SOUTH AFRICAN SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS - *2015*

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REPUBLIC OF SOUTH AFRICA

NACI
NATIONAL ADVISORY COUNCIL ON INNOVATION

innovation
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Acronyms

ARC	Agricultural Research Council
BRIC	Brazil, Russian Federation, India and China
BRICS	Brazil, Russian Federation, India, China and South Africa
CESM	Classification of Educational Subject Matter
CSIR	Council for Scientific and Industrial Research
DHET	Department of Higher Education and Training
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GNI	Gross National Income
HDI	Human Development Index
HRDSA	Human Resource Development Strategy of South Africa
HSRC	Human Sciences Research Council
IT	Information Technology
MRC	Medical Research Council
NACI	National Advisory Council on Innovation
NDP	National Development Plan
NECSA	South African Nuclear Energy Corporation
NGO	Non-Government Organisation
NPO	Non-Profit Organisation
NRF	National Research Foundation
NSC	National Senior Certificate
NSI	National System of Innovation
NZ	New Zealand
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
R&D	Research and Development
RCA	Revealed Comparative Advantage
RTA	Revealed Technology Advantage
SA	South Africa
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
SDGs	Sustainable Development Goals
SET	Science, Engineering and Technology
STI	Science, Technology and Innovation
TIMMS	Trends in International Mathematics and Science Study
UNCTAD	United Nations Conference on Trade and Development
UNCTADstat	United Nations Conference on Trade and Development Statistical Database
UNISA	University of South Africa
USA	United States of America
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Foreword by Prof Cheryl de la Rey
NACI Chairperson

On behalf of the National Advisory Council on Innovation (NACI) I am delighted to present the annual report on the 2015 South African Science, Technology and Innovation (STI) Indicators. This publication is part of our contribution to building the monitoring, evaluation and learning capability necessary for assessing the health of the National System of Innovation (NSI).

Compared to previous publications, the 2015 South African STI Indicators report focuses more on international comparisons against which South Africa can benchmark its progress in innovation. Comparisons are made with countries such as Japan, South Korea, the United Kingdom, the United States and the BRIC group of countries (Brazil, Russia, India and China). This benchmarking exercise aims to stimulate debate and identify issues that need to be addressed for South Africa to be a knowledge-driven economy. Other new aspects in this 2015 publication include indicators of South African universities' performance in knowledge generation, inter-sectoral research collaboration and co-authorships and research prioritisation.

It is important to note that although there have been improvements, South Africa still experiences STI data related challenges. In an attempt to address some of these challenges, NACI has identified a number of interventions or initiatives such as the development of an Innovation Scorecard for South Africa and the development of a National Science, Technology and Innovation Information Portal.

The reader is reminded that the earlier version of the booklet published in 2014 is still a useful reference in certain instances because it included a significant amount of data which is not necessarily repeated in this current version.

Without delving into the details, the 2015 STI indicators publication indicates overall progress in some areas and a lack of progress in other areas. For instance, the science, engineering and technology research capacity development pipeline and research and development investment as a proportion of the Gross Development Product (GDP) remain serious challenges.

I sincerely hope that NSI stakeholders (including policy makers, the private sector and non-government organisations), the public and the international community will find this 2015 STI indicators publication informative, clear and useful.

Acknowledgements

The South African Science, Technology and Innovation Indicators booklet is produced annually by the National Advisory Council on Innovation using data that is collected from a wide range of data sources. The data is then analysed to provide critical information on the status and progress of the NSI towards meeting the country's set national objectives.

NACI wishes to acknowledge the technical inputs, expert guidance and leadership of the project leader, Dr Azar Jammine, as well as contributions from the project team members Ms Louisa Zondo, Ms Zanele Monnakgotla and Ms Claire Busetti, who are all also members of the NACI Council.

Prof Anastassios Pouris is thanked for the valuable expert advice he provided during the conceptualisation and development of this booklet.

NACI Secretariat members involved in the project are Dr Mlungisi Cele, Mr Petrus Letaba, Ms Rudzani Maila and Mr Thabo Mosenthal. The role they played as well as their invaluable contributions throughout the project is greatly acknowledged.

Lastly, the cooperation of the following institutions and their officials who were of great assistance to NACI during the data collection processes is highly appreciated: the Department of Science and Technology, Department of Higher Education and Training, Department of Basic Education and the Human Science Research Council's Centre for Science, Technology and Innovation Indicators. All data sources are acknowledged in detail throughout the various sections of the booklet.

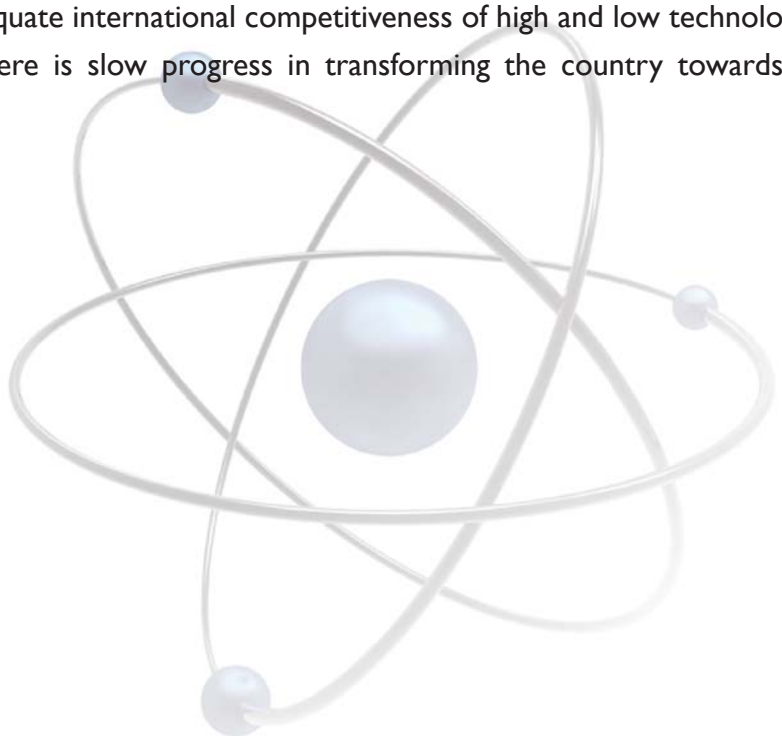
Key Highlights

The South African system of innovation needs to respond to the triple challenge of unemployment, poverty and inequality through value-adding activities such as human capital development, research and development (R&D) and technical progress. It is geared towards enhancing business growth through innovation, wealth creation through economic growth and thereby bringing about an improvement in the quality of life. These activities combine all the efforts from the government, business sector, universities, science councils, not-for-profit organisations, international partners, etc.

NACI has adopted the logical indicator framework suggested within the 2012 National Research and Development Strategy to monitor the health of the South African NSI. The performance of South Africa's NSI is also benchmarked against the BRIC group of countries (Brazil, Russia, India and China), Japan, South Korea, the United Kingdom and the United States.

The Science, Engineering and Technology (SET) research capacity development pipeline for South Africa is insufficient, as indicated by the decreased proportion of SET enrolments and graduations. In addition to the shortage of SET human capital, the country spends a relatively low proportion of its Gross Domestic Product (GDP) on R&D although there is meaningful progress in terms of the number of scientific publications. Unfortunately, much of the growth in scientific publications is not in the Natural Sciences, Engineering and Technology, the scientific fields that seem to be the priority of innovation-driven economies.

South Africa produces relatively few innovations in both the high and low technology sectors (e.g. paper and textile machinery). The export performance of the country, as categorised by technology intensiveness, also indicates the inadequate international competitiveness of high and low technology manufacturers which implies that there is slow progress in transforming the country towards a knowledge-based economy.



International benchmarking of South Africa's NSI performance (recent years)

Performance Indicator	South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Future R&D Capacity									
SET enrolments (%)	29.6	33.9	_	42.6	_	34.7	47.1	40.8	31.3
SET Human Capital									
SET graduations (%)	30.0	28.2	35.1	_	_	35.9	46.6	39.0	34.4
Current R&D Capacity									
General Expenditure on R&D (% of GDP)	0.73	1.15	1.13	0.82	2.01	3.47	4.15	1.66	2.74
Natural Sciences publications (% of world share)	0.82	2.69	3.25	4.96	21.34	5.86	3.83	6.66	23.77
Engineering and Technology publications (% world share)	0.50	2.04	2.05	5.31	24.84	4.99	5.82	4.75	18.20
Social Sciences publications (% world share)	1.36	1.36	0.48	0.93	4.77	1.57	1.86	12.96	39.22
Medical and Health Sciences publications (% world share)	0.68	3.04	0.55	2.43	10.54	5.70	3.35	8.47	33.11
Agricultural Sciences publications (% world share)	1.01	9.14	0.47	5.14	13.20	4.73	3.54	4.15	18.45
Humanities publications (% world share)	1.46	1.05	1.12	0.43	1.68	0.81	1.07	13.94	34.29
Technical Progress									
FDI Outflow (% world share)	0.512	0.261	4.167	0.727	8.565	8.390	2.256	4.403	24.879
Technology receipts per GDP (%)	0.033	0.016	0.036	0.032	0.009	0.800	0.365	0.669	0.748
Imported Know-How									
Technology payments per GDP (%)	0.495	0.074	0.431	0.237	0.203	0.455	0.735	0.368	0.242
% World share of FDI Inflow	0.465	5.088	1.706	2.802	8.446	0.157	0.87	5.881	14.688
Business Performance									
High technology manufactured exports (% world share)	0.10	0.28	0.28	0.78	21.30	3.74	4.66	2.73	8.22
Medium technology manufactured exports (% world share)	0.50	0.81	0.78	1.07	10.85	7.18	4.72	3.28	10.01

Low technology manufactured exports (% world share)	0.25	0.48	0.59	2.78	29.29	2.24	2.16	1.96	5.02
Resource-based manufactured exports (% world share)	0.84	2.15	4.84	3.49	5.98	2.02	2.89	2.24	9.37
Primary product exports (% world share)	0.61	2.41	7.44	1.30	2.05	0.45	0.40	1.66	5.28
Wealth Creation									
Agriculture Value-Added (% of GDP)	2.6	5.6	4.2	17.8	9.2	1.2	2.3	0.7	1.4
Manufacturing Value-Added, Excl. Manufacturing (% of GDP)	13.9	10.9	15.6	17.1	35.9	18.5	30.3	10.6	12.4
Industry value-added (% of GDP)	14.6	12.5	20.2	13.0	6.8	7.7	7.9	10.4	8.1
Services value-added (% of GDP)	68.9	71.0	60.0	52.1	48.1	72.6	59.4	78.4	78.1
Labour force participation rate (%)	57.1	56.0	68.9	52.5	70.7	59.5	62.4	62.7	62.9
Unemployment rate (%)	25.1	4.8	5.1	3.6	4.7	3.7	3.5	6.3	6.2
Quality of life									
Life expectancy at birth (years)	57.4	74.5	70.1	68.0	75.8	83.5	81.9	80.7	79.1
GNI per Capita (2011 PPP $)	12 122	15 175	22 352	5 497	12 547	36 927	33 890	39 267	52 947
Human Development Index	0.666	0.755	0.798	0.609	0.727	0.891	0.898	0.907	0.915

1. Future and R&D Capacity

The NDP articulates the building of national capabilities through quality early childhood development, schooling, college, university and adult education and training programmes. The new sustainable development goals (SDGs) also seek to ensure inclusive and quality education for all and promote lifelong learning through targets such as ensuring that there is equal access for all women and men to affordable and quality technical, vocational and tertiary education (including university education). In this section of the booklet, the pass rates for the National Senior Certificate (NSC) in Mathematics and Physical Science at different percentage levels are analysed and a further analysis is conducted on SET enrolments in higher education.

1.1 NSC Pass Rate for Mathematics and Physical Science

Table 1.1 shows the total number of individuals with an NSC pass over the period 2008-2015 as well as the number of NSC passes with Mathematics and Physical Science over the same period.

Table 1.1: NSC Passes with Mathematics and Physical Science

	2008	2009	2010	2011	2012	2013	2014	2015
Total NSC Passes	344 794	339 114	364 513	348 117	377 829	349 779	403 874	455 825
Mathematics Passes (> 40%)	89 186	85 491	81 473	67 592	80 707	97 786	79 048	84 296
% Females who Passed Mathematics at > 40%	48.4	48.3	48.3	46.2	47.5	48.2	47.2	46.5
Mathematics Passes (> 50%)	62 388	52 866	50 195	41 586	51 231	63 151	50 365	53 588
% Females who Passed Mathematics at > 50%	47.9	47.4	47.3	44.8	46.0	46.4	45.3	44.3
Mathematics Passes (> 60%)	41 667	31 786	30 543	24 577	30 355	37 782	30 782	31 811
% Females who Passed Mathematics at > 60%	47.8	46.6	46.5	43.8	44.8	44.4	43.6	43.1
Physical Science Passes (> 40%)	61 480	45 531	60 943	61 128	70 074	78 676	62 031	69 698
% Females who Passed Physical Science at > 40%	46.5	45.9	47.8	46.3	48.1	48.9	47.7	48.2
Physical Science Passes (> 50%)	32 524	22 329	37 853	37 106	43 639	47 030	37 749	42 433
% Females who Passed Physical Science at > 50%	46.5	45.7	46.5	44.4	46.2	45.9	45.3	45.8
Physical Science Passes (> 60%)	16 620	10 308	22 759	21 840	25 640	26 467	22 116	24 611
% Females who Passed Physical Science at > 60%	47.3	45.9	45.9	43.9	44.6	43.4	43.4	43.8

Source: Department of Basic Education

Between 2014 and 2015, there was a 13% increase in the number of learners who passed the NSC. During the same period, the number of learners who achieved a 50% pass in Physical Science increased by 12% which was more than that for Mathematics (6%). In order to realise the objectives of the National Development Plan (NDP), more passes of at least 50% in Mathematics and Physical Science are required. Moreover, Mathematics and Physical Science are critical subject requirements for higher education SET qualification enrolments.

