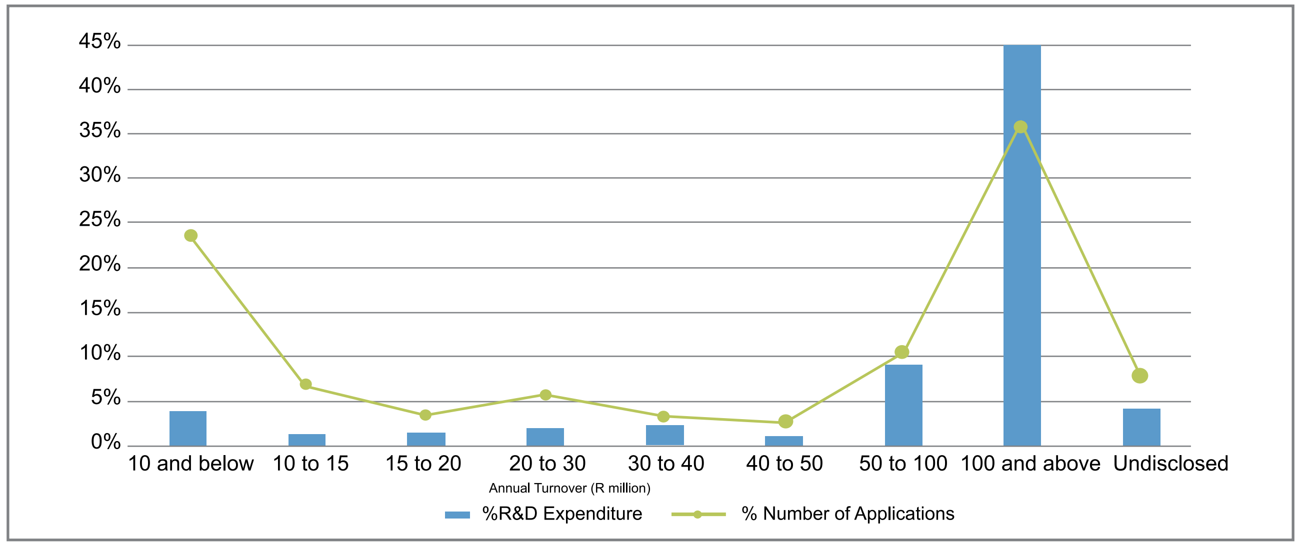
Source: *IDC "SPII Annual Reports"*

The R&D Tax Incentive is a further government instrument under the management of the Department of Science and Technology. This indirect R&D funding for business is aimed at stimulating private sector research and development through an additional 50% deduction of R&D expenditure on the company's income statement for the purposes of the calculation of tax due.

Through this incentive, at a corporate income tax rate of 28%, most companies benefit from a tax reduction of 14% of the qualifying R&D expenditure.

As figure 12 illustrates, most R&D Tax Incentive beneficiaries are large companies with revenue in excess of 100 million rand. Although about 25% of the beneficiaries are companies with revenue of less or equal to 10 million rand, in terms of qualifying R&D expenditure, this is less than 5% of all beneficiaries in the 2006 to 2011 period.

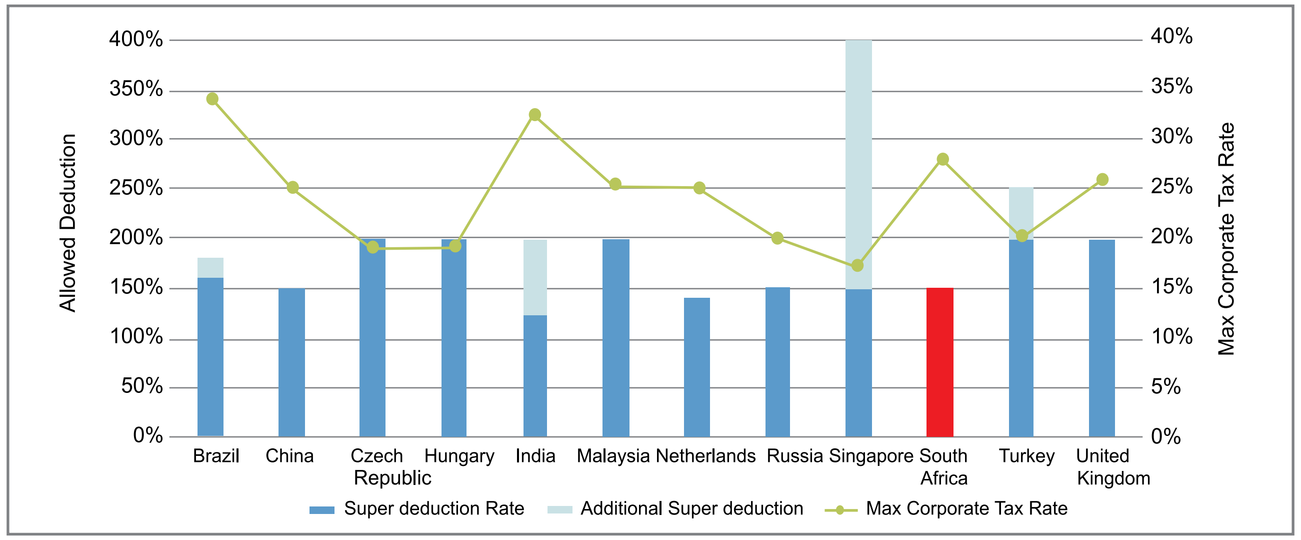
Figure 12: Cumulative Distribution of R&D Tax Incentive Beneficiaries by Turnover (2006-2011)



Source: *DST "2011/12 R&D Tax Incentive Annual Report to Parliament"*

Figure 13 compares the generosity of South Africa's R&D tax incentive to those of other countries, including BRICS countries. The maximum corporate tax rate is also shown on the graph as the generosity of this type of incentive also depends on this rate. Although the allowed deduction of 15% for South Africa is low when compared to countries such as Malaysia, the Netherlands and the United Kingdom, the comparatively high corporate tax rate makes the 15% deduction for South Africa relatively attractive.

Figure 13: Comparative Generosity of R&D Tax Incentives



Source: *Adapted from Deloitte "2012 Global Survey of R&D Tax"*

6. IMPORTED KNOW-HOW

Within an open innovation system such as that in South Africa, imported know-how is a very important component of knowledge acquisition and generation. This chapter evaluates trends in technology balance of payments as well as high technology trading as key indicators of effective usage of imported know-how.

6.1 Technology balance of payments

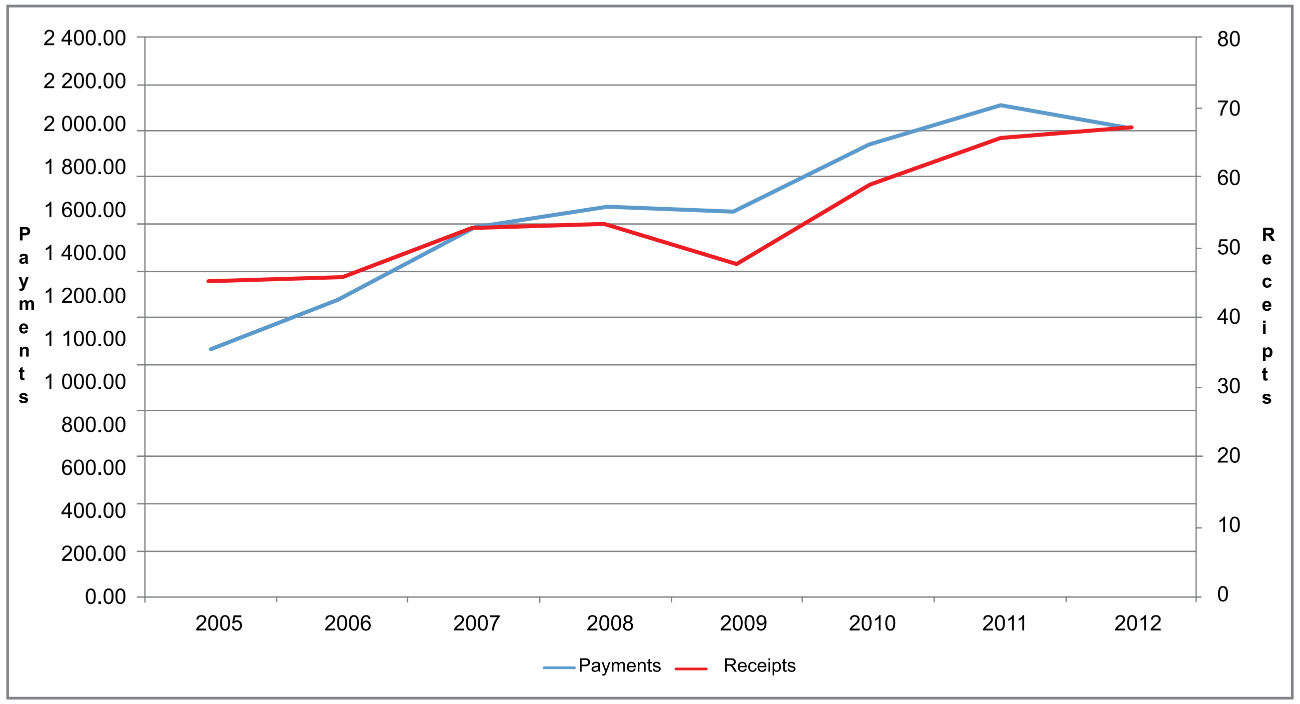
Despite a slowdown in technology receipts and payments in 2009, these receipts have since experienced growth in 2010, 2011 and 2012. The growth in 2012 occurred despite a decline in technology payments. This growth in technology receipts is important as from 2005 to 2012 technology payments almost doubled although technology receipts increased by only half over the same period, as indicated in table 17 and figure 14.