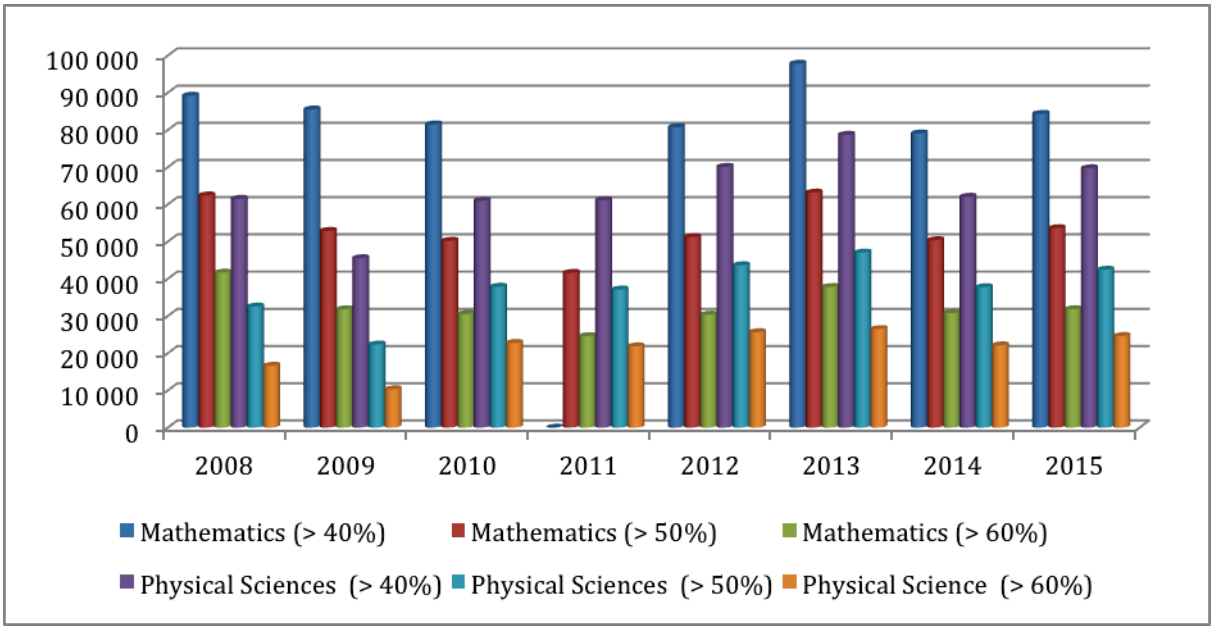


Figure 1.1: Trends in the Number of Learners Passing Matric Mathematics and Physical Science

1.2 SET Enrolments

When looking at enrolments across the various South African public higher education institutions (table 1.2 and figure 1.2), SET constitutes more than 25% of enrolments at the majority of the institutions, except for the University of South Africa (UNISA) (11.9% in 2014), the University of Zululand (18.8%) and North West University (19.8%), etc. The highest SET enrolment rate is at Sol Plaatjie University (63.7%), followed by Mangosuthu University of Technology (61.2%) and Vaal University of Technology (53.5%).

As the percentage proportion of UNISA enrolments (33.9%) compared to the total public higher education enrolments is very high, its low SET enrolment rate weighs heavily on the total SET enrolments (29.6% in 2014).

Table 1.2: Public Higher Education SET Enrolments by Institution, 2014

Institution	Total Enrolments	SET Enrolments	% SET Enrolments
Cape Peninsula University of Technology	33 186	16 329	49.2
University of Cape Town	26 357	11 397	43.2
Central University of Technology	14 352	6 301	43.9
Durban University of Technology	26 472	12 954	48.9
University of Fort Hare	13 063	3 496	26.8
University of the Free State	31 032	8 935	28.8
University of Johannesburg	49 789	15 745	31.6
University of KwaZulu-Natal	45 465	17 884	39.3

University of Limpopo	23 384	11 914	50.9
Mangosuthu University of Technology	11 377	6 960	61.2
Nelson Mandela Metropolitan University	26 510	9 413	35.5
North West University	63 135	12 483	19.8
University of Pretoria	56 376	25 840	45.8
Rhodes University	7 519	2 303	30.6
University of South Africa	328 491	39 252	11.9
University of Stellenbosch	28 869	13 927	48.2
Tshwane University of Technology	56 785	22 878	40.3
University of Venda	13 497	4 963	36.8
Vaal University of Technology	19 319	10 328	53.5
Walter Sisulu University	23 946	7 147	29.8
University of Western Cape	20 582	7 794	37.9
University of the Witwatersrand	32 721	15 737	48.1
University of Zululand	16 663	3 126	18.8
Sol Plaatjie University	124	79	63.7
University of Mpumalanga	140	40	28.6
Total	969 154	287 221	29.6

Source: DHET "Higher Education Information Management System"

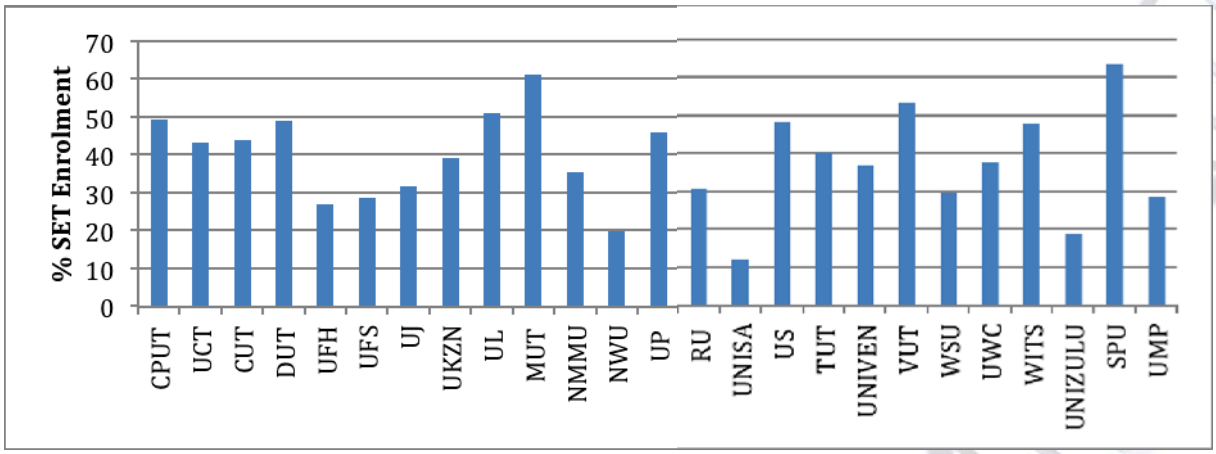


Figure 1.2: Percentage of SET Enrolments at Public Higher Education Institutions, 2014

As table 1.3 and figure 1.3 show, the SET enrolments at South African public higher education institutions is relatively lower compared to that of countries such as India (42.6%) and Brazil (33.9%). South Africa has a relatively high level of enrolments in the Education field (17.1% in 2014).

Table 1.3: Benchmarking South African Percentage of University Enrolments (recent years)

	South Africa	Brazil	India	Japan	South Korea	United Kingdom	United States
SET	29.6	33.9	42.6	34.7	47.1	40.8	31.3
Social Sciences, Business and Commerce and Humanities	53.3	44.3	53.3	48.9	47.1	46.6	48.9
Education	17.1	18.9	4.1	7.6	5.8	8.0	8.4
Unspecified	-	2.9	-	8.8	-	4.6	11.4

Source: World Economic Forum "Human Capital Report 2015"

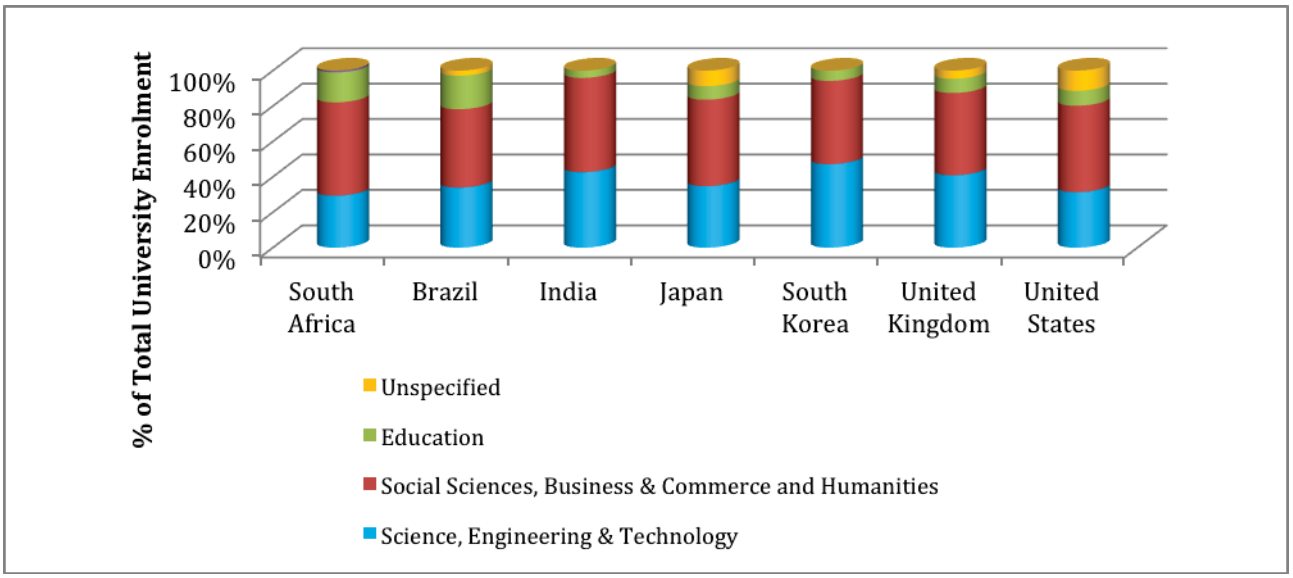


Figure 1.3: Distribution of University Enrolments by Field of Study

South Africa faces the challenge of low quality education in subjects such as Mathematics and Science as indicated by South Africa's poor performance in international benchmarking tests such as the

2. SET Human Capital

Trends in International Mathematics and Science Study (TIMMS) and the Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) study. The Human Resource Development Strategy of South Africa (HRDSA) targets a top ten ranking for South Africa in terms of the level of human capital stock, as indicated by the number of engineers, artisans, medical doctors and doctoral students per 100 000 population. This chapter analyses the number of SET graduations and R&D researchers.

2.1 SET Graduations

Over the past ten years, there has been a gradual increase in the total number of SET graduations as well as the proportion of female SET graduates, with females accounting for at least 50% of these graduations since 2013 (table 2.1.). In 2014, the largest proportion of total SET graduations was at the undergraduate level (30.6%). Postgraduate completion rates in SET, as a proportion of the total postgraduate completion rate, are also increasing. The slight increase in postgraduate SET graduations between 2013 (27.7%) and 2014 (28.3%) is encouraging following the slight decline from 29.9% to 27.7% experienced between 2012 and 2013.