Table 17: SA Technology Balance of Payments (Million USD)

	2005	2006	2007	2008	2009	2010	2011	2012
Payments	1 070.6	1 282.0	1 596.3	1 675.9	1 658.0	1 941.2	2 117.9	2 016.7
Receipts	45.3	45.8	52.9	53.7	47.7	59.2	65.8	67.3

Source: *The World Bank "World Development Indicators"*

Figure 14: SA Technology Balance of Payments (Million USD)



Explanatory note: The technology balance of payments registers the commercial transactions related to international technology and know-how transfers. It consists of money paid or received for the use of patents, licences, know-how, trademarks, designs, technical services and for industrial research and development conducted abroad.

South Africa ranks 6th in terms of technology payments on the GII and this is not surprising given the high value of technology payments per capita compared to Brazil, China and India (table 18). Technology payments as a proportion of GERD for South Africa are the highest among the BRICS countries, and even higher than Japan, the United Kingdom and the United States. High R&D expenditure is used widely as an indicator of potential for knowledge absorption. Increased R&D intensity is necessary if a country is to learn the imported technologies and to compete efficiently as a knowledge-based economy.

Table 18: Level of Imported Know-How Dependency for Selected Countries, 2012 or Recent Year

	South Africa	Brazil	China	India	Russia	Japan	United Kingdom	United States
Technology Payments per Capita ($)	39	19	13	2	53	156	133	127
% of Technology Payments to GERD	50	14	10	12	23	14	21	10

6.2 High-technology manufacturing imports and exports

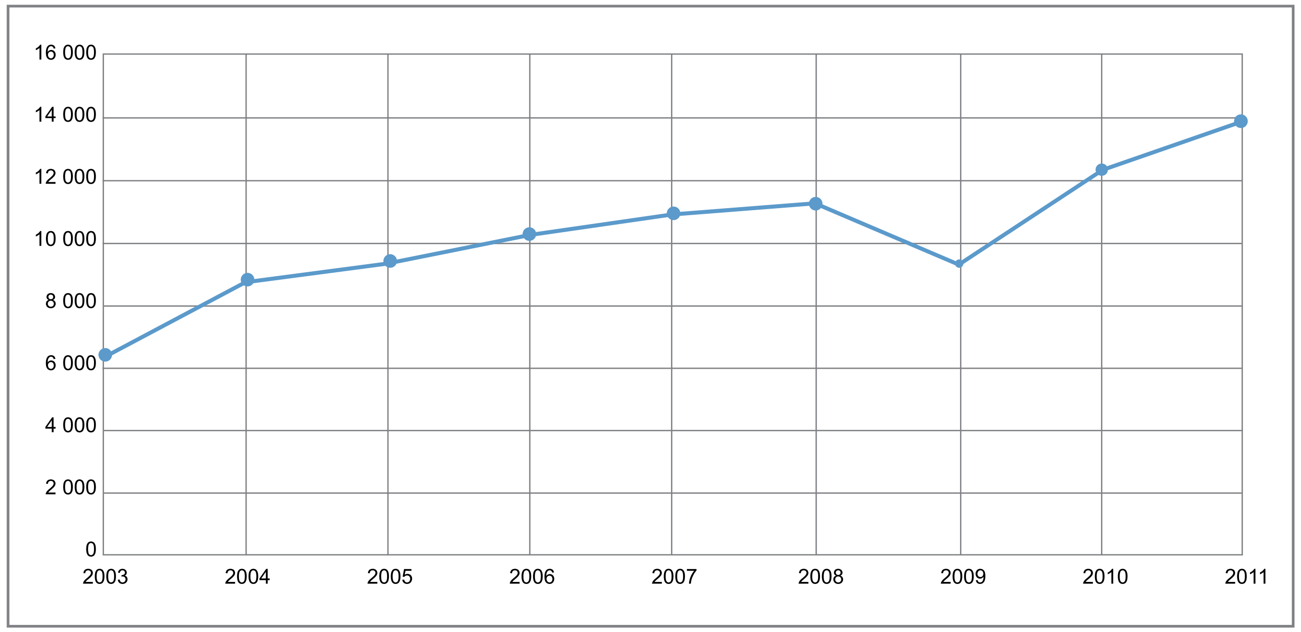
As shown in table 19 and figure 15, there was a growing trade deficit in South Africa's high-technology manufacturing industry, the only slowdown occurring in 2009. The rate of trade deficit growth differed for various industries during the 2003 – 2012 period, with the highest growth occurring in the electronics sector at an average of 14.5%, followed by the pharmaceuticals sector (12.7%), scientific instruments (11.0%), office, accounting and computing machinery (10.7%) and aerospace sectors (3.5%).

Table 19: SA Trade Deficit in High-Technology Manufacturing Industries (Million USD)

Industry	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electronics	1 631	2 449	3 157	3 632	3 675	3 744	3 040	4 368	4 721
Office, accounting and computing machinery	1 485	2 194	2 440	2 650	2 699	2 602	2 135	2 880	3 262
Pharmaceuticals	793	958	1176	1335	1472	1 581	1 599	2 128	2 240
Aerospace	1 519	1 979	1 189	957	1 222	1 506	1 030	1 100	1 479
Scientific instruments	911	1 187	1 382	1 702	1 833	1 861	1 525	1 835	2 159
Total	**6 339**	**8 767**	**9 344**	**10 276**	**10 901**	**11 294**	**9 329**	**12 311**	**13 861**

Source: *OECD "Main Science and Technology Indicators"*

Figure 15: South African High-Technology Manufacturing Trade Deficit Trends (Million Current USD)



Explanatory note: The selection of industries is based on the OECD classification of high-technology.

7. SET HUMAN CAPITAL

The SET human capital development strategy for South Africa is guided mainly by the national HRDSA, a policy framework that focuses on human resource development elements such as (i) educational attainment, (ii) skills development, (iii) science and innovation, and (iv) labour market/employment policies. Commitment Six of the strategy has the following key priorities: (1) to increase the supply of skilled personnel in areas of science, engineering and technology and (2) to improve South Africa's performance in areas of teaching, research, innovation and the commercial application of high-level science, engineering and technology knowledge.

7.1 Researchers

Table 20 indicates that the number of South African researchers per 1 000 FTE has levelled at 1.4; this trend is similar to the number of SET enrolments previously shown. The NRDS aimed to make this number 1.1 by 2012. This is one of the key indicators for priority 6.2 of the HRDSA.

Table 20: Researchers per 1 000 FTE Employed

	2003	2004	2005	2006	2007	2008	2009	2010
South Africa	1.2	1.5	1.4	1.4	1.4	1.4	1.5	1.4
China	1.2	1.3	1.5	1.6	1.9	2.1	1.5	1.6
Russian Federation	7.3	7.1	6.8	6.7	6.7	6.4	6.4	6.3
Japan	10.1	10.1	10.4	10.4	10.4	10.0	10.1	10.2
United Kingdom	7.1	7.4	7.9	8.0	7.9	7.9	8.1	8.2
United States	10.2	9.8	9.6	9.6	9.5	-	-	-

Source: *OECD "Main Science and Technology Indicators"*

7.2 SET graduations

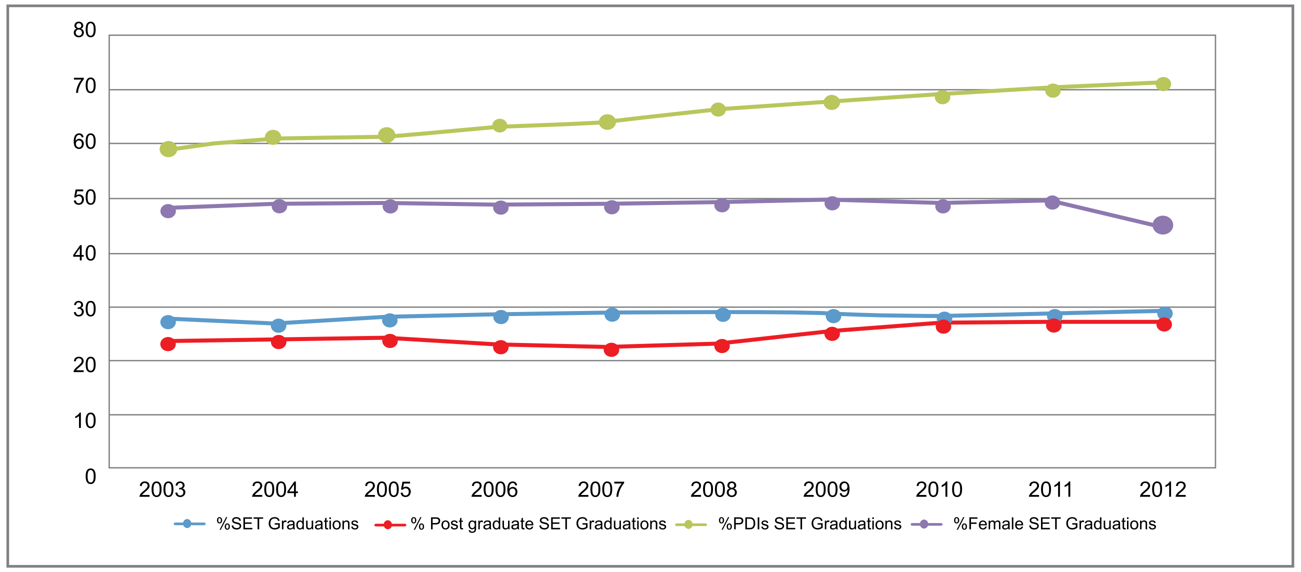
The number of postgraduate SET graduations has shown some improvement over time, with an increase of 4% between 2003 and 2012. The South African ten-year innovation plan aims for SET graduations to constitute 35% of all graduations by 2018. In terms of transformation, there was a decline in 2012 (4%) in the number of female students graduating with SET degrees, although on a positive note there has been a constant increase in the number of SET graduations among students from previously disadvantaged groups (Africans, Indians and Coloureds).