Table 2.1: Higher Education SET Graduations

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of Total SET Graduations	33 506	33 542	36 429	39 306	41 511	42 760	46 099	48 848	53 176	55 574
% Undergraduate SET Graduations	28.9	29.3	29.5	29.9	28.7	27.6	28.6	29.6	30.1	30.6
% Postgraduate SET Graduations	24.9	26.1	26.4	27.6	29.4	28.7	28.9	29.1	27.7	28.3
% Total SET Graduations	27.8	28.5	28.8	29.4	28.9	27.9	28.7	29.4	29.4	30.0
% Female SET Graduations	48.9	48.7	49.2	49.5	49.3	49.1	49.4	49.4	50.0	50.2

Source: DHET "Higher Education Information Management System"

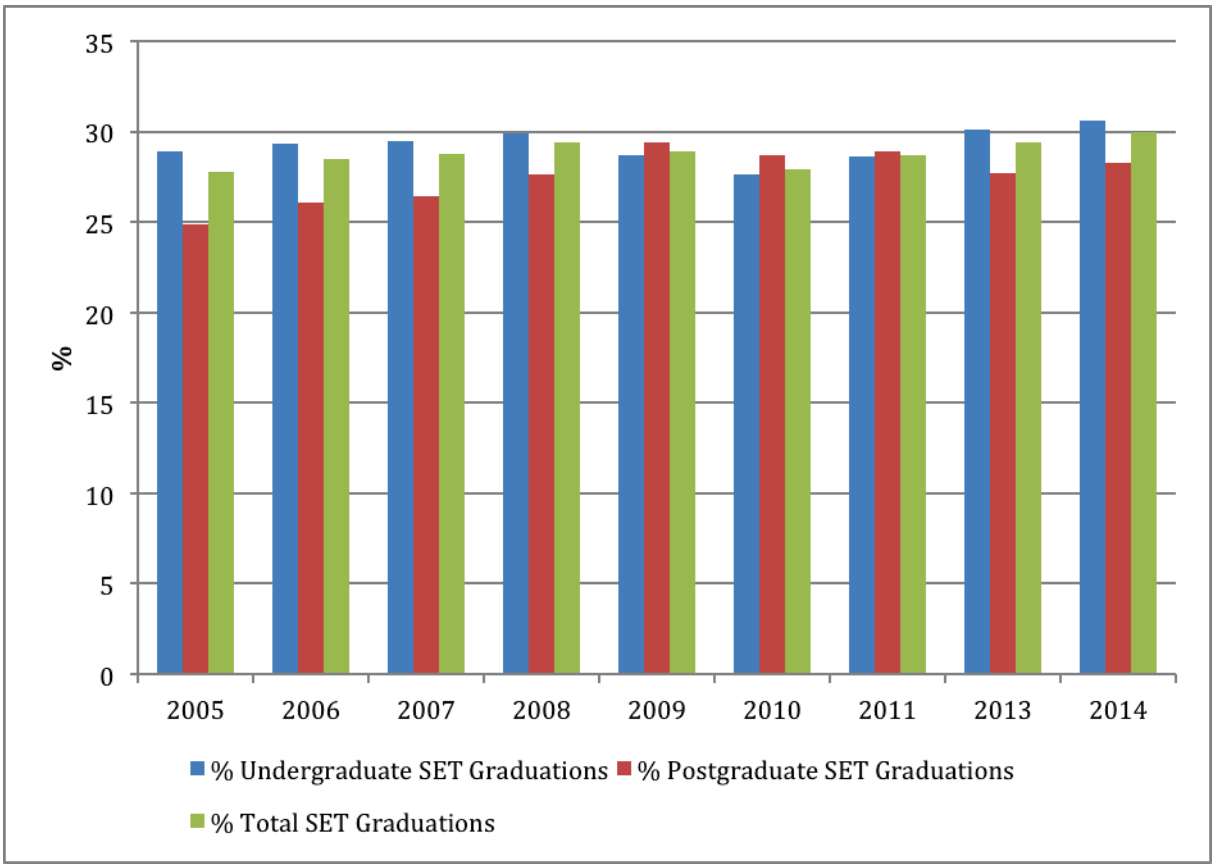


Figure 2.1: Trends in Percentage SET Graduations

International benchmarking of South Africa's SET graduation levels is similar to that of SET enrolments. A low proportion of all graduations are in SET in comparison to countries such as South Korea (46.6%) and the United Kingdom (39.0%) but higher than that of Brazil (28.3%). In contrast, as table 2.2 and figure 2.2 show, the proportion of graduations in the Education field is comparably very high (20.0%), similar to the enrolments.

Table 2.2: Benchmarking of South African Percentage of University Graduations (recent years)

	South Africa	Brazil	Russia	Japan	South Korea	United Kingdom	United States
Science, Engineering & Technology	30.0	28.2	35.1	35.9	46.6	39.0	34.4
Social Sciences, Business & Commerce and Humanities	50.0	46.2	54.0	50.2	46.0	49.9	56.1
Education	20.0	20.1	9.2	7.2	7.4	10.2	9.5
Unspecified	-	5.5	1.7	6.7	-	0.9	-

Source: World Economic Forum "Human Capital Report 2015"

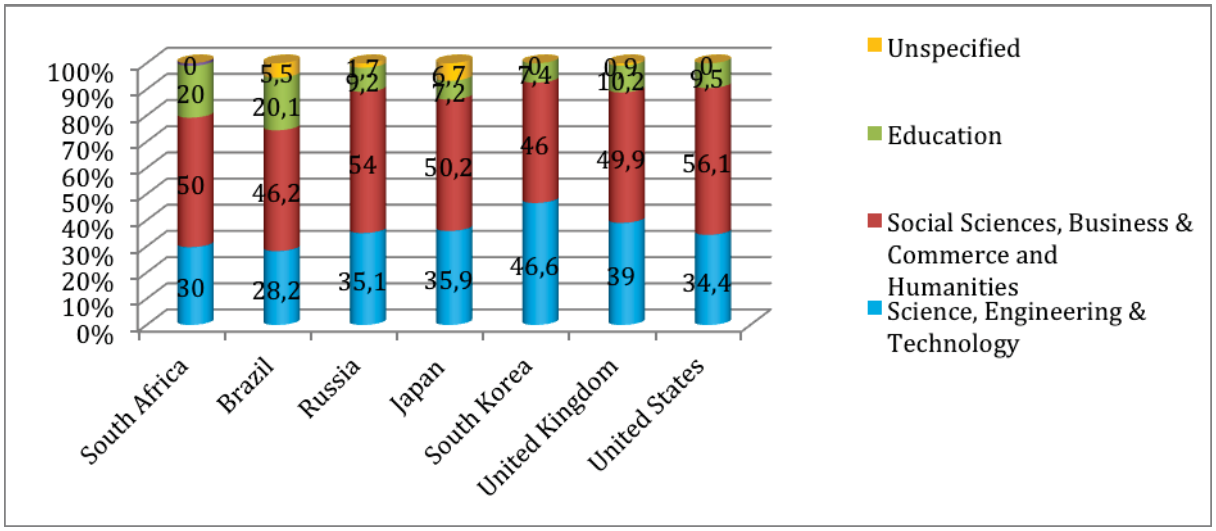


Figure 2.2: Distribution of University Graduations by Fields of Study

Table 2.3 indicates the number of doctoral degrees that were awarded by South African universities between 2010 and 2014. Over the past five years, there has been a steady increase in the absolute number of SET doctoral degrees awarded. These are also seen to constitute a relatively large proportion of total doctoral degrees awarded (27.1% in 2014), followed by Humanities (24.9%) and Life Sciences (22.0%). The increasing level of SET doctoral degrees being awarded indicates the establishment of a solid pool of researchers which is critical in building NSI research capacity. However, it should also be said that there was an impressive increase in doctoral degrees awarded in other fields besides SET. In fact, the proportion of SET doctoral degrees awarded declined from 28.5% in 2010 to 27.1% in 2014.

Table 2.3: Doctoral Degrees Awarded by South African Universities

	2010	2011	2012	2013	2014
SET[1]	406	469	505	580	612
Life Sciences, Health Professions and Related Clinical Sciences	320	372	465	478	496
Business and Commerce	106	129	162	159	193
Humanities[2]	357	355	437	475	562
Social Sciences	95	99	109	143	166
Education	137	152	200	216	229
Total	1 421	1 576	1 878	2 051	2 258

Source: DHET "Higher Education Information Management System"

1 Excluding CESM 09 and 13 (Health Professions & Related Clinical Sciences and Life Sciences)
2 Excluding CESM 20 (Social Sciences)

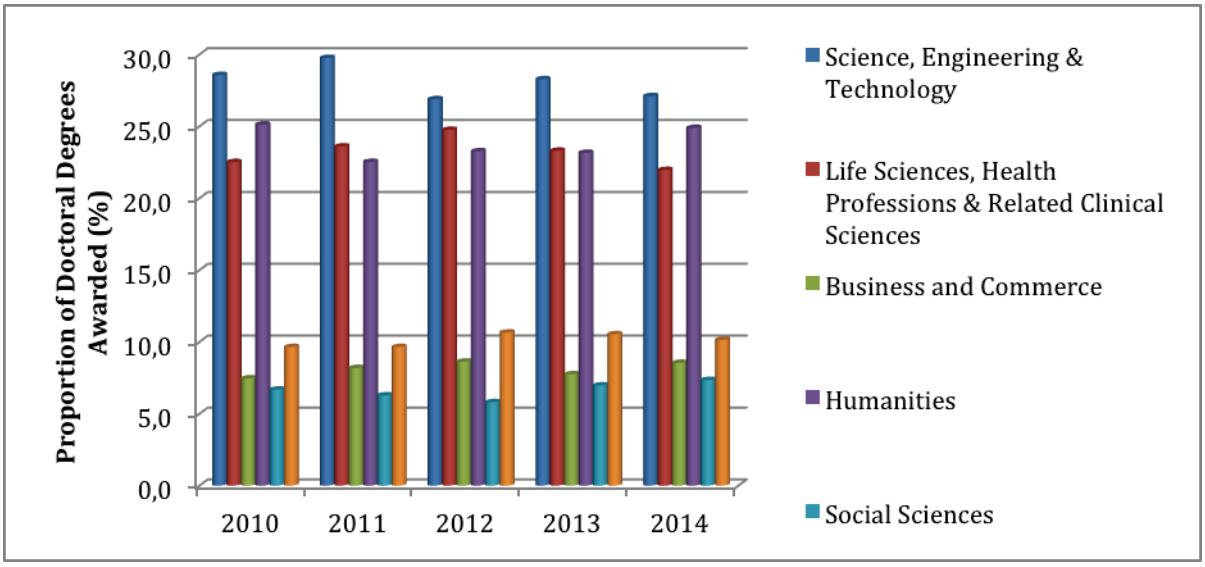


Figure 2.3: Trend in Proportion of Doctoral Degrees Awarded by Field of Study

In terms of racial distribution, the majority of SET doctoral degrees are now being awarded to Africans (table 2.4 and figure 2.4) and this proportion continues to increase. The first year in which the number of SET doctoral degrees awarded to Africans exceeded that of whites was 2013 and this is encouraging from a transformational viewpoint bearing.

Table 2.4: SET Doctoral Degrees Awarded in South African Public Universities by Population Group

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
African	172	156	164	193	254	275	326	410	461	525
Coloured	28	16	36	32	41	41	41	49	53	51
Indian	43	40	43	52	48	55	72	80	88	85
White	317	309	345	296	357	354	408	436	452	437

Source: DHET "Higher Education Information Management System"

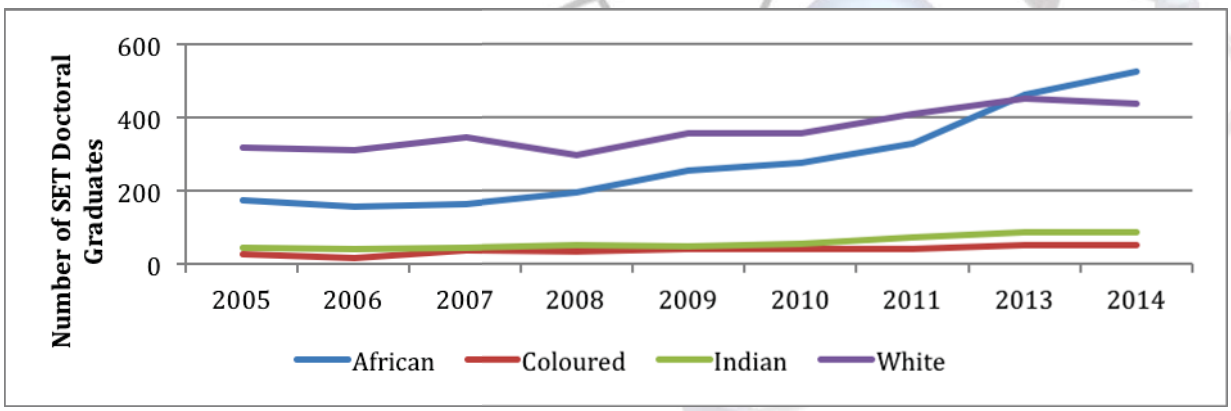


Figure 2.4: Trend in SET Doctoral Degrees Awarded by Population Group

2.2 Researchers in R&D

It is deduced from the data in table 2.5 and illustrated in figure 2.5 below that by far the largest proportion of all researchers are to be found in the higher education sector (65.0% in 2013/14). This is followed by considerably smaller proportions for the business sector (22.1%), science councils (7.0%) and government (4.4%). Most researchers in the higher education and business sectors are white (54.7% and 68.2% respectively), in contrast to the demographics of new doctoral SET graduations in which Africans have become the majority. Good progress towards transformation within the NSI has been achieved by the government and science councils, as the proportion of African researchers is much higher relative to the number of white researchers in these institutions. The gender balance in these institutions is also quite favourable compared with the business sector where white males dominate.

Table 2.5: Number of Researchers in Headcounts by Population Group and Gender, 2013/14

	African		Coloured		Indian		White		
	Male	Female	Male	Female	Male	Female	Male	Female	Total
Business	580	494	146	133	339	276	2 830	1 384	6 182
Higher Education	3 349	2 156	543	601	803	800	5 041	4 919	18 212
Government	251	248	51	64	34	65	250	266	1 229
Science Councils	467	334	52	56	63	104	519	361	1 956
Not-for-Profit	71	74	14	25	18	28	99	106	435

Source: Department of Science and Technology "National Survey of Research and Development, 2013/14"

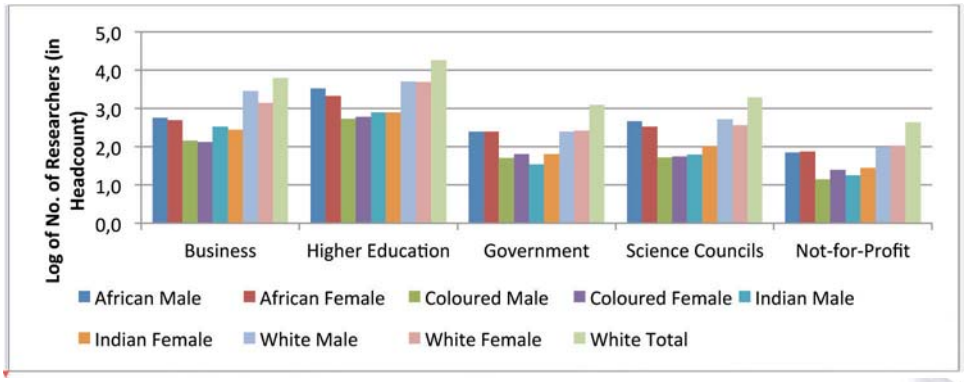


Figure 2.5: Trend in Number of Researchers by Population Group and Gender, 2013/14

3. Current R&D Capacity

According to the NDP, research and innovation by universities, science councils, departments, non-government organisations (NGOs) and the private sector have a key role to play in improving South Africa's global competitiveness. Coordination between these different role players is suggested as one of the fundamental issues needing attention. In this section, an analysis is conducted on the level of R&D funding and expenditure. Data on scientific publications shows the activity of South African researchers in major research fields. The knowledge networks section shows trends in both local and international scientific research collaboration.

3.1 R&D Funding and Expenditure

As figure 3.1 shows, the highest source of R&D funding in 2013/14 was government (42.9%), followed by the business sector (41.4%). A large proportion of government funded R&D expenditure goes to the higher education sector (48.8%) while only 6.2% goes to the business sector in the form of direct and indirect R&D funding.

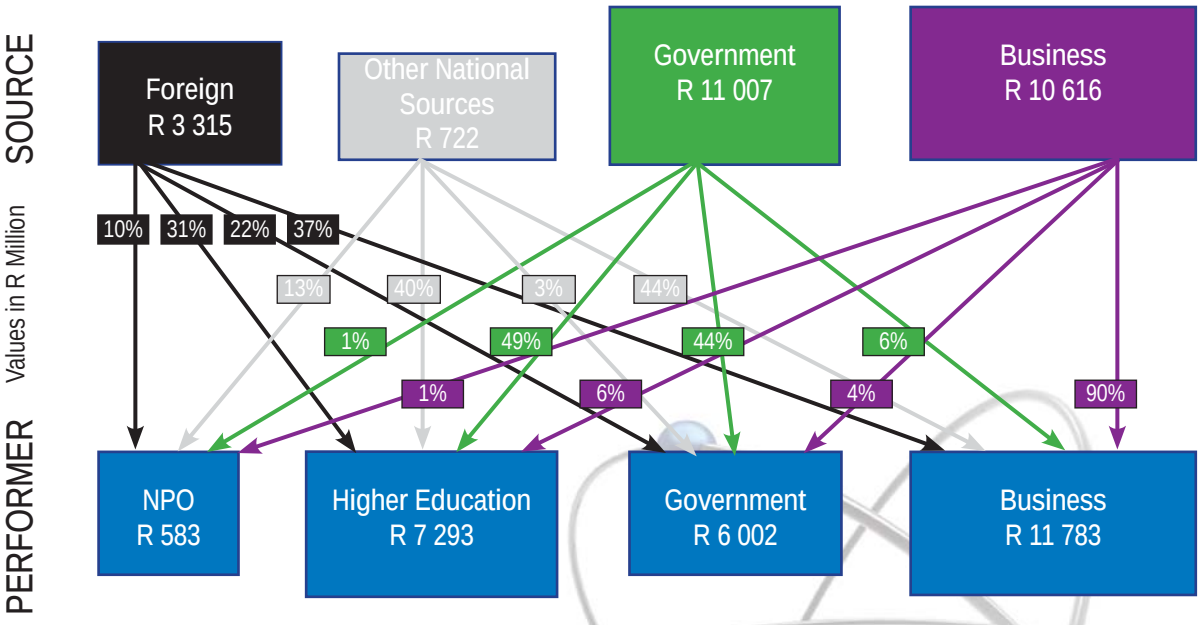


Figure: 3.1: R&D Funding and Expenditure by Sector
Source: Department of Science and Technology "National Survey of Research and Development, 2013/14"

On the other hand, the business sector accounts for the largest proportion of the country's R&D expenditure (45.9%), followed by the higher education sector (28.4%).

As table 3.1 shows, a high proportion of R&D expenditure is on Natural Sciences research (30.5% in 2013/14), followed by Engineering and Technology (25.2%), Medical and Health Sciences (18.2%), Social Sciences (17.5%), Agricultural Sciences (8.6%) and Humanities (2.3%). The research fields in which the proportion of R&D expenditure has grown most significantly since 2005/06 are the Social Sciences (from 9.8% to 17.5%, an increase of 7.7%), followed by Medical and Health Sciences (up 3.4% from 14.8% to 18.2%). Over the same period, the proportion of R&D expenditure devoted to Engineering and Technology has declined by 6.5% (from 31.7% to 25.2%) and that of Natural Sciences has declined by 3.9% (from 34.4 to 30.5%). This is somewhat disturbing for those hoping to see the rising numbers of SET graduates translating into more research spending in these disciplines.

Table 3.1: Proportion of R&D Expenditure by Research Field

	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Natural Sciences	34.4	34.3	34.5	33.7	33.2	33.3	33.8	30.6	30.5
Engineering and Technology	31.7	31.9	32.3	33.5	30.2	28.4	26.5	25.8	25.2
Medical and Health Sciences	14.8	15.1	14	14.9	16.7	17.1	17.2	17.2	18.2
Agricultural Sciences	6.8	6.9	6.8	5.5	6.9	6.5	7.7	7.6	8.6
Social Sciences	9.8	9.4	9.7	9.6	10.7	12.4	12.6	16.8	17.5
Humanities	2.5	2.4	2.7	2.8	2.3	2.3	2.2	2	2.3

Source: Department of Science and Technology "National Survey of Research and Development, 2012/13"

As table 3.2 shows, in 2013/14 a very high proportion of business R&D expenditure was in the services sector (47.4%), followed by the manufacturing sector (32.2%). However, given that services dominate the South African economy as a proportion of its GDP, the services sector's R&D expenditure as a percentage of value-added is very low (0.26%) compared to that of the manufacturing sector (0.90%).

Table 3.2: Business R&D Expenditure in Different Sectors, 2013/14

	R&D Expenditure (R million)	R&D Expenditure as % of Sector Value-Added
Agriculture, Hunting, Forestry and Fishing	364	0.50
Industry, Excl. Manufacturing	2 039	0.39
Manufacturing	3 793	0.90
Services	5 586	0.26
Total	11 782	0.37

Source: Department of Science and Technology "National Survey of Research and Development, 2012/13"; value-added data from World Development Indicators

As table 3.3 shows, South Africa's R&D expenditure as a percentage of GDP is very low (0.74% in 2003), especially in comparison to other services-dominated economies such as Brazil (1.15% in 2012), Japan (3.47%), the United Kingdom (1.66%) and the United States (2.74%). Among the BRICS group of countries, South Africa also has the lowest GDP R&D expenditure, having been overtaken by India in 2010. The revised target for the country is a 1.5% GDP R&D expenditure by 2019. Most of the R&D expenditure for countries with high R&D intensity is sourced from industry (75.33% in the case of South Korea, 77.26% for Japan and 60.85% for the United States).

Table 3.3: Benchmarking of R&D Expenditure as a Percentage of GDP

	South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
2006	0.90	0.99	1.07	0.80	1.38	3.41	2.83	1.65	2.55
2007	0.88	1.08	1.12	0.79	1.38	3.46	3.00	1.68	2.63
2008	0.89	1.13	1.04	0.84	1.46	3.47	3.12	1.69	2.77
2009	0.84	1.12	1.24	0.82	1.68	3.36	3.29	1.74	2.82
2010	0.74	1.16	1.13	0.80	1.73	3.25	3.47	1.69	2.74
2011	0.73	1.14	1.09	0.82	1.79	3.38	3.74	1.69	2.76
2012	0.73	1.15	1.13	-	1.93	3.34	4.03	1.62	2.70
2013	0.73	-	1.13	-	2.01	3.47	4.15	1.66	2.74

Source: OECD "Main Science and Technology Indicators", Brazil and India data from UNESCO Institute of Statistics

3.2 Knowledge Generation

The number of South African scientific publications continues to grow rapidly, resulting in South Africa's global publication share rising from 0.51% in 2005 to 0.81% in 2014 (table 3.4 and figure 3.2). Taking into account the fact that in 2014 the South African population accounted for 0.75% of the total world population, a 0.81% share in global scientific publication is satisfactory. There has also been a dramatic growth in the number of citations relative to global levels between 2013 and 2014 from an index value of 1.03 to 1.74. An index value of 1 indicates that the number of citations is in line with the global average. Hence, an index value of 1.74 indicates that South Africa's citation rate is significantly more than the world average.

Table 3.4: Total Number of South African Scientific Publications

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of Publications	4 797	5 447	6 120	6 900	7 589	8 165	9 486	10 250	10 980	12 071
% World Share of Publications	0.51	0.55	0.58	0.61	0.64	0.67	0.73	0.75	0.76	0.81
Citations Relative to the World	0.92	0.91	0.83	0.93	0.91	0.99	0.94	1.04	1.03	1.74

Source: Thomson Reuters "InCites"

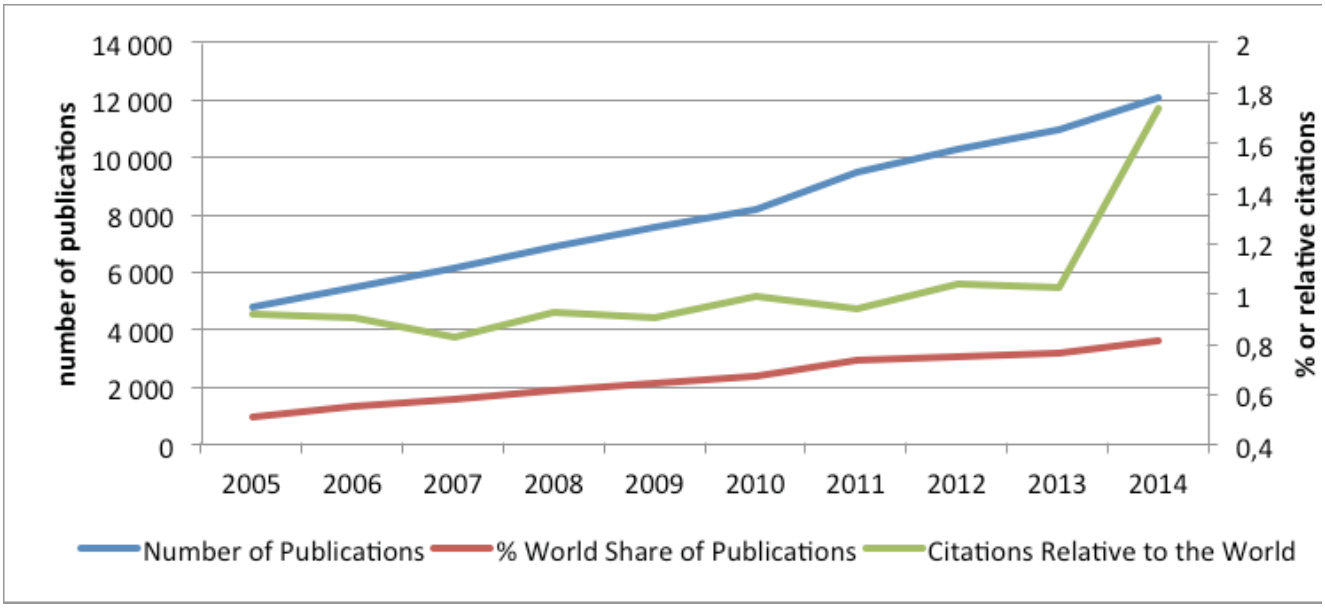


Figure 3.2: Trends in South African Scientific Publications and Citations

Table 3.5 shows that the Natural Sciences contributed most to the large increase in citations relative to the global average in 2014. Citations from Natural Sciences publications increased from 1.05 in 2013 to 2.21 in 2014. Although Natural Sciences publications have the largest share of total South African publications (49.70% in 2014), this proportion has been in decline from the high of 55.39% in 2006.

On a positive note, this decline in the national share does not reflect a decline in the performance of Natural Sciences. In fact, the actual number of Natural Sciences publications increased from 3 017 in 2006 to 5 999 in 2014. This resulted in an increase in the global share of publications in the Natural Sciences for South Africa from 0.56% in 2006 to 0.82% in 2014. In contrast, the substantial increase in R&D expenditure for Social Sciences has resulted in a rapid increase in scientific publications in this field from a world share of 0.74% in 2005, to 1.03% in 2009 and 1.36% in 2014.

The implications of declining R&D investment in Engineering and Technology are visible in terms of the low growth in its percentage of global scientific publications from 0.47% in 2011 to 0.50% in both 2013 and 2014. The country's share of Engineering and Technology publications also decreased slightly from 15.90% in 2007 to 15.03% in 2014. In 2014, the Humanities field had the lowest national share of publications (4.75%) but performed the best in terms of its global share (1.46%).