Table 21: Higher Education SET Graduations

	% SET Graduations	% Postgraduate SET Graduations	% PDIs SET Graduations	% Female SET Graduations
2003	27.5	23.4	58.7	48.0
2004	26.9	23.9	60.9	49.0
2005	27.8	24.1	61.2	48.9
2006	28.5	22.8	62.8	48.7
2007	28.8	22.4	64.1	49.2
2008	29.4	22.9	66.4	49.3
2009	28.5	25.3	67.7	49.5
2010	27.9	26.9	69.2	49.1
2011	28.7	27.0	70.1	49.4
2012	29.4	27.2	71.5	44.4

Source: *Department of Higher Education and Training "HEMIS"*

Figure 16: Trends in Higher Education SET Graduations



Explanatory note: Higher education graduation data include all public higher education institutions. SET includes the Classification of Educational Subject Matter (CESM) 2008 categories: Agriculture; Agricultural Operations and Related Sciences; Architecture and the Built Environment; Computer and Information Sciences; Engineering; Health Professions and Related Clinical Sciences; Family Ecology and Consumer Sciences; Life Sciences; Physical Sciences; Mathematics and Statistics; and Military Sciences.

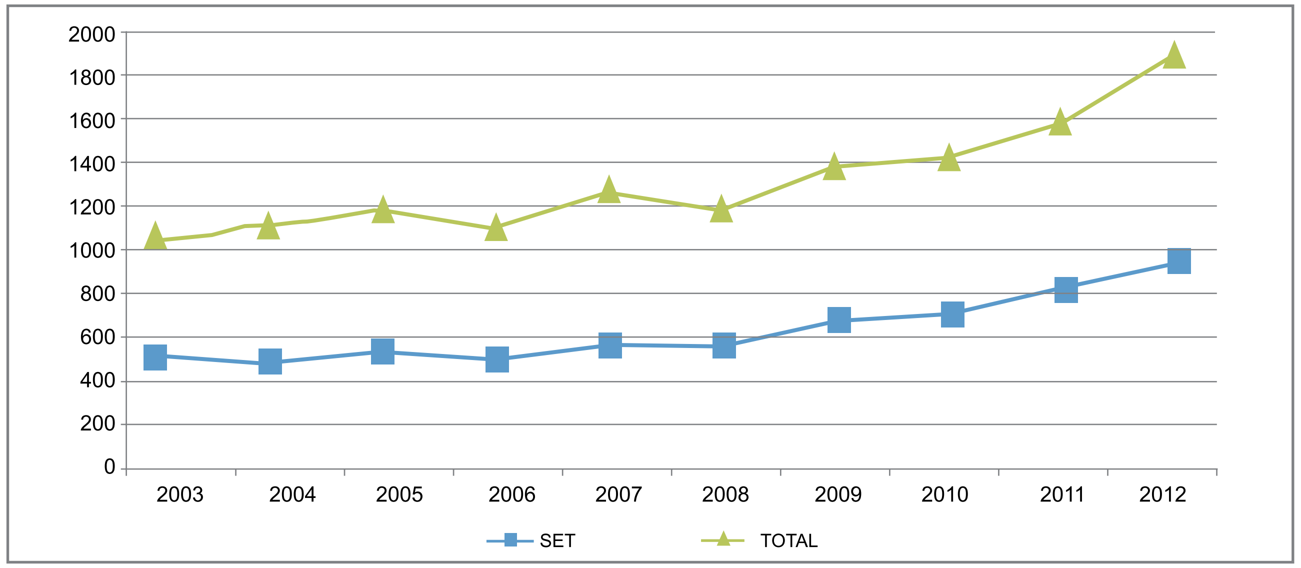
As shown in table 22, since 2009 there has been a sustained increase in the total number of doctoral degrees awarded by South African universities as well as in the number of SET doctoral degrees awarded. TYIP has a target of 3 000 SET PhD graduates per year. The rise in high quality publications output is possibly a reflection of this growing pool of doctoral graduates.

Table 22: Doctoral Degrees Awarded By South African Public Universities

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
SET	522	499	561	522	590	575	704	730	854	985
Total	1 052	1 105	1 189	1 100	1 274	1 182	1 380	1 421	1 576	1 878

Source: *Department of Higher Education and Training "HEMIS"*

Figure 17: Doctoral Degrees Awarded by South African Universities



SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

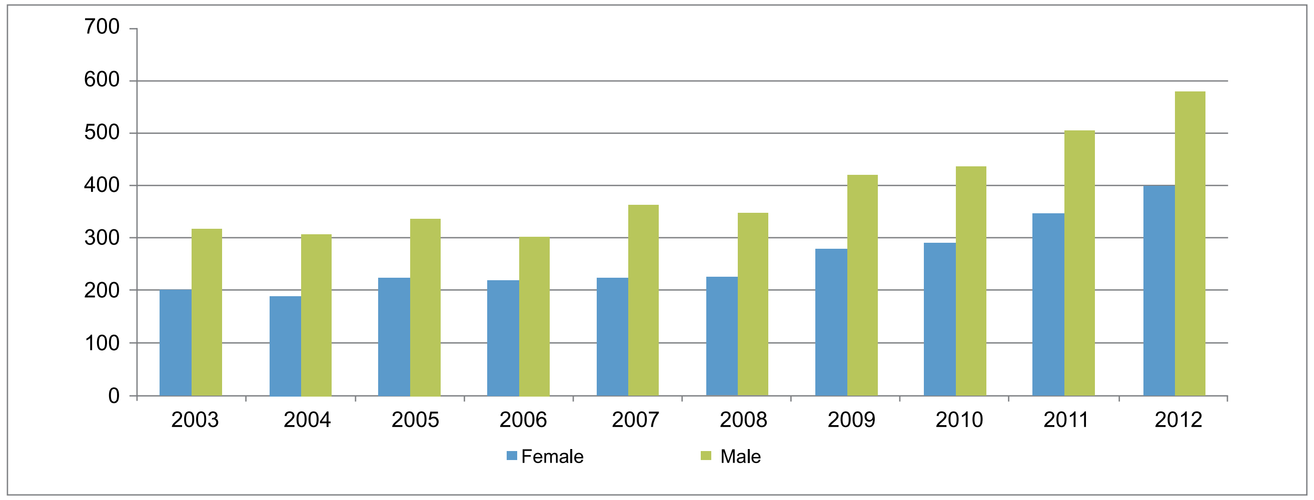
As indicated in table 23 and figure 18, the trends in the increase in doctoral degrees awarded are similar among both males and females, although the number of female students graduating with doctoral degrees is still lower than male doctoral graduates. Between 2003 and 2012, the average annual growth in the number of women awarded doctoral degrees was 8.4%, while for men it was 7.4%.

Table 23: Doctoral Degrees Awarded by South African Universities per Gender

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Females	203	191	225	220	225	227	281	292	349	402
Males	319	309	336	302	365	348	423	439	505	580

Source: *Department of Higher Education and Training "HEMIS"*

Figure 18: Doctoral Degrees Awarded by South African Universities per Gender



7.3 Research chairs

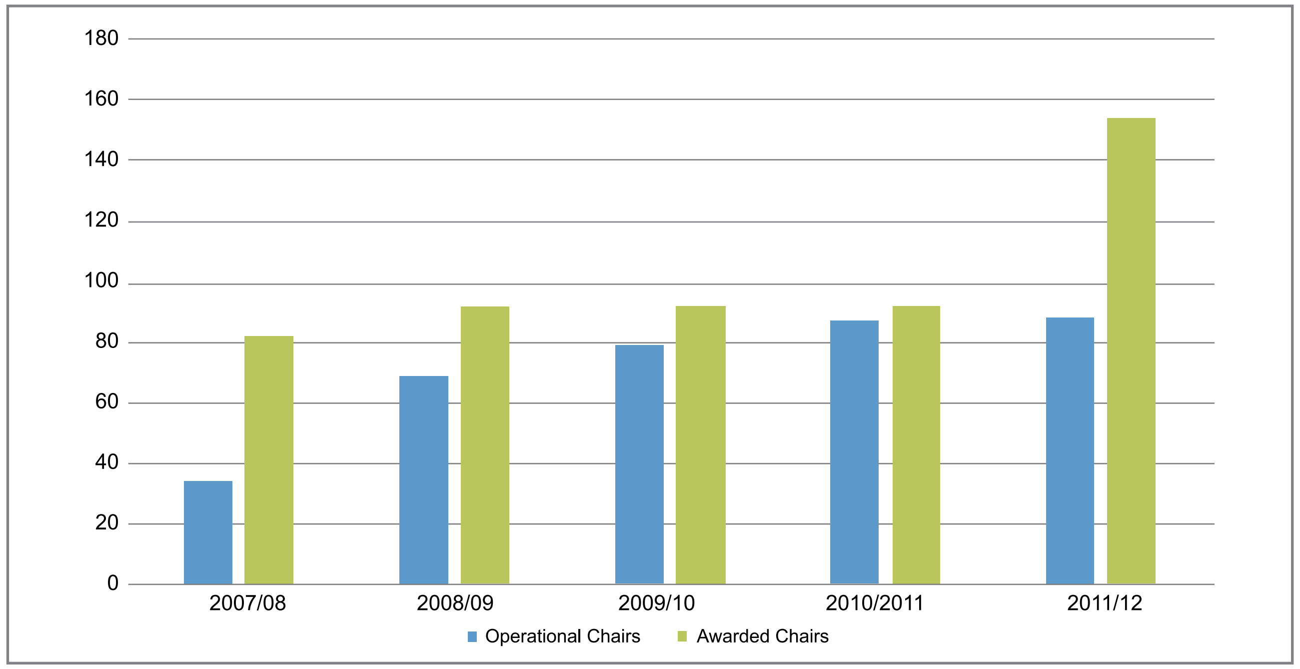
The South African Research Chairs Initiative (SARChi) is an initiative of the Department of Science and Technology (through the NRF) to strengthen and improve the research and innovation capacity of public universities to produce high quality postgraduate students, research and innovation outputs. The number of research chairs targeted by TYIP is 500 by 2018. The milestone of 210 research chairs by 2010 has already been missed, as in the 2011/12 financial year there were only 88 operational and 154 awarded research chairs (table 24).