Table 3.5: Scientific Publications in Various Scientific Fields

	Natural Sciences				Engineering and Technology			
	No. of Publications	% World Share	% Country Share	Citations Relative to the World	No. of Publications	% World Share	% Country Share	Citations Relative to the World
2005	2 653	0.52	55.31	0.94	755	0.38	15.74	0.95
2006	3 017	0.56	55.39	0.95	864	0.41	15.86	0.74
2007	3 211	0.59	52.47	0.87	973	0.43	15.90	0.78
2008	3 446	0.61	49.94	0.96	955	0.39	13.84	0.81
2009	3 819	0.65	50.32	0.98	1 064	0.41	14.02	0.85
2010	4 033	0.67	49.39	0.98	1 284	0.47	15.73	0.85
2011	4 762	0.74	50.20	0.95	1 440	0.48	15.18	0.78
2012	5 117	0.76	49.92	1.02	1 483	0.48	14.47	0.72
2013	5 524	0.78	50.31	1.05	1 715	0.50	15.62	0.86
2014	5 999	0.82	49.70	2.21	1 814	0.50	15.03	0.81

	Medical and Health Sciences				Agricultural Sciences			
2005	1 262	0.41	26.31	1.11	362	0.83	7.55	1.11
2006	1 330	0.41	24.42	1.09	408	0.86	7.49	0.91
2007	1 618	0.47	26.44	1.04	427	0.80	6.98	0.98
2008	1 854	0.50	26.87	1.24	488	0.83	7.07	0.92
2009	1 930	0.49	25.43	1.14	587	0.96	7.73	0.82
2010	2 149	0.53	26.32	1.37	585	0.93	7.16	0.92
2011	2 345	0.55	24.72	1.26	695	1.04	7.33	0.89
2012	2 780	0.61	27.12	1.41	659	0.95	6.43	0.88
2013	2 968	0.62	27.03	1.28	774	1.10	7.05	0.92
2014	3 320	0.68	27.50	1.38	704	1.01	5.83	1.00

	Social Sciences				Humanities			
2005	495	0.74	10.32	0.73	216	1.08	4.50	0.95
2006	645	0.88	11.84	0.62	232	1.10	4.26	0.63
2007	742	0.90	12.12	0.59	345	1.49	5.64	0.77
2008	977	1.01	14.16	0.60	463	1.60	6.71	1.16
2009	1 103	1.03	14.53	0.60	480	1.46	6.32	1.04
2010	1 240	1.11	15.19	0.76	456	1.32	5.58	1.14
2011	1 377	1.13	14.52	0.57	528	1.44	5.57	0.79
2012	1 521	1.21	14.84	0.67	487	1.30	4.75	1.37
2013	1 564	1.18	14.24	0.75	522	1.32	4.75	1.85
2014	1 847	1.36	15.30	0.71	570	1.46	4.72	1.36

Source: Thomson Reuters "InCites"

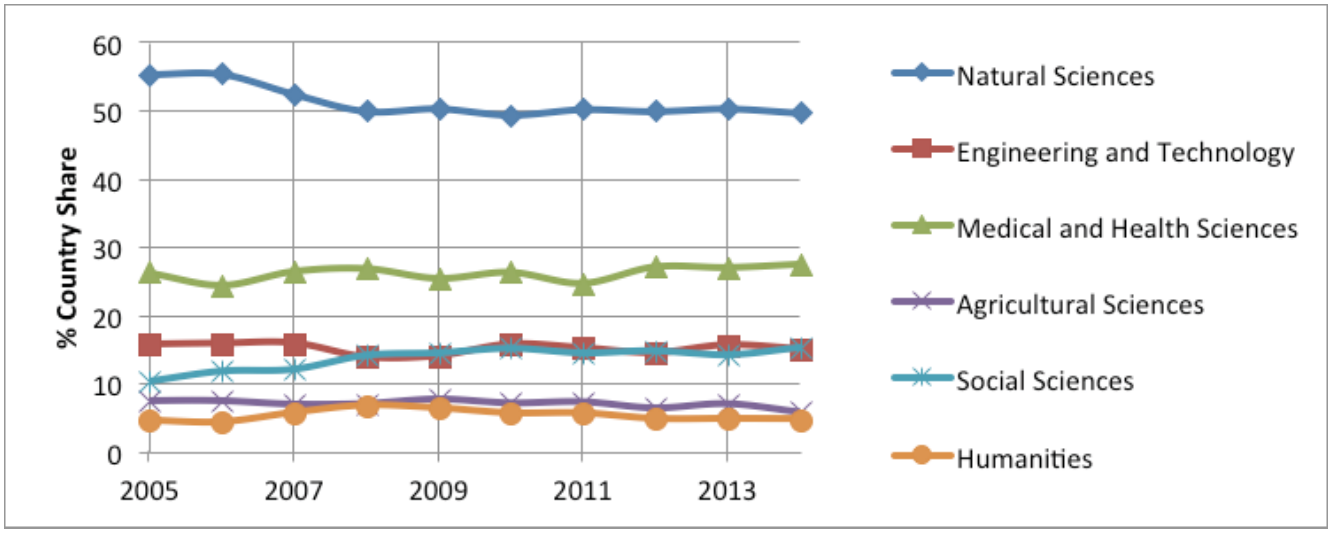


Figure 3.3: Trend in National Share of South African Scientific Publications in Various Scientific Fields

Table 3.6 further shows that the Physical Sciences and Astronomy specifically contributed to this extraordinary increase in citations relative to the global average. South African publications in this field are cited about seven times more than the world average. Physical Sciences and Astronomy publications contribute to 9.14% of the country's total publications and 0.65% of the total global publications in the Natural Sciences. Out of all Natural Sciences publications in 2014, at least 41% of these were in Biological Sciences. As one paper can focus on different scientific areas, the total of all Natural Sciences publications in table 3.6 (6 468) is different to the one shown in table 3.5 (5 999).

Table 3.6: Scientific Publications in Various Natural Sciences Research Areas, 2014

	No. of Publications	% World Share	% Country Share	Citations Relative to the World
Mathematics	537	0.81	4.45	1.00
Computer and Information Sciences	129	0.28	1.07	0.62
Physical Sciences and Astronomy	1 103	0.65	9.14	6.84
Chemical Sciences	1 039	0.53	8.61	0.79
Earth and Related Environmental Sciences	1 144	1.18	9.48	1.07
Biological Sciences	2 464	1.09	20.41	1.03
Other Natural Sciences	52	1.14	0.43	0.47

Source: Thomson Reuters "InCites"

The international benchmarking of scientific publications in various fields should take into account the differences in the structures of economies. Like South Africa, Brazil, Japan, the United Kingdom and the United States are service-oriented economies and their prioritisation of scientific research provides some guidance for South Africa.

Table 3.7 shows that the country's share of Engineering and Technology scientific research (15.03% in 2014) is very similar to that of the United Kingdom (15.36%), the United States (16.59%) and Brazil (17.91%) but much lower than Japan (23.06%). South Korea and the BRIC group of countries have the largest country or territory share of scientific publications in Engineering and Technology (38.21% and 32.71% respectively). The highest contribution to the BRIC value is from China (36.17%) and India (32.97%).

South Africa's global competitiveness in terms of the number of citations relative to the rest of the world is highest in Natural Sciences publications. This is followed by citations in the Medical and Health Sciences and then the Humanities (table 3.7 and figure 3.4). The United Kingdom has relatively high citations in Agricultural Sciences (1.62) and is very competitive in other areas as is the case with the United States.

Table 3.7: International Benchmarking of Scientific Research Prioritisation, 2014

	Natural Sciences				Engineering and Technology			
	No. of Publications	% World Share	% Country Share	Citations Relative to the World	No. of Publications	% World Share	% Country Share	Citations Relative to the World
South Africa	5 999	0.82	49.70	2.21	1 814	0.50	15.03	0.81
BRIC	235 144	32.24	62.03	0.87	123 974	34.24	32.71	0.96
Brazil	19 635	2.69	47.55	0.68	7 395	2.04	17.91	0.85
Russia	23 726	3.25	76.85	0.93	7 433	2.05	24.07	0.65
India	36 183	4.96	62.04	0.99	19 229	5.31	32.97	0.97
China	155 600	21.34	62.60	0.91	89 917	24.84	36.17	0.99
Japan	42 743	5.86	54.61	1.03	18 051	4.99	23.06	0.95
South Korea	27 928	3.83	50.70	0.89	21 048	5.82	38.21	0.90
United Kingdom	48 545	6.66	43.40	1.33	17 184	4.75	15.36	1.20
United States	173 318	23.77	43.65	1.25	65 876	18.20	16.59	1.19

	Medical and Health Sciences				Agricultural Sciences			
South Africa	3 320	0.68	27.50	1.38	704	1.01	5.83	1.00
BRIC	80 295	16.56	21.18	0.84	19 522	27.95	5.15	0.82
Brazil	14 741	3.04	35.70	0.74	6 385	9.14	15.46	0.47
Russia	2 687	0.55	8.70	1.15	327	0.47	1.06	0.88
India	11 760	2.43	20.16	0.77	3 591	5.14	6.16	0.76
China	51 107	10.54	20.56	0.79	9 219	13.20	3.71	1.09
Japan	27 634	5.70	35.30	0.93	3 306	4.73	4.22	0.74
South Korea	16 234	3.35	29.47	0.83	2 473	3.54	4.49	0.79
United Kingdom	41 075	8.47	36.72	1.29	2 897	4.15	2.59	1.62
United States	160 539	33.11	40.43	1.20	12 880	18.45	3.24	1.18

	Social Sciences				Humanities			
South Africa	1 847	1.36	15.30	0.71	570	1.46	4.72	1.36
BRIC	10 198	7.54	2.69	0.94	1 675	4.95	0.44	0.64
Brazil	1 841	1.36	4.46	0.88	410	1.05	0.99	0.45
Russia	644	0.48	2.09	0.56	438	1.12	1.42	0.36
India	1 260	0.93	2.16	0.82	169	0.43	0.29	0.36
China	6 453	4.77	2.60	1.03	658	1.68	0.26	0.82
Japan	2 122	1.57	2.71	0.88	317	0.81	0.40	0.91
South Korea	2 511	1.86	4.56	0.68	419	1.07	0.76	1.00
United Kingdom	17 541	12.96	15.68	1.26	5 452	13.94	4.87	1.36
United States	53 082	39.22	13.37	1.15	13 410	34.29	3.38	1.18

Source: Thomson Reuters "InCites"

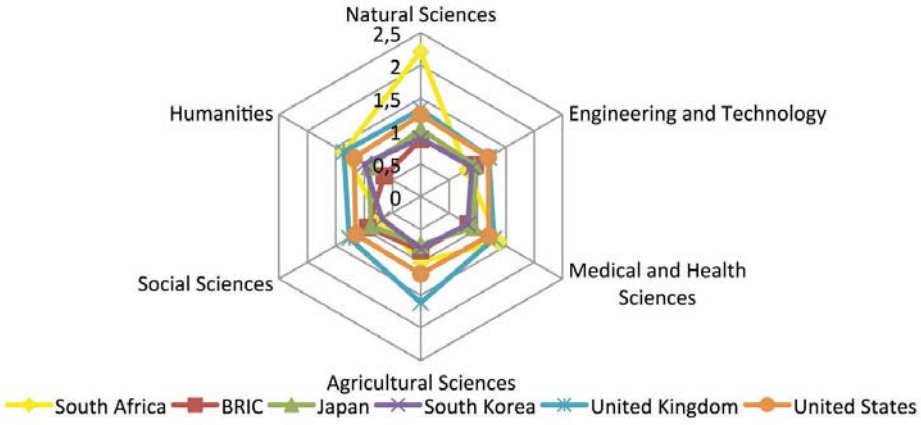


Figure 3.4: Benchmarking of South African Research Impact for Various Scientific Fields, 2014

3.3 Higher Education Research Publications

Research articles are probably among the most important outputs of universities. Academics are promoted according to their research output and universities are subsidised by the government according to the research outputs produced by their staff members. This section presents the performance of the university sector during the ten-year period from 2005 to 2014.

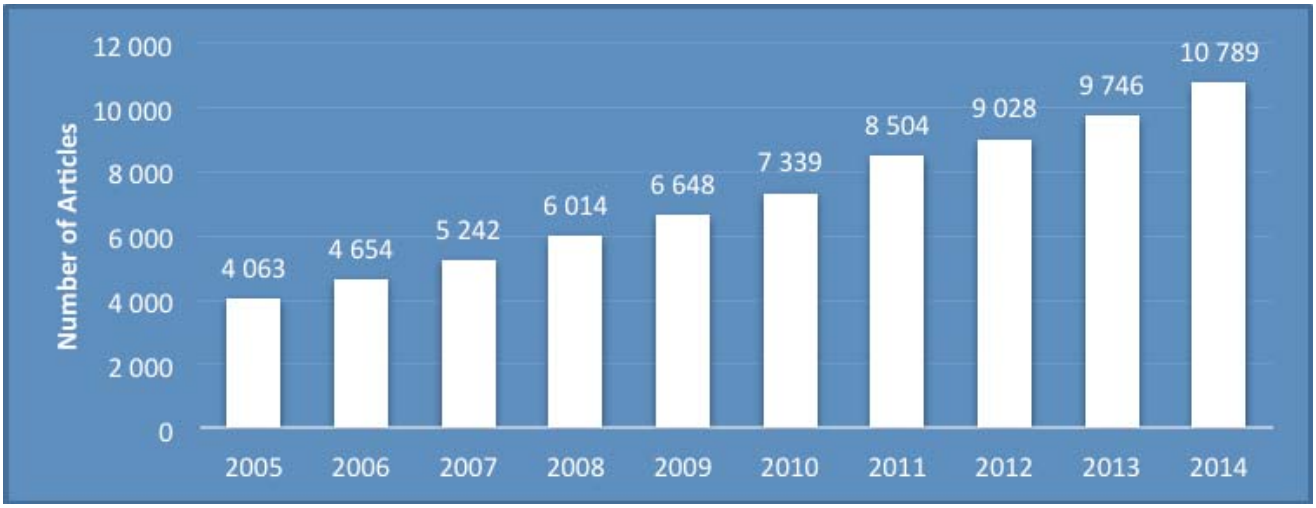


Figure 3.5: Number of Articles Produced by South African Universities

Figure 3.5 shows that the country's universities have consistently produced an increasing number of articles during the period. Research on the topic (Pouris 2012, Inglesi-Lots et al. 2011)[1] identifies that the main underlying factor for the apparent growth is the financial incentives offered by the Department of Higher Education and Training (DHET) to universities. Other incentives affecting the sector are the National Research Foundation's (NRF) rating of researchers, as well as the increase in the number of journals covered by Thomson-Reuters and others.