Table 24: South African Research Chairs

	2007/08	2008/09	2009/10	2010/11	2011/12
Operational Chairs	34	69	79	87	88
Awarded Chairs	82	92	92	92	154

Sources: *National Research Foundation "2012 Five Year Review of the SARChi" and "2011/12 Annual Progress Report on SARChi"*

Figure 19: South African Research Chairs



In 2010/11, of the 92 awarded research chairs, 46% went to Natural and Agricultural Sciences, 22% to Social Sciences, 17% to Health Sciences, 10% to Humanities and 5% to Engineering and Applied Technology (NRF "2011/12 Annual Progress Report on SARChi"). Excluding the 62 newly awarded research chairs, most were awarded to UCT (28), followed by Wits University (17), Stellenbosch University (10), UKZN (8) and Pretoria University (6).

Following Minister Pandor's directive to the NRF Board, the newly awarded research chairs took into account an inclusive NSI, increasing the number of participating universities from 15 to 21. The gender and racial redress issues were given adequate consideration as in 2011/12 there were 49% female and 57% previously disadvantaged postgraduate students supported by research chairs.

The research chair holders in 2011/12 supervised 461 doctoral, 505 masters' and 137 honours students. This translates to approximately 2.8% of the total postgraduate SET enrolments (39 072); 6.6% of doctoral SET enrolments (7 017); 2.2% of masters' SET enrolments (22 499); and 1.4% of honours SET enrolments (9 556). In 2011/12 the 74 reported research chairs produced 763 peer reviewed journal articles, 24 books, 72 chapters in books and 12 patents.

8. TECHNICAL PROGRESS (IMPROVEMENT AND INNOVATION)

The NRDS identified technical progress as one of the key drivers in achieving high quality of life, economic growth and wealth creation for South African citizens. The strategy suggested indicators such as patents, high-tech start-ups, business innovation investment and key technology missions as key to monitoring technological improvements and innovation. This chapter focuses on trends in patents and the share in high-technology exports.

8.1 Patents

Patents data is useful in determining the level of technological development. Not all industries rely on patents to protect their intellectual property and this should be kept in mind when comparing patents across industrial sectors. As indicated in table 25, there are generally more patents in the pharmaceutical sector than in the ICT sector (e.g. telecommunications). Relatively high numbers of patents are published for medical technology and chemical engineering although overall there has been decline in the number published, as is the case for other technologies, as reflected in the trends in figure 20. This decline in the number of published patents is in contrast to the significant growth in high impact journal publications.

Table 25: Total South African Patent Publications by Selected Technologies

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Telecommunications	28	26	41	42	28	21	27	9	8
Computer Technology	23	33	35	28	19	34	34	46	41
Medical Technology	75	104	64	72	74	88	44	54	55
Biotechnology	24	37	30	20	32	25	41	31	34
Pharmaceuticals	52	49	45	69	40	41	46	43	53
Chemical Engineering	96	90	117	102	69	87	82	72	59
Environmental Technology	37	24	35	34	25	41	26	34	27
Other Technologies	874	997	1 085	1 147	1 180	1 103	1 064	936	877
Yearly Total	1 209	1 360	1 452	1 514	1 467	1 440	1 364	1 225	1 154

Source: *WIPO "IP Statistics Data Center"*

Over the 2003 – 2011 period, the decline in number of patents published was on average 0.3% per year, with telecommunications patents experiencing an average decrease of 6.8% per year and chemical engineering patents 3.9% per year. There was an average yearly increase of 12.6% for computer technology and 11.2% for biotechnology. Pharmaceutical patent publications experienced an average yearly increase of 3.6%, although there was a sharp increase of 23.3% from 2010 to 2011.

Figure 20: Trends in South African Patents Published

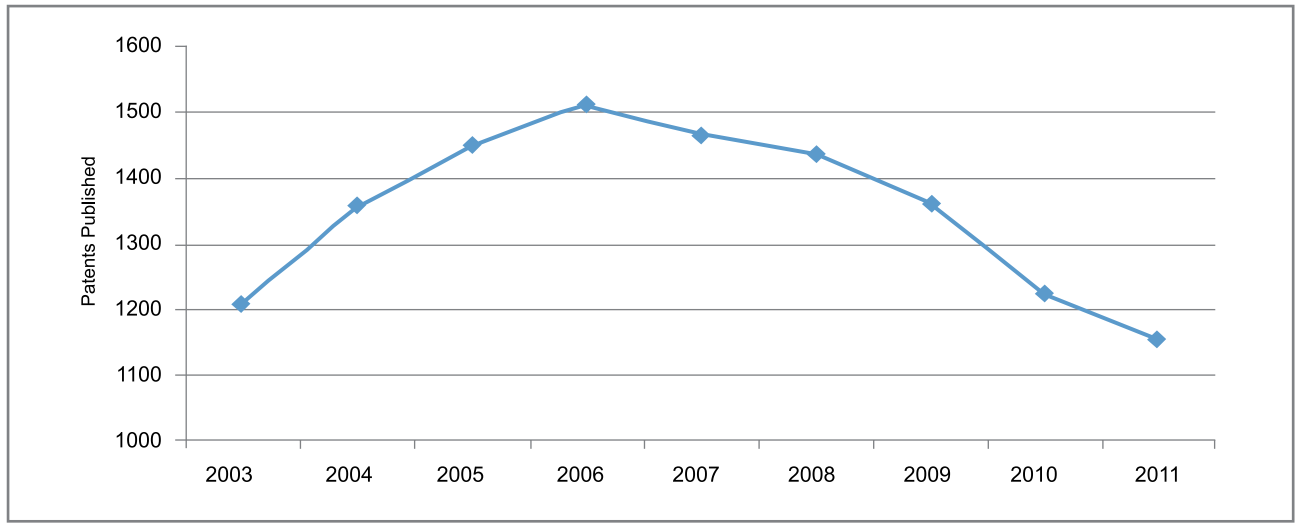
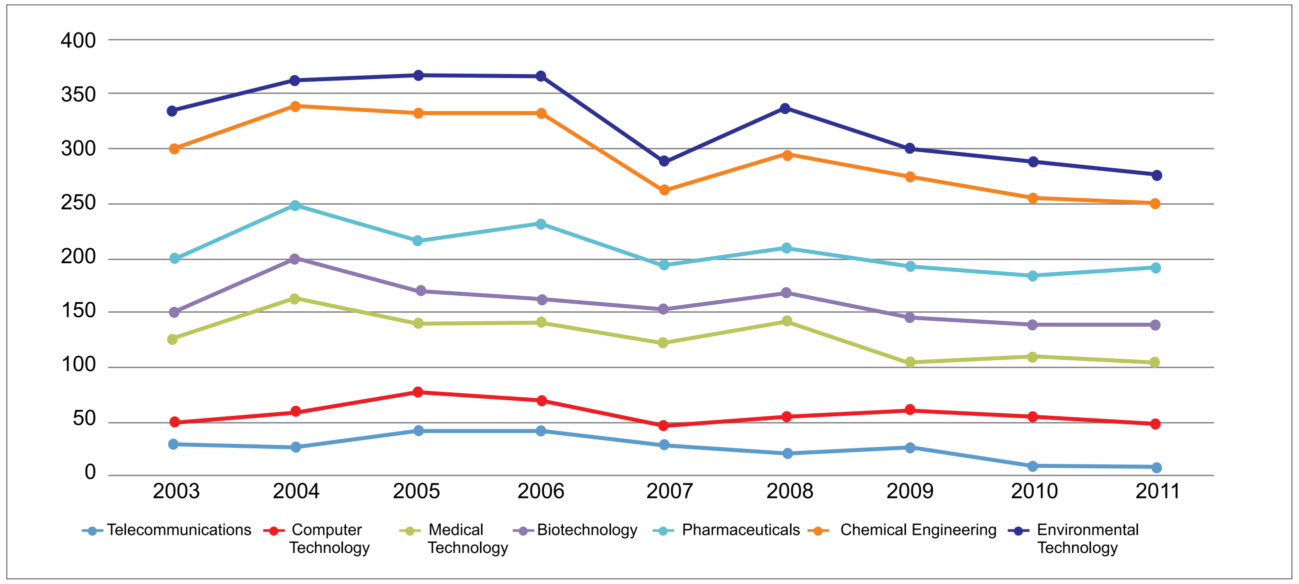


Figure 21: Trends in South African Patents Published by Selected Technologies



There was a sharp decline in patents granted at the South African Patent Office while there were signs of a slight increase in South African patents granted in countries such as the United States, Australia, Canada, Japan and India. The NRDS and TYIP targets are respectively set at 200 and 250 South African originated patents granted annually by the United States patent office. These targets are unlikely to be achieved as in 2011 the total was only 123, as shown in table 26, an increase of only 23% (23 patents) from 2002.

Table 26: SA Patents Granted by Selected Patent Offices

Patent Office	2003	2004	2005	2006	2007	2008	2009	2010	2011
South African Patent Office	924	957	1 010	868	918	863	833	822	567
United States	112	100	87	109	82	91	93	116	123
Australia	64	59	55	34	44	31	59	76	84
European Patent Office	35	56	55	59	58	53	49	53	53
China	32	21	37	28	37	38	47	34	44
Canada	11	18	22	21	23	34	26	40	41
Japan	9	0	2	8	10	18	23	30	26
Russian Federation	9	8	13	7	11	10	16	16	15
United Kingdom	16	24	15	8	7	10	9	6	7
New Zealand	18	13	13	4	10	6	7	14	13
Mexico	10	7	7	6	9	12	16	12	14
Republic of Korea	6	0	10	12	12	17	5	7	7
Singapore	12	7	6	10	9	6	2	6	8
India	6	6	0	0	0	0	0	20	20
Brazil	0	0	0	1	0	3	2	7	5
Other Patents Offices	93	112	161	71	116	140	64	122	97
Total Patents Granted	**1 357**	**1 388**	**1 493**	**1 246**	**1 346**	**1 332**	**1 251**	**1 381**	**1 124**

Source: *WIPO "IP Statistics Data Center"*

In the same way as journal publication efficiency was compared, table 27 reflects a comparison of South African patents with other BRICS countries and Japan, the United Kingdom and the United States. Although the South African world share of high impact journal publications is 0.73%, the world share of patents publications is only 0.08%.