1 Pouris, A. (2012). "Scientometric research in South Africa and successful policy instruments." Scientometrics, 91:317–325.
Inglesi-Lotz, R. & Pouris, A. (2011). "Scientometric impact assessment of a research policy instrument: The case of rating researchers on scientific outputs in South Africa." *Scientometrics*, 88(3): 747–760.

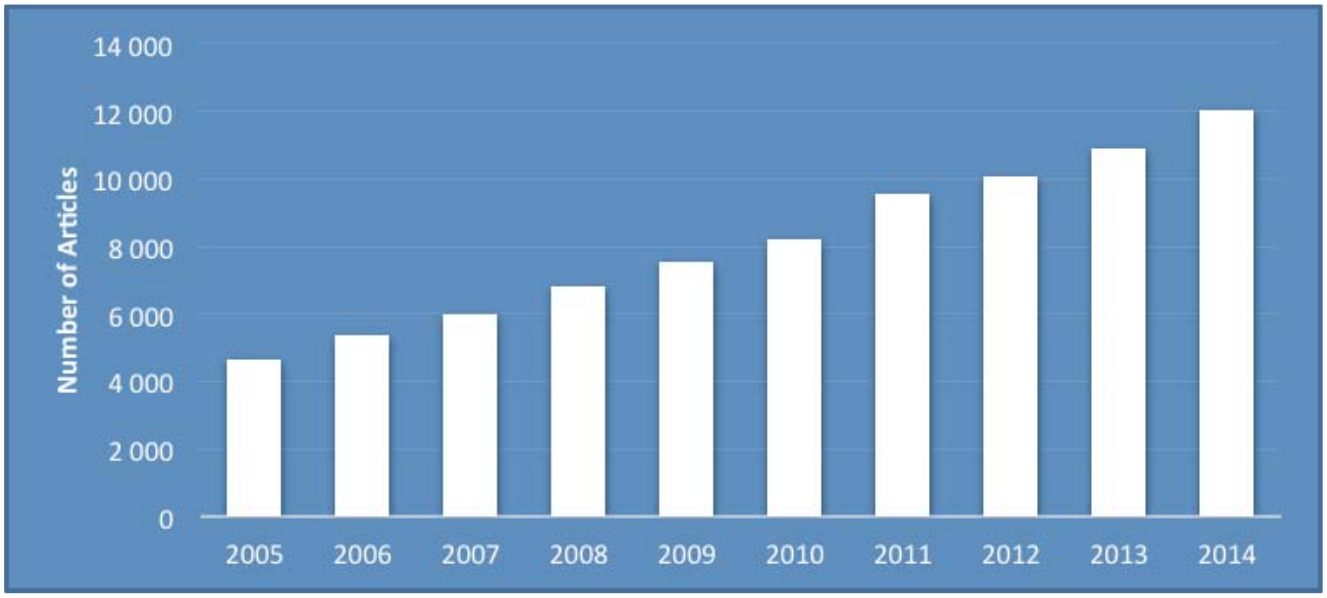


Figure 3.6: Number of Articles Produced by the South African System of Innovation

The share of articles produced by universities out of the total number of South African articles is illustrated below in Figure 3.7. It is apparent that the universities produced slightly less than 90% of the country's research output between 2010 and 2014.

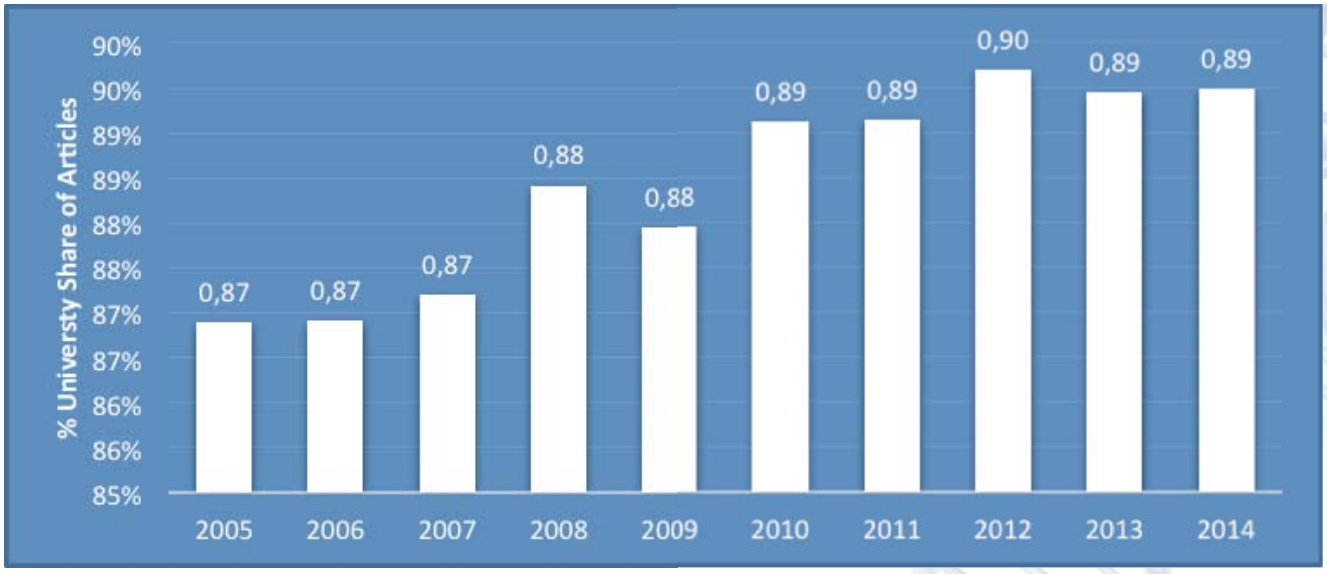


Figure 3.7: Share of Articles Produced by South African Universities in the System of Innovation

Figure 3.8 shows the most prolific South African universities and the number of articles they produced during the period 2005-2014. On top of the list is the University of Cape Town. The Universities of the Witwatersrand, Pretoria, Stellenbosch and KwaZulu-Natal follow with similar numbers of articles. Other universities each produce less than half the number of articles produced by the five top institutions.

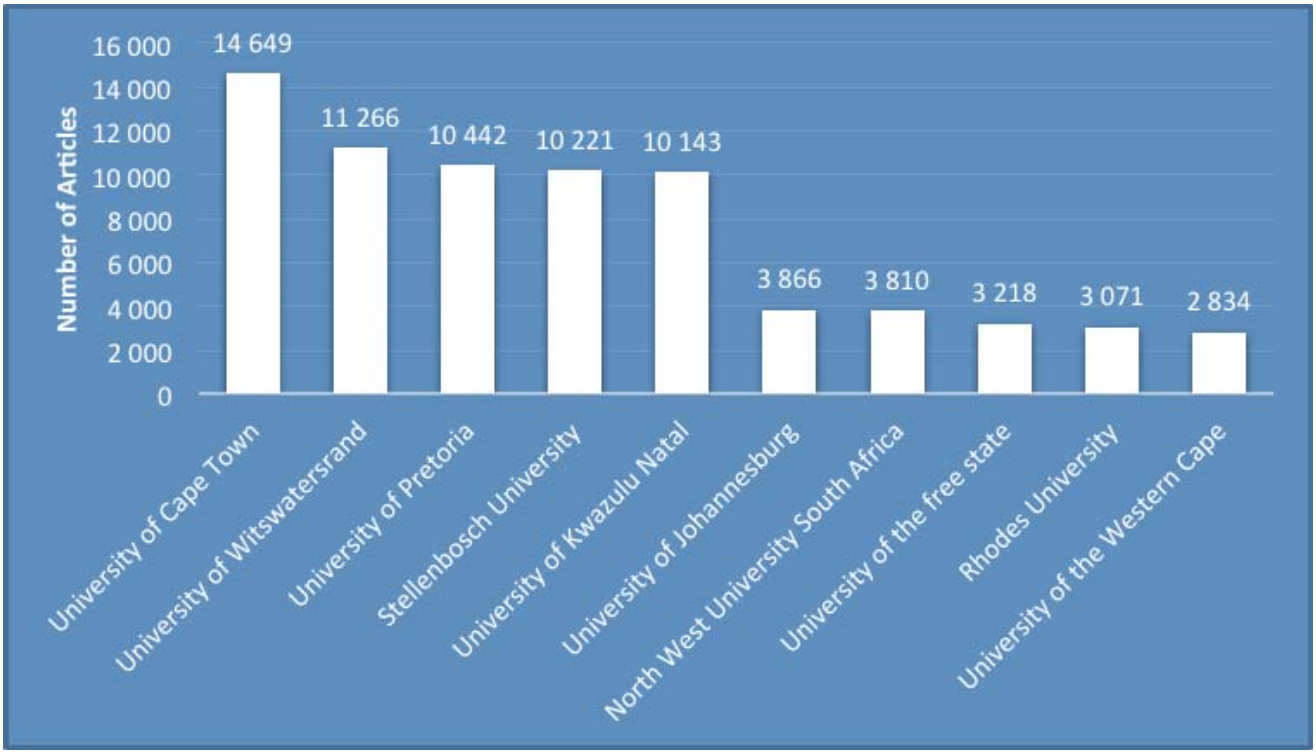


Figure 3.8: Prolific South African Universities 2005-2014

Figure 3.9 shows the annual production of articles of the Universities of Cape Town, the Witwatersrand and Pretoria. All universities have an increasing number of articles produced by members of staff. The University of the Witwatersrand increased its article production by slightly more than the University of Pretoria over the past decade.

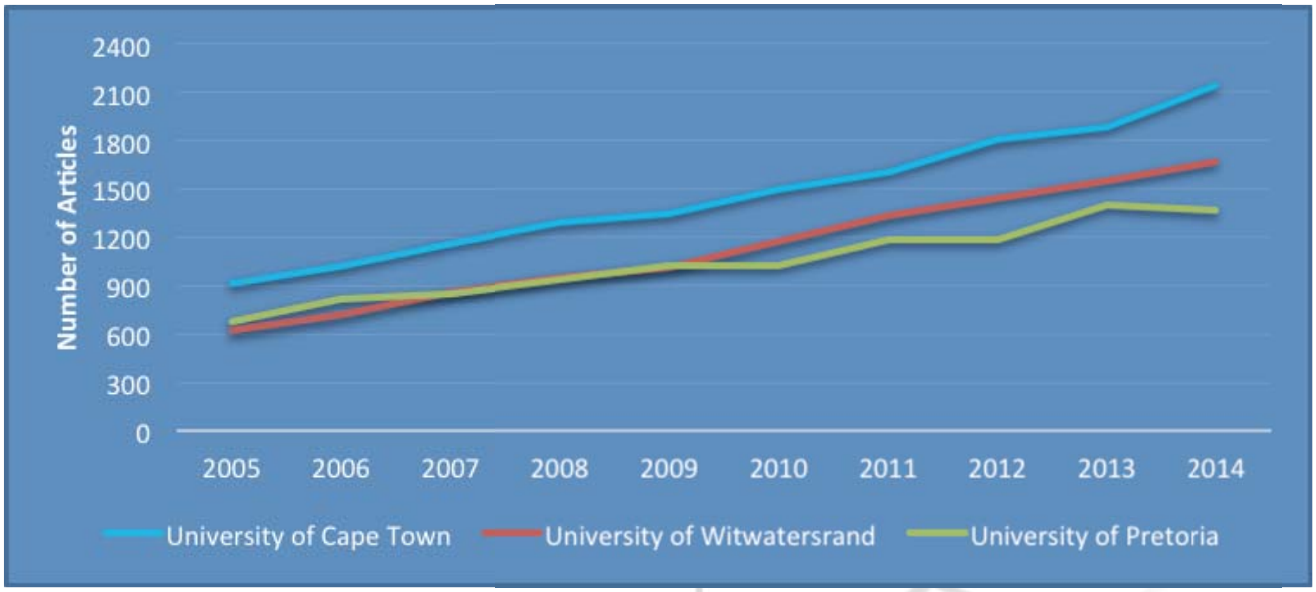


Figure 3.9: Publication Trends: Top South African Universities 2005-2014

Figure 3.10 shows the research areas emphasised by the country's universities during the period 2005-2014. Environmental Science: Ecology is first, followed by Chemistry, Engineering and Physics.

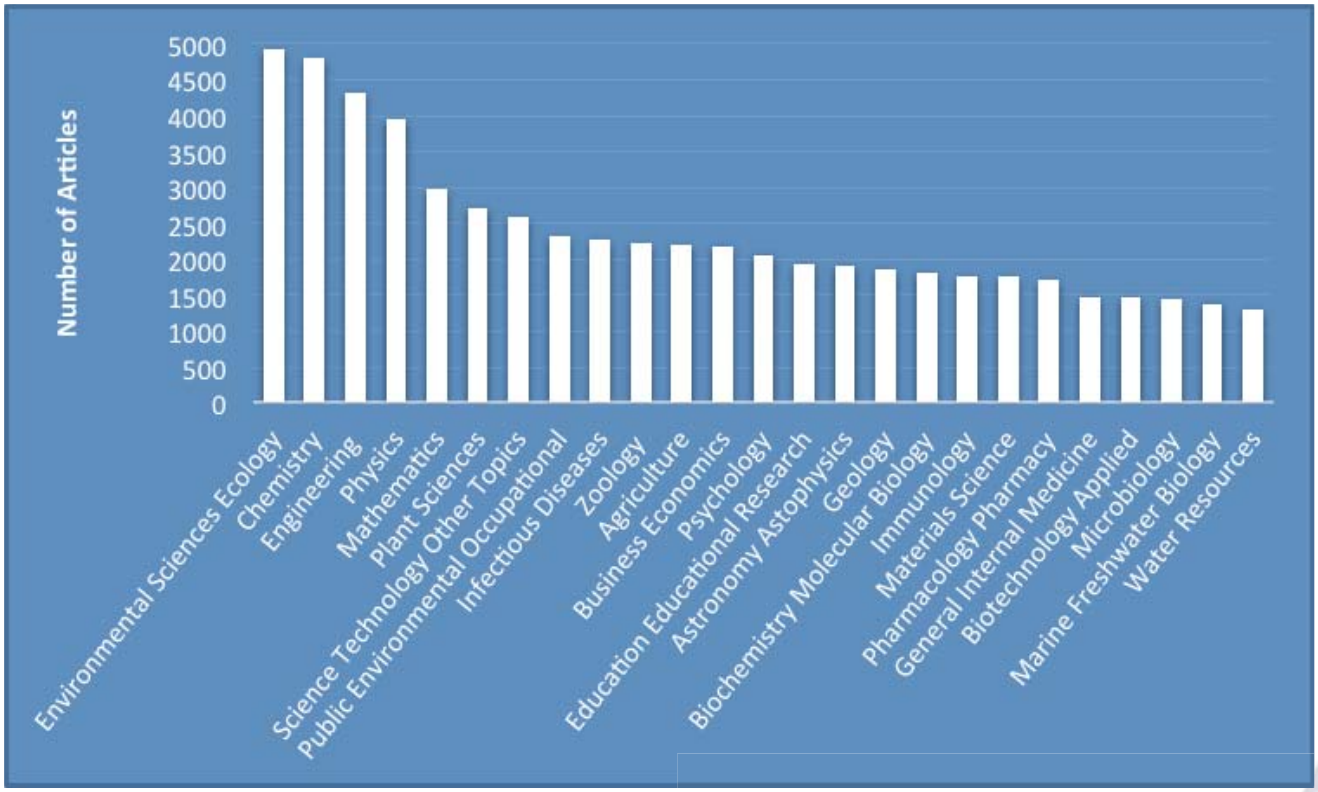


Figure 3.10: Research Areas Emphasised by the South African Universities 2005-2014

Tables 3.8 to 3.11 show the activity indices of the prolific disciplines of selected South African universities. The activity index was proposed by Frame (1977). It characterises the relative research effort a country devotes in a given subject field. In this report, the index characterises the relative research effort a university devotes in a given subject field in the national context. A value of 1 indicates that the university's research effort in the given field corresponds precisely to the national average. Values above 1 reflect higher than average activity and values lower than 1 reflect a lower than average effort dedicated to the particular field.

Table 3.8: Activity Indices – University of Cape Town

Research Areas	Activity Index
General Internal Medicine	2.01
Immunology	1.86
Astronomy Astrophysics	1.62
Infectious Diseases	1.50
Public Environmental Occupational Health	1.21
Science Technology Other Topics	1.14
Physics	1.13
Environmental Sciences Ecology	1.07
Engineering	0.78
Chemistry	0.59

Table 3.9: Activity Indices – University of the Witwatersrand

Research Areas	Activity Index
Immunology	1.86
Infectious Diseases	1.86
Mathematics	1.70
Physics	1.70
Public Environmental Occupational Health	1.67
Geology	1.46
Science Technology Other Topics	1.23
Engineering	0.84
Chemistry	0.78
Environmental Sciences Ecology	0.57

Table 3.10: Activity Indices – University of Pretoria

Research Areas	Activity Index
Veterinary Sciences	4.73
Religion	3.30
Business Economics	1.49
Zoology	1.49
Agriculture	1.48
Engineering	1.38
Plant Sciences	1.35
Environmental Sciences Ecology	1.11
Science Technology Other Topics	0.92
Chemistry	0.62

Table 3.11 Activity Indices – University of Stellenbosch

Research Areas	Activity Index
Microbiology	1.84
Agriculture	1.60
Biochemistry Molecular Biology	1.48
Infectious Diseases	1.16
Environmental Sciences Ecology	1.13
Engineering	1.06
Plant Sciences	1.01
Mathematics	0.96
Physics	0.90
Chemistry	0.86

The University of Cape Town is undertaking twice as much research in General Medicine relative to the national average. Similarly, the University of Pretoria is producing 4.73 times more research in Veterinary Science and 3.30 times more research in Religion.

Figure 3.11 shows the countries collaborating with the South African universities in research output. US and South African researchers collaborated for 11 049 of the country's articles during the ten-year period. England and Germany follow with approximately 7 296 and 4 373 articles respectively. Nigeria is the only African country appearing in the list with 1 073 entries.

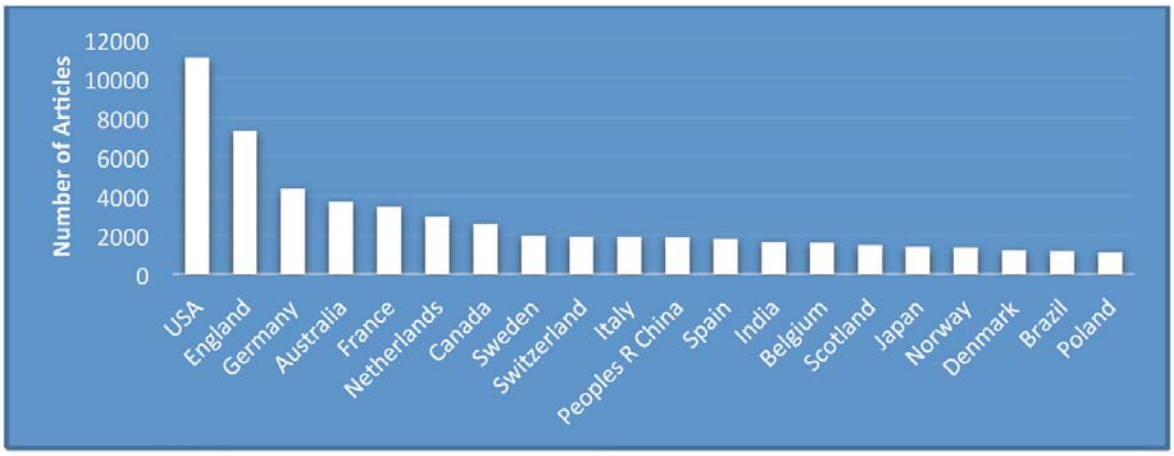


Figure 3.11: Countries Collaborating with South African Universities: Articles 2005-2014

Table 3.12 shows the research areas emphasised in the collaborative activities of South African universities. Physics, Environmental Sciences: Ecology and Chemistry are on top of the list with more than 2 000 each articles during the period. A comparison of table 3.12 with figure 3.11 indicates that the top research areas and the top international collaboration areas are the same.

Table 3.12: Research Areas Emphasised in International Collaboration 2005-2014

Research Areas	Record Count
Physics	2 694
Environmental Sciences Ecology	2 655
Chemistry	2 271
Engineering	1 810
Infectious Diseases	1 730
Astronomy Astrophysics	1 582
Science Technology other Topics	1 521
Mathematics	1 519
Public Environmental Occupational Health	1 504
Immunology	1 403

Plant Science	1 342
Geology	1 257
Zoology	1 182
Biochemistry Molecular Biology	1 078
Pharmacology Pharmacy	907
Microbiology	898
Agriculture	896
Materials Science	848
Psychology	840
Business Economics	754
General Internal Medicine	745
Virology	719
Evolutionary Biology	700
Genetics Heredity	633
Veterinary Sciences	625

Box: Chapter Terminology

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

Journals: Thomson Reuters selects journals each year and the selected journals become part of the Web of Knowledge. The journals selected are notable for their relatively high citation ranking 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.

Changes over time: Time series may present variations depending on the time the information is extracted from the databases. Up-dates of information, merging of corporate names, corrections of wrong entries, cut off points in uploading data are some of the factors affecting changes over time.

Table 3.13 shows the collaboration matrix of South Africa and five groups of countries. The groups are North America (USA and Canada), Europe, Africa (excluding South Africa), Australia and New Zealand, and BRIC (Brazil, Russia India and China).

Table 3.13: Collaboration Matrix: South Africa and Five Groups of Countries 2010-2014

	South Africa	North America	Europe	Africa	BRIC	Australia and New Zealand
South Africa	x	12 471	18 906	5 373	4 326	4 173
North America	12 471	x	480 958	36 153	200 600	66 735
Europe	18 906	480 958	x	64 762	315 365	89 147
Africa	5 373	36 153	64 762	x	12 489	5 575
BRIC	4 326	200 600	315 365	12 489	x	33 017
Australia and New Zealand	4 173	66 735	89 147	5 575	33 017	x

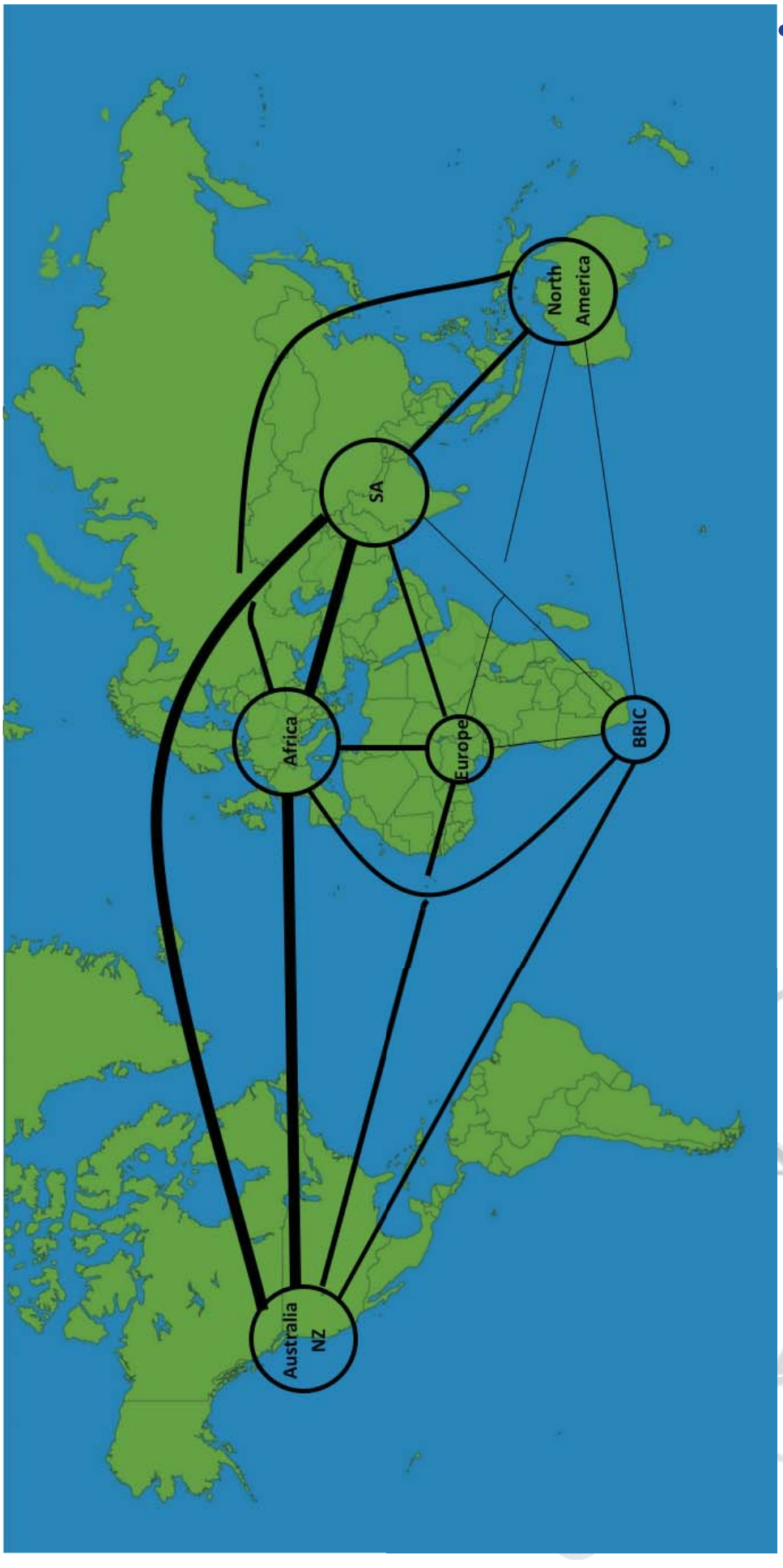


Figure 3.12: Macro Collaboration Map: South Africa, North America, Europe, Africa (excluding SA) and BRIC 2010-2014

3.4 Inter-Sectoral Collaboration

In this section, the inter-sectoral collaboration between universities, science councils and the business sector is identified and described. The science councils sector is defined to include what in South Africa are called science councils (i.e. CSIR, MRC, ARC, MINTEK, etc.) but also national facilities such as the South African Astronomical Observatory, iThemba Labs, etc. The business sector includes private companies and parastatals. A search identified more than 60 such organisations.