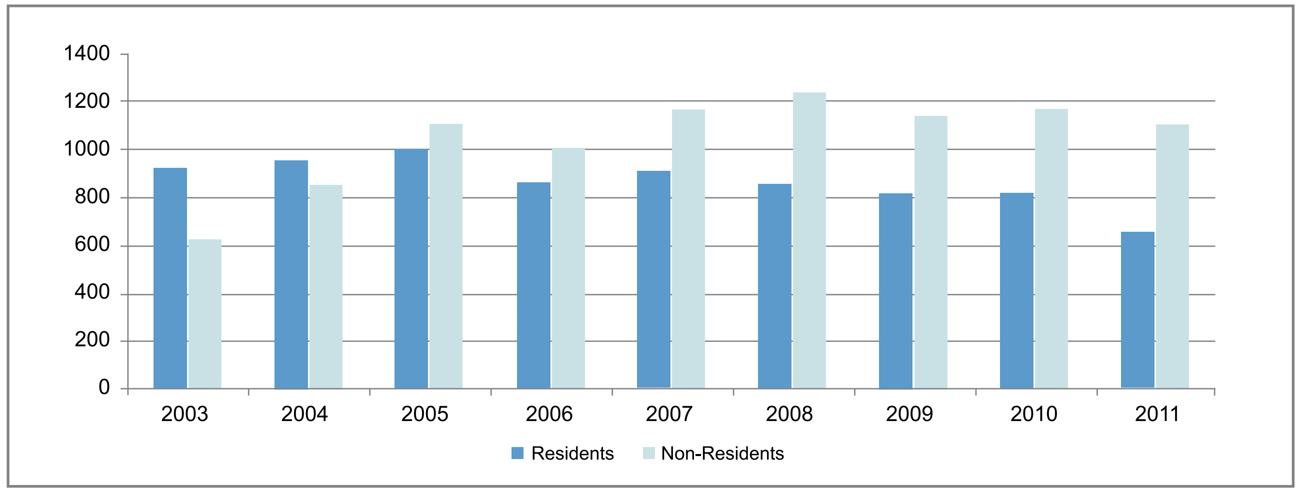
SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

Table 27: Summarised Patents Efficiency for South Africa and Selected Countries (Most Recent Year)

	South Africa	Brazil	China	India	Russia	Japan	United Kingdom	United States
Patent Applications	1 761	6 363	436 144	15 860	31 463	474 984	50 749	440 433
World Share of Patents Published (%)	0.08	0.29	19.99	0.73	1.44	21.77	2.33	20.19
Patent Applications per Million Capita (pmc)	35	32	324	13	155	3 708	809	1 413
Patent Applications per 100 Researchers FTE	9	5	36	11	7	72	20	31
Patent Applications per 100 Million $ PPP R&D Expenditure	44	25	245	65	94	340	128	108
Patents Granted	1 124	947	118 164	2 884	22 179	384 848	18 374	202 207
Patents Granted pmc	22	5	88	2	155	3 004	293	649

Sources: *patents application and granted data from WIPO "IP Statistics Data Center"; 2011 population data from Population Reference Bureau; 2010/11 R&D expenditures and FTE researchers from OECD "Main Science and Technology Indicators"; South Africa's R&D expenditure and FTE researchers, from DST "National Survey of Research and Experimental Development", 2010/11; R&D expenditure and FTE researchers' data for Brazil and India from 2010 UNESCO Science Report.*

Figure 22: South African Patents Application by Residents & Non-Residents



Source: *WIPO "IP Statistics Data Center"*

As shown in figure 22, since 2005 South African-originated non-resident patent applications have exceeded those of residents. The gap continues to widen as in 2011 only 27% of South African originated patent applications came from residents. The 2013 GII ranks South Africa 38th out of 142 countries in terms of PCT patent applications per GDP by residents.

8.2 High-technology exports

South Africa's percentage share of high-technology exports by various high-technology industries as shown in table 28 is in line with the 0.08% world share of patents published. As of 2011, the high-technology industry with the highest market share has been the aerospace industry (0.15%), followed by scientific instruments (0.09%). In general, there are signs of stagnation in most high-technology sectors' export market share with the pharmaceutical industry showing a slight decline from a value of 0.06% in 2003 and 2004 to 0.04% at the beginning of 2009.

Table 28: SA % Export Market Share for High-Technology Manufacturing Industries

Industry	2003	2004	2005	2006	2007	2008	2009	2010	2011
Electronics	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Office, Accounting and Computing Machinery	0.03	0.03	0.03	0.05	0.04	0.05	0.04	0.04	0.04
Pharmaceuticals	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04
Aerospace	0.07	0.16	0.37	0.27	0.23	0.25	0.10	0.09	0.15
Scientific Instruments	0.08	0.08	0.09	0.08	0.09	0.10	0.11	0.08	0.09

Source: *OECD "Main Science and Technology Indicators"*

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

9. BUSINESS PERFORMANCE AND KEY INDUSTRIAL SECTORS

The National Industry Policy Framework (NIPF) advocates the prioritisation of key sectors where government intervention is necessary to eliminate growth and employment constraints. In response to the NIPF, numerous industrial action plans have been adopted, the latest of which is the 2013/14 – 2015/16 Industrial Policy Action Plan. This action plan calls for the scaling up and broadening of interventions in sectors prioritised since 2007. These sectors are mainly in manufacturing and range from low-technology intensive industries (agro-processing, clothing and textiles, paper printing, wood and furniture), to medium technology-intensive industries (motor vehicles, plastics, fabricated metal products and rail transport equipment) to high-technology intensive pharmaceutical industries.

9.1 Employment in manufacturing industry

Table 29 and figure 23 reflect trends in employment within South Africa's manufacturing industry, arranged by the degree of technology intensity. The data is also disaggregated by gender as prescribed by the NRDS.

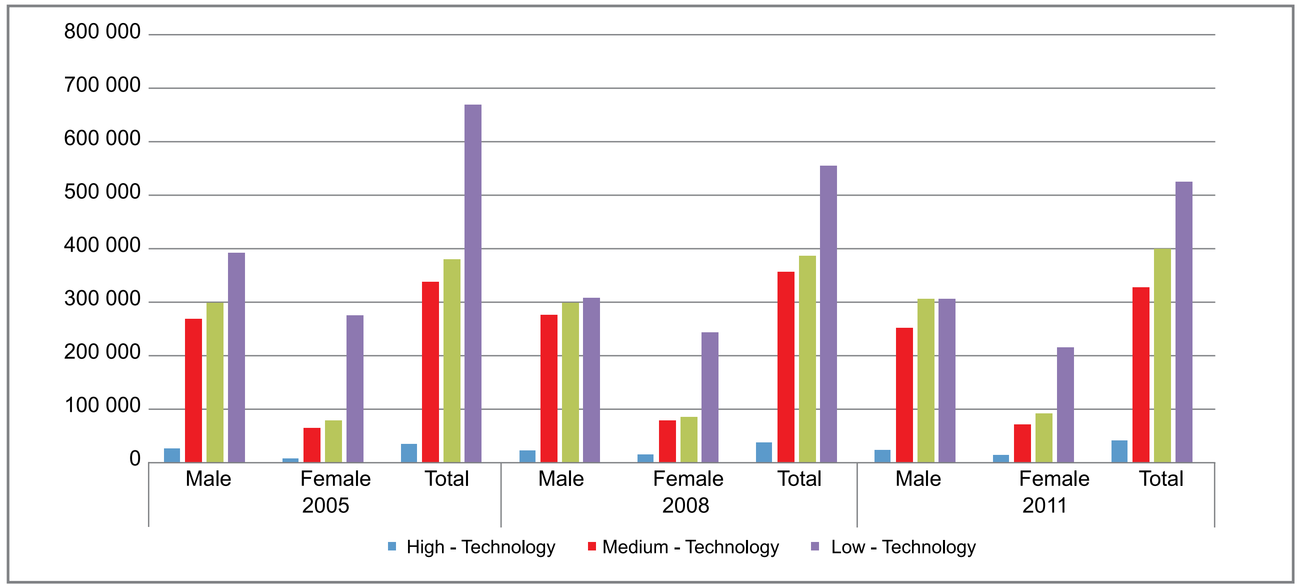
Table 29: Formal Employment in SA Manufacturing Industry

Industry	2005			2008			2011		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
High-Technology	28 700	9 729	38 429	25 187	16 674	41 861	27 594	17 082	44 676
Medium High-Technology	271 695	68 875	340 570	277 888	81 158	359 046	255 740	73 751	329 491
Medium Low -Technology	300 970	82 299	383 269	299 998	87 156	387 154	308 489	94 129	402 618
Low-Technology	395 519	278 041	673 560	311 030	245 079	556 109	309 215	218 589	527 804
Total	996 884	438 944	1 435 828	914 103	430 067	1 344 170	901 038	403 551	1 304 589

Source: *computed by NACI from StatsSA "Manufacturing Industry: Financial", 2005, 2008 and 2011 reports*

The trend in South Africa's manufacturing employment shows a decline in employment from 1 435 828 in 2005 to 1 304 589 in 2011, the equivalent of a 9% drop. This translates to the loss of approximately 1.5% manufacturing jobs per year. Over the same period (2005 to 2011), low-technology intensive industries lost 21.6% jobs and medium high-technology 3.3%. By contrast, there was a gain of 16.3% jobs in high-technology intensive industries and 5.0% in medium low-technology industries. Most jobs created in the high-technology manufacturing sector went to women.

Figure 23: Trends in Formal Employment in SA Manufacturing Industry



The pattern of employment shows a shift from low- to high-technology industry, although the role of medium low-technology intensive industries is still vital to South Africa's economy. In 2011 high-technology intensive industries contributed 3.4% of the total manufacturing employment while in the same year medium high-technology intensive industries contributed 25.3% of manufacturing jobs.

Explanatory note: The selection of industries is based on the OECD classification of industries based on their R&D intensities. Industries in the high-technology sector are Aerospace; Computers, Accounting and Office Machinery; Communication Electronics; Pharmaceuticals; and Scientific and Professional Instruments. Medium high-technology industries are Motor Vehicles; Electrical Machinery; Chemicals; Other Transport Equipment; and Non-Electrical Machinery. Medium low-technology industries are Rubber and Plastic Products; Shipbuilding; Other Manufacturing; Non-Ferrous Metals; Recycling of Waste and Scrap; Non-Metallic Mineral Products; Fabricated Metal Products; Petroleum Refining; and Ferrous Metals. Low-technology industries are Paper Printing; Clothing and Textiles; Food, Beverages and Tobacco; as well as Wood and Furniture.

9.2 Value addition in manufacturing industry

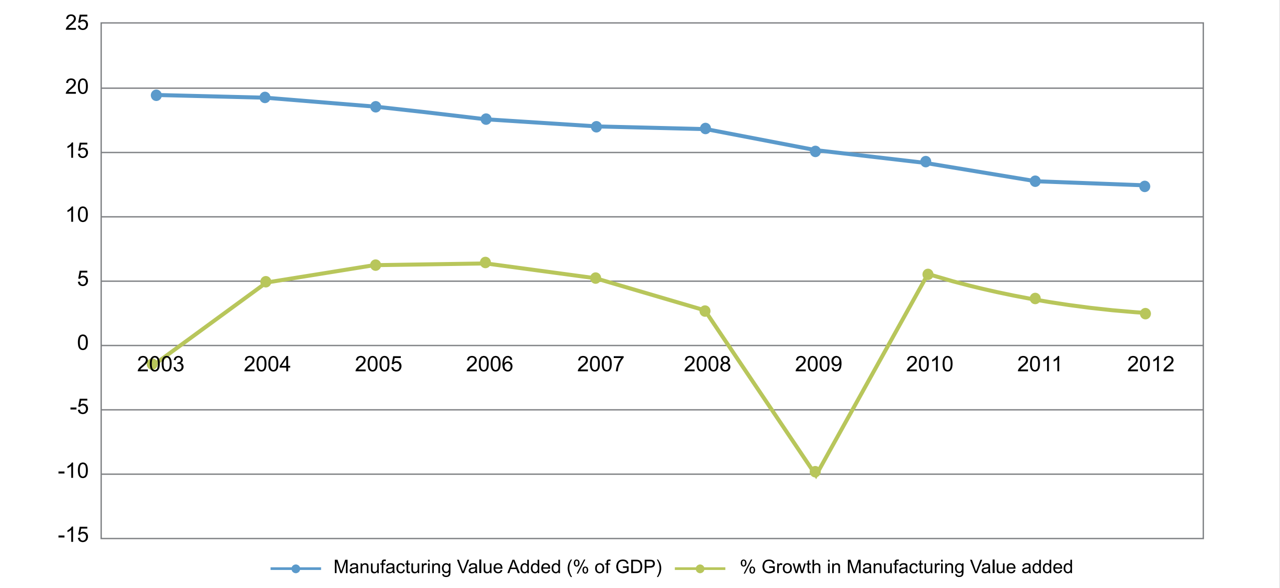
South Africa's manufacturing industry experienced a steady decline in manufacturing value added as a percentage of GDP between 2003 and 2012. This decline has increased dramatically since 2009, a trend that is reflected in other global economies such as the United States. The fall in the contribution of manufacturing value added to South Africa's GDP is the result of an inconsistent and declining percentage growth in manufacturing value added, as shown in figure 24.

Table 30: Performance of SA Manufacturing Industry

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Manufacturing Value Added (% of GDP)	19.4	19.2	18.5	17.5	17.0	16.8	15.2	14.2	12.8	12.4
% Growth in Manufacturing Value Added	-1.5	4.9	6.2	6.4	5.2	2.6	-10.1	5.5	3.6	2.4

Source: *The World Bank "World Development Indicators"*

Figure 24: Trends in Manufacturing Value Added



The poor contribution of South Africa's manufacturing value added to GDP is not unique, as can be seen in table 31; South Africa's position is comparable to that of Brazil, the United Kingdom and the United States.

Table 31: Benchmarking of Manufacturing Value Added as % of GDP (2012 or Most Recent Year)

South Africa	Brazil	China	India	Russia	Japan	United Kingdom	United States
12	13	30	14	16	19	11	13

Source: *The World Bank "World Development Indicators"*

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

10. QUALITY OF LIFE

Quality of life is one of the high level goals stipulated by the NRDS and is useful as a key component in the measurement of the performance of the NSI. It is directly influenced by technological improvement and innovation as well as by growing SET human capital. It is indirectly influenced by the performance of key industrial sectors through another high level goal, i.e. wealth creation. Technical progress improves the quality of life in different ways such as by the discovery of new vaccines, technological interventions to enable women to take on jobs traditionally done by men, and stimulation of key industries that result in accelerated economic growth and reductions in unemployment.

A transformation in SET human capital demography assists in the reduction of income and expenditure inequalities. An increase in researchers per available workforce also means the improvement of school life expectancy, which in its turn enhances the adult literacy rate. The literate and higher earning population is better equipped to make life decisions that will reduce the possibility of homicides. Wealth creation by key industrial sectors leads to high GDP per capita.

Table 32: Comparative Analysis of Quality of Life Indicators (2012 or Most Recent Year)

Indicator	South Africa	Brazil	Russia	India	China	Japan	United Kingdom	United States
HIV/AIDS Prevalence Rate (% ages 15 - 49)	17.8	0.5	1.0	0.3	0.1	0.1	0.2	0.6
Prevalence of HIV, Female (% ages 15 - 24)	11.9	0.1	-	-	-	0.1	0.1	0.2
Prevalence of HIV, Male (% ages 15 - 24)	5.3	0.1	-	-	-	0.1	0.1	0.3
ARVs Coverage (%)	66	71	-	-	-	-	-	-
Life Expectancy at Birth: Total (years)	59	73	69	66	75	83	81	79
Life Expectancy at birth: female (years)	61	77	75	68	76	86	83	81
Life Expectancy at Birth: Male (years)	57	70	63	64	74	79	79	76
Crime: Homicides per 100 000 Inhabitants	32	21	10	3	1	-	1	5
Income Inequality (Gini Index)	69.0	54.7	40.1	33.9	42.1	-	-	-
Unemployment Rate (%)	24.7	8.3	6.6	3.5	4.1	4.5	7.8	8.9
Adult Literacy Rate (%)	81	90	100	63	95	99	99	99
GDP per Capita (PPP dollar)	11 440	11 909	23 504	3 876	9 233	35 178	36 901	49 965

Sources: *CIA "World Factbook"; UNDP "Human Development Indicators"; the World Bank "World Development Indicators"; the Presidency "Development Indicators 2012"*

South African quality of life indicators are benchmarked against other BRICS countries and Japan, the United Kingdom and the United States, as reflected in table 32. Some progress has been made in terms of improvement in life expectancy and an increase in ARVs coverage to combat HIV/AIDS. The GDP per capita is competitive relative to the BRICS countries although there is high income inequality in South Africa, as evidenced by the high unemployment rate.

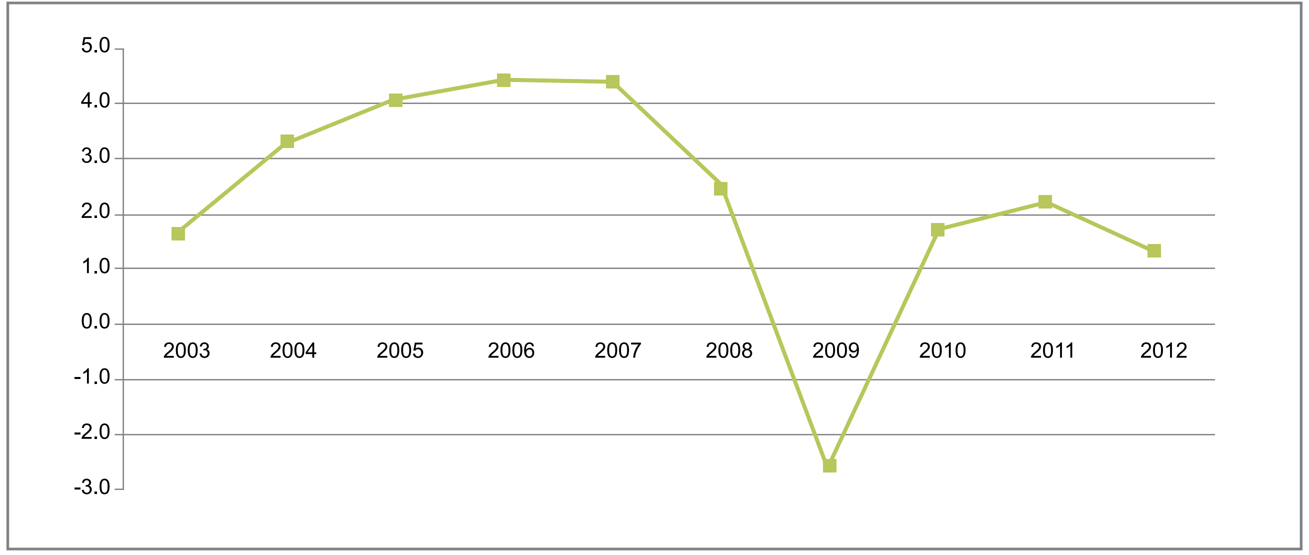
Although South Africa's GDP per capita is higher than that of India and China and comparable to that of Brazil, its growth reached a peak in 2007, collapsing with the start of the global economic recession. Growth was negative in 2009, followed by a revival in GDP per capita growth in 2010 and 2011; it slowed again in 2012, as shown in table 33 and figure 25.

Table 33: Real GDP per Capita Growth (2000 Constant Prices)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
% Growth in GDP per Capita	1.6	3.3	4.1	4.4	4.4	2.5	-2.6	1.7	2.2	1.3

Source: *The World Bank "World Development Indicators"*

Figure 25: Real GDP per Capita Growth



Explanatory note: Real GDP per capita growth is the annual growth of the size of the economy divided by the size of the population and adjusted for price changes and inflation.

One of the government's 2009 – 2014 Medium Term Strategic Framework (MTSF) objectives is to ensure a more equitable distribution of the benefits of economic growth and to reduce inequality. As indicated in table 34, income inequalities are declining slowly from the Gini coefficient of 0.72 in 2005, 0.70 in 2009 to 0.69 in 2010. Although this is promising and indicative of some success of the combined interventions by government and the private sector, South Africa's inequality is still the greatest among the BRICS countries.

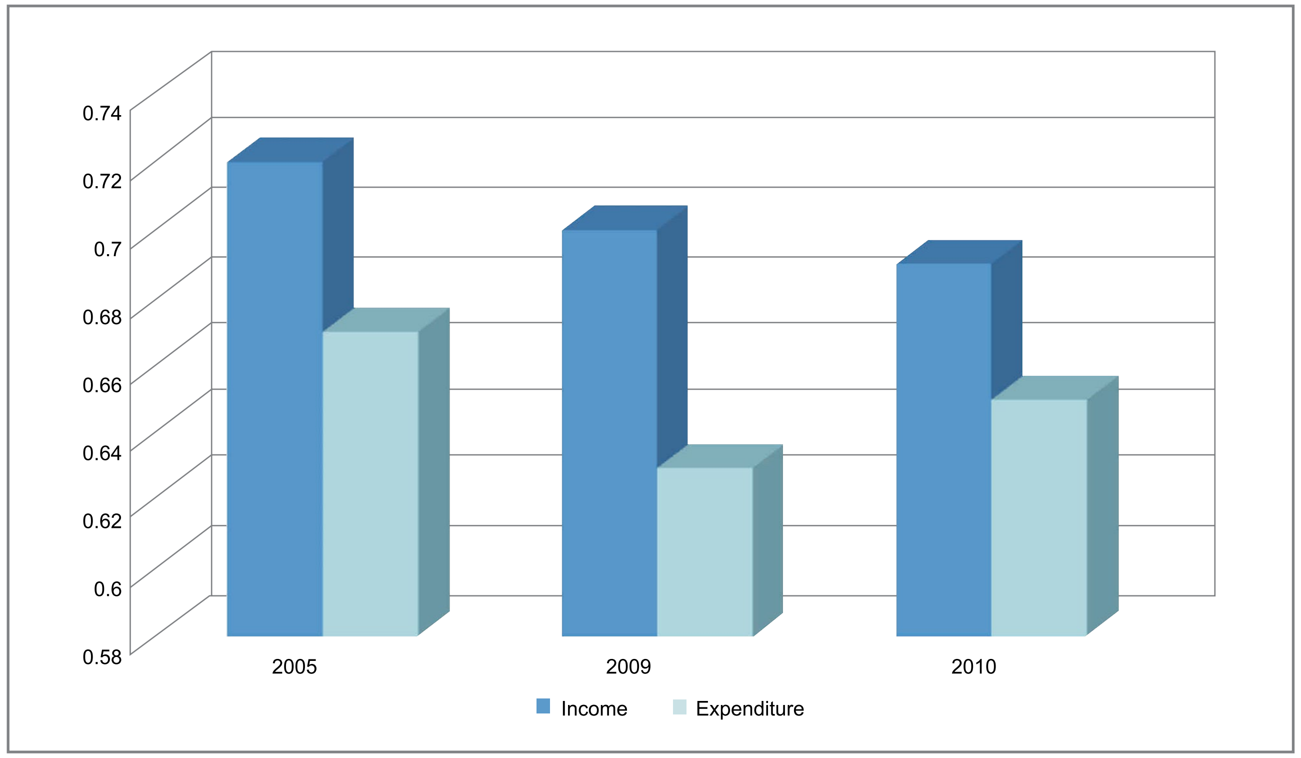
Table 34: Income and Expenditure Inequality: SA Gini Coefficient

Year	Income	Expenditure
2005	0.72	0.67
2009	0.70	0.63
2010	0.69	0.65

Source: *The Presidency "Development Indicators 2012"*

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

Figure 26: Income and Expenditure Inequality as Measured by the Gini Coefficient



Explanatory note: Income and expenditure inequality refers to the extent of the disparity between high income and low income households. The Gini coefficient measures the inequality as a proportion of its theoretical maximum. It can range from 0 (no inequality) to 1 (complete inequality). The expenditure values do not include taxes while the income values include wages, social grants and salaries at constant 2011 prices.

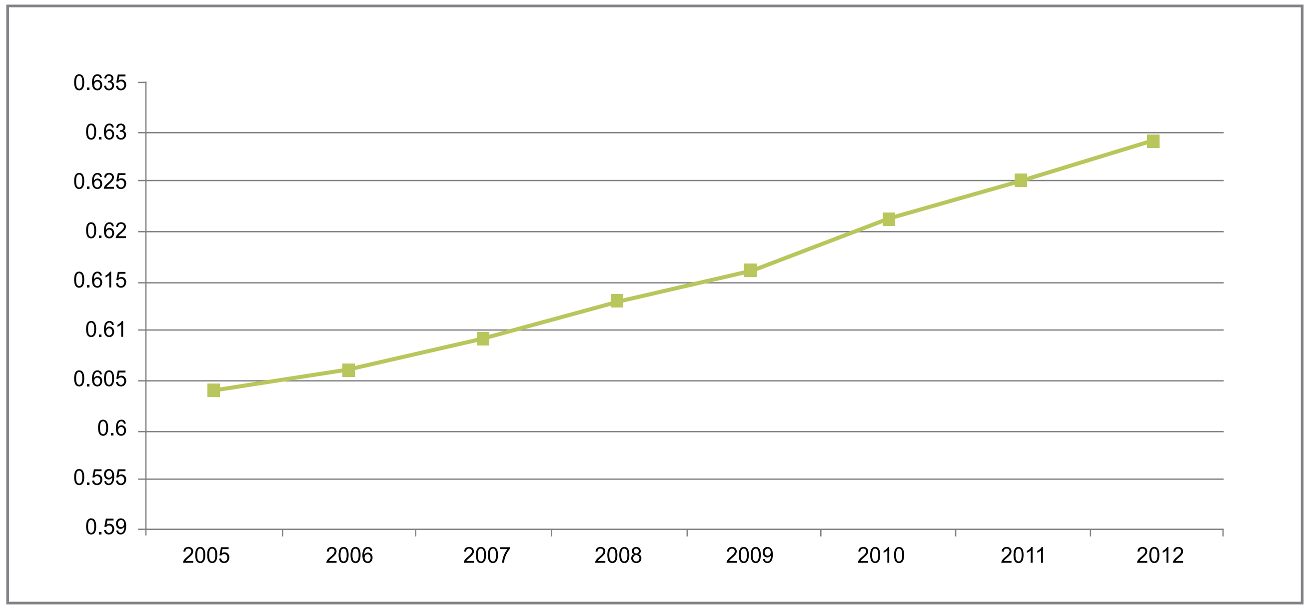
The South African Human Development Index (HDI) is growing yearly although the average annual percent growth between 2000 and 2012 was only 0.11%. This is much lower than most BRICS countries, with India seeing relatively the highest growth of 1.5%, followed by China (1.42%), Russia (0.84%) and Brazil (0.73%). For the same period, the medium human development countries (the category into which South Africa falls) experienced an annual growth of 1.29% while Sub-Saharan Africa had an average annual growth of 1.34%. In the year 2012, South Africa ranked 121st out of more than 200 countries. Brazil, Russia, India and China were ranked 85th, 55th, 136th and 101st respectively.

Table 35: SA Human Development Index (HDI)

Year	2005	2006	2007	2008	2009	2010	2011	2012
Human Development Index	0.604	0.606	0.609	0.613	0.616	0.621	0.625	0.629

Source: *UNDP "Human Development Indicators"*

Figure 27: SA Human Development Index



***Source:** UNDP "Human Development Indicators, UNDP*

The main challenge facing South Africa remains the low life expectancy at birth, although the negative trend is gradually reversing. Education is the greatest contributor to the country's HDI score owing to relatively more expected years of schooling (13.1 in 2012). GNI per capita is the second highest contributor to South Africa's HDI score. Some challenges facing quality of life in South Africa, as revealed by the 2013 Human Development Report, are the high prevalence rate of HIV among young females, high maternal mortality rates (300 deaths per 100 000 live births in 2010), the high percentage of youth unemployment (55%) and high homicides rates.

Explanatory note: The Human Development Index (HDI) is a summary measure of three dimensions of human development: health– leading a long and healthy life, measured by life expectancy at birth; education– being knowledgeable, measured by adult literacy and school enrolment; and income– having a good standard of living, measured by GDP per capita.

11. WEALTH CREATION

As is illustrated in table 36, most of the turnover and value addition in South Africa's manufacturing industry comes from medium and low-technology intensive industries, with a contribution of 41.6% and 38.2% respectively. The profit margin of 4.3% is, however, lowest in these industries. The high-technology sector has the highest profit margin (6.3%), while the largest contribution in turnover, value-added and profit margin is made by the pharmaceuticals industry. This industry has the highest profit margin in the South African manufacturing industry (11.0%), followed by recycling and other manufacturing (10.1%), non-electrical machinery (7.1%) and electrical machinery (6.8%). Industries with negative profit margins include shipbuilding (-3.9%) and aerospace (-1.1%). Overall, the profit margin for the South African manufacturing industry in 2011 was 5.0%.

Table 36: Profit Performance for SA Manufacturing Industry, 2011

	Value-Added	Turnover	Net Profit After Tax	Profit Margin
	R million			%
High -Technology	15 271	43 359	2 718	6,3
Medium High-Technology	117 260	476 542	29 063	6,1
Medium Low-Technology	152 632	665 334	28 343	4,3
Low- Technology	114 795	414 971	19 853	4,8
Total Manufacturing	**399 958**	**1 600 206**	**79 977**	**5.0**

***Source:** computed by NACI from StatsSA "2011 Manufacturing Industry: Financial"*

The high-technology manufacturing industry is dominated by a few large enterprises with an income contribution of 5, 10 and 20, the largest companies being 62%, 72% and 82%. On average, the five largest enterprises in South Africa earn 50% of the total manufacturing income.

Table 37: Income Generation in SA Manufacturing Industry, 2011

	Total Income	Income of 5 Largest Enterprises	Income of 10 Largest Enterprises	Income of 20 Largest Enterprises
	R million	% Income Distribution		
High -Technology	45 314	62	72	82
Medium High-Technology	491 890	57	71	79
Medium Low-Technology	688 854	61	73	78
Low-Technology	452 179	27	37	49
Total Manufacturing	**1 678 236**	**50**	**62**	**71**

***Source:** computed by NACI from StatsSA "2011 Manufacturing Industry: Financial"*

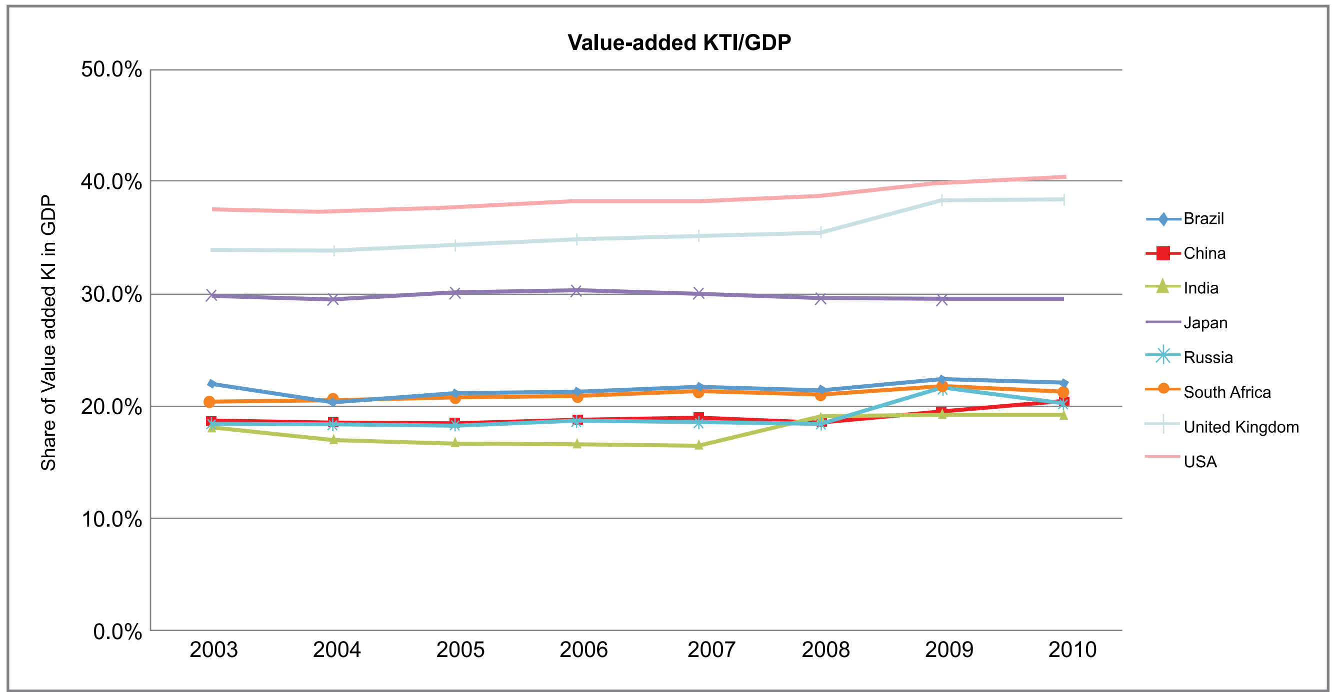
South Africa's value added by knowledge and technology intensive industries as a percentage of GDP is competitive among the BRICS countries, being second only to Brazil. This growth was consistent over the 2003 – 2010 period (except in 2008) although it has taken place at a relatively slow pace. TYIP has set targets of approximately 30% of economic growth being attributable to technical progress and more than 50% of national income being derived from knowledge-based industries.

Table 38: Value Added by Knowledge and Technology Intensive Industries as Percentage of GDP

Countries	2003	2004	2005	2006	2007	2008	2009	2010
Brazil	22.0	20.4	21.1	21.2	21.7	21.4	22.3	22.0
China	18.6	18.5	18.4	18.7	18.9	18.6	19.4	20.4
India	18.1	16.9	16.6	16.6	16.5	19.0	19.2	19.3
Japan	29.8	29.5	30.0	30.2	30.0	29.5	29.4	29.6
Russia	18.4	18.3	18.3	18.7	18.5	18.4	21.7	20.2
South Africa	20.3	20.5	20.7	20.9	21.3	21.0	21.8	21.3
United Kingdom	33.9	33.9	34.3	34.8	35.2	35.4	38.3	38.4
USA	37.5	37.2	37.6	38.1	38.1	38.5	39.9	40.3

***Source:** tabled for NACI by Quantitative Evidence Research Consultancy*

Figure 28: Value Added by Knowledge and Technology-Intensive Industries



Explanatory note: Technology intensive industries are high-technology manufacturing industries as classified by the OECD, viz.: Aerospace; Pharmaceuticals; Computers, Accounting and Office Machinery; Communication Electronics; and Scientific and Professional Instruments. Knowledge intensive industries are Communications; Business Services; Financial Services; Communication Services; Educational Services; and Health Services.

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

12. LIST OF FIGURES

13. LIST OF TABLES

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

14. LIST OF ACRONYMS

ASSAf	Academy of Science for South Africa
BERD	Business Expenditure on Research and Development
BRICS	Brazil, Russia, India, China and South Africa
CeSTII	Centre for Science, Technology and Innovation Indicators
CESM	Classification of Educational Subject Matter
CIA	Central Intelligence Agency
DHET	Department of Higher Education and Training
DST	Department of Science and Technology
DTI	Department of Trade and Industry
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
GII	Global Innovation Index
GNI	Gross National Income
HDI	Human Development Index
HEI	Higher Education Institution
HG	Higher Grade
HRDSA	Human Resource Development Strategy of South Africa
IBSS	International Bibliography of Social Sciences
ICT	Information and Communication Technology
IDC	Industrial Development Corporation
IP	Intellectual Property
ISI	Institute for Scientific Information
MTSF	Medium Term Strategic Framework
NACI	National Advisory Council on Innovation
NDP	National Development Plan
NIPF	National Industry Policy Framework
NRDS	National Research and Development Strategy
NRF	National Research Foundation
NSI	National System of Innovation
OECD	Organisation for Economic Cooperation and Development
PCT	Patent Cooperation Treaty
PDIs	Previously Disadvantaged Individuals
PPD	Product Process Development
PPP	Purchasing Power Parity
R&D	Research and Development
S&T	Science and Technology
SARChi	South African Research Chairs Initiative
SET	Science, Engineering and Technology
SG	Standard Grade
SITC	Standard International Trade Classification
SPII	Support Programme for Industrial Innovation
StatsSA	Statistics South Africa
THRIP	Technology and Human Resources for Industry Programme
TIA	Technology Innovation Agency
TYIP	Ten Year Innovation Plan
UKZN	University of KwaZulu-Natal
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Office

APPENDIX A

NACI, in partnership with the Academy of Science of South Africa (ASSAf), undertook this study during the 2013/14 financial year in order to assess the science, technology and innovation indicators that determine the health of the NSI and to identify gaps in the available data. These indicators were grouped into five categories and complement the traditional R&D focused indicators that are still equally important. Table A1 indicates whether the suggested indicator represents input or output for the NSI. This work will be refined further through stakeholder consultations and evidence-based studies.

Table A1: Summary of New Proposed Innovation Indicators

Category	Proposed New Indicators	Input/ Output
Knowledge Demand	Knowledge and technology intensity of manufactured goods	Output
	Contribution to the manufacturing trade balance	Output
	Foreign student population in higher education	Output
	Employment of tertiary level graduates	Output
Knowledge Mobilisation	Participation in lifelong learning	Input
	Education system resources	Input
	Access to ICTs	Input
Knowledge Application	Licensing of patents	Output
	Entrepreneurship	Output
	Economic impact of innovations	Output
Knowledge Flows	Foreign direct investment networks	Input
	Innovation networks	Input & Output
	International flows of human resources	Output
Social Impact	Social cohesion	Input & Output
	Social impact of innovations	Output
	Innovation in the public sector	Input & Output

SOUTH AFRICAN SCIENCE AND TECHNOLOGY INDICATORS

NOTES

NOTES

NOTES

Private Bag X894, Pretoria, 0001, South Africa
Email: naci@dst.gov.za, Website: www.naci.org.za , Tel: +27 (0) 12 844 0252, Fax: +27 (0) 12 844 0957

NATIONAL ADVISORY COUNCIL ON INNOVATION