The science councils produce less than 2 000 articles per year and the business sector around 100 articles annually. The most prolific organisations among the science councils are the MRC and CSIR, followed by the ARC and HSRC. In the business sector, the most prolific organisations are Sasol and NECSA, followed by Clinvet.

Table 3.14 shows the research areas emphasised by these three sectors. Chemistry is on top of the list for universities and business sectors. It is interesting to note that the areas of priority in business (e.g. energy fuels, mining mineral processing, etc.) are not among the top research areas in science councils.

Table 3.14: Research Areas Emphasised by Various Sectors 2010-2014

Universities	Science Councils	Business Sector
Chemistry	Science and Technology: other	Chemistry
Environmental Sciences: Ecology	Biochemistry Molecular Biology	Engineering
Engineering	Astronomy Astrophysics	Materials Science
Physics	Public Environmental Occupational Health	Energy Fuels
Science and Technology: other	Physics	Nuclear Science Technology
Mathematics	Environmental Sciences Ecology	Metallurgy, Metallurgical Engineering
Plant Sciences	Infectious Diseases	Parasitology
Public Environmental Occupational Health	Chemistry	Mining Mineral Processing
Infectious Diseases	Immunology	Veterinary Sciences

Table 3.15 shows the inter-sectoral co-authorship matrix. The diagonal values show the total output of the particular sector. All other values represent the co-authored articles between the sectors. The three sectors together co-authored only 26 articles.

Table 3.15: Inter-Sectoral Co-Authorship Matrix 2010-2014

Sectors	Universities	Science Councils	Business Sector
Universities	45 386*	4 229	281
Science Councils	4 229	8 828*	34
Business Sector	281	34	455*

**Diagonal values reflect total output of the sector*

Figures 3.13 to 3.16 show the inter-sectoral collaborations in a proportional manner. It is apparent that universities produce most South African research articles and generate most of the collaborations between the sectors with the other two sectors contributing in less significant ways.

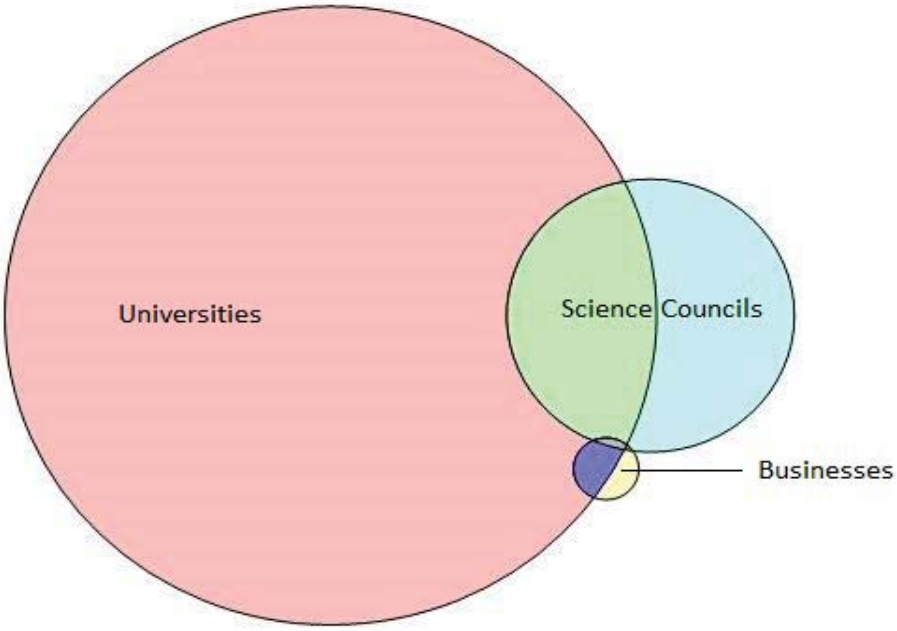


Figure 3.13: Proportional Venn Diagram: Universities, Science Councils and Business Co-Authorship 2010-2014

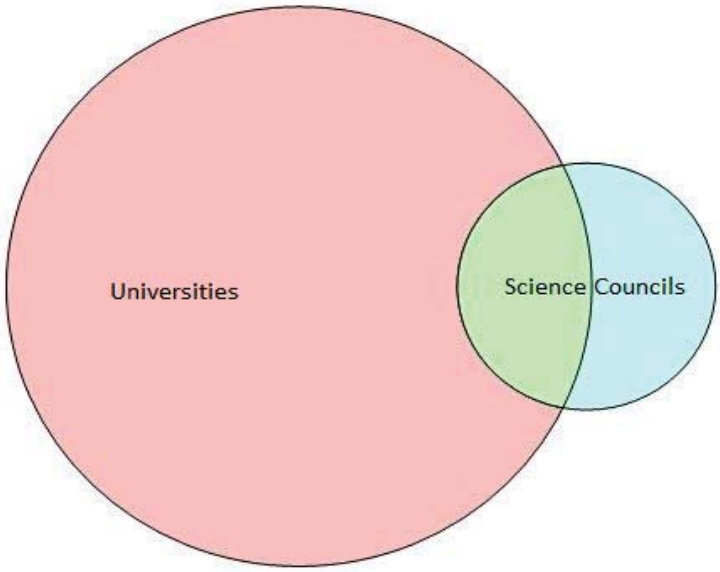


Figure 3.14: Proportional Venn Diagram: Universities, Science Councils Co-Authorship, 2010-2014

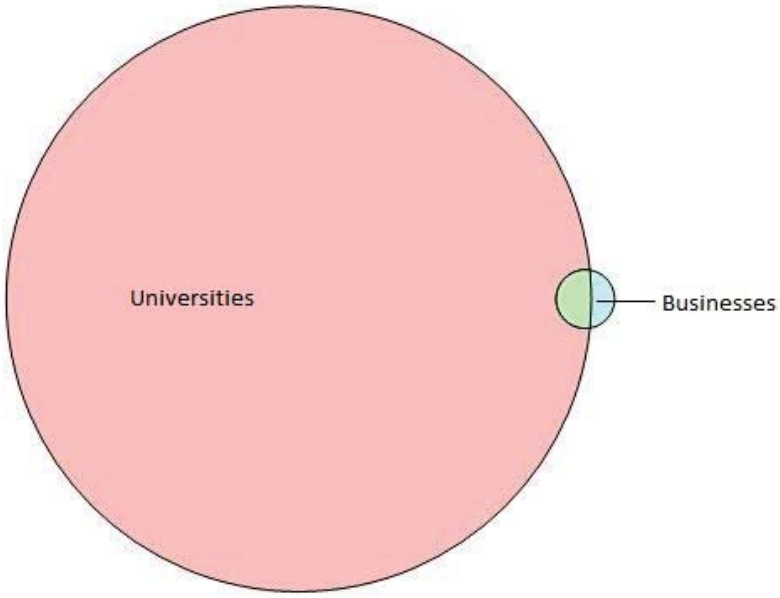


Figure 3.15: Proportional Venn Diagram: Universities and Business Co-Authorship, 2010-2014

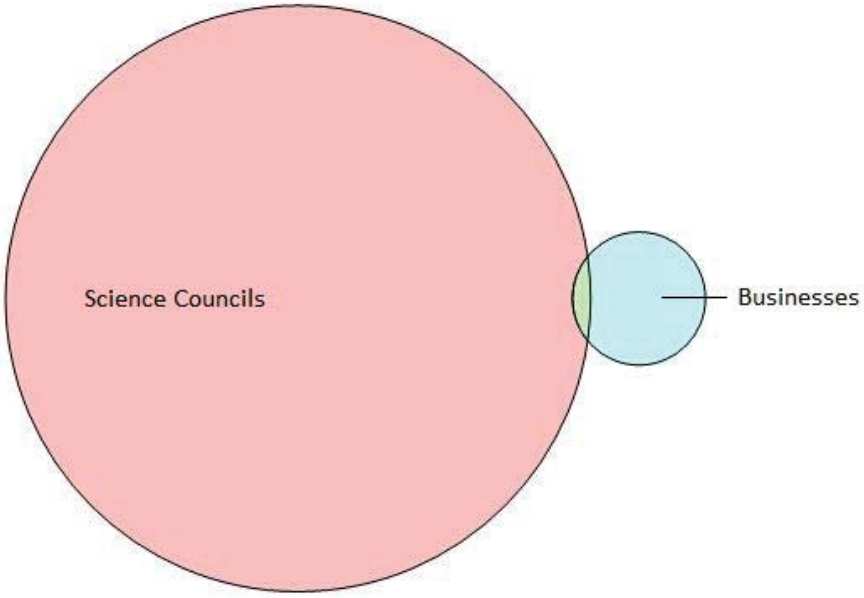


Figure 3.16: Proportional Venn Diagram: Science Councils and Business Co-Authorship, 2010-2014

Figures 3.17, 3.18 and 3.19 show the research areas emphasised in the inter-sectoral collaborations. In the collaboration between universities and science councils, emphasis is placed on Physics, Infectious Diseases, Materials Science and Science and Technology. In the collaboration between universities and the business sector, emphasis is placed on Chemistry. For science councils and businesses, the emphasis is on Metallurgy and Metallurgical Engineering. It should be mentioned that both the structure of an industry and the structure of a science council affects the areas in which collaboration occurs.

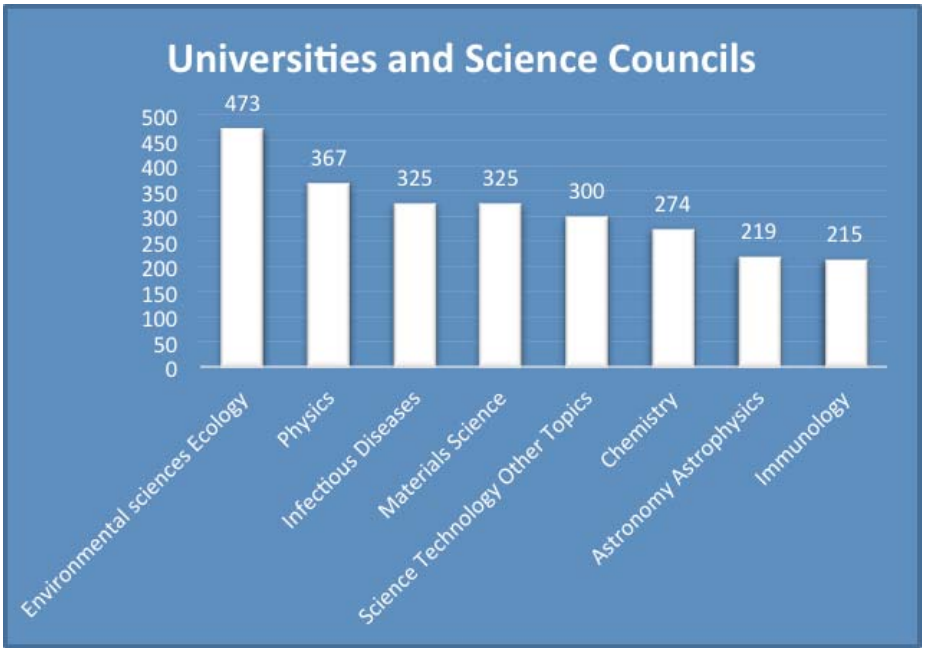


Figure 3.17: Research Areas Emphasised in Universities and Science Councils Collaboration

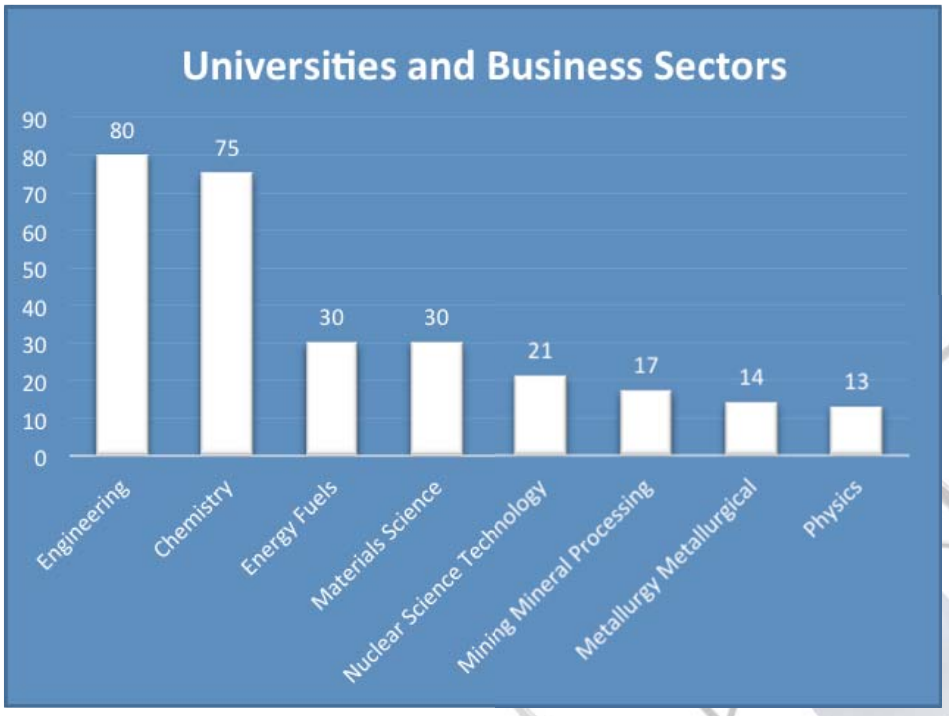


Figure 3.18: Research Areas Emphasised in Universities and Business Collaboration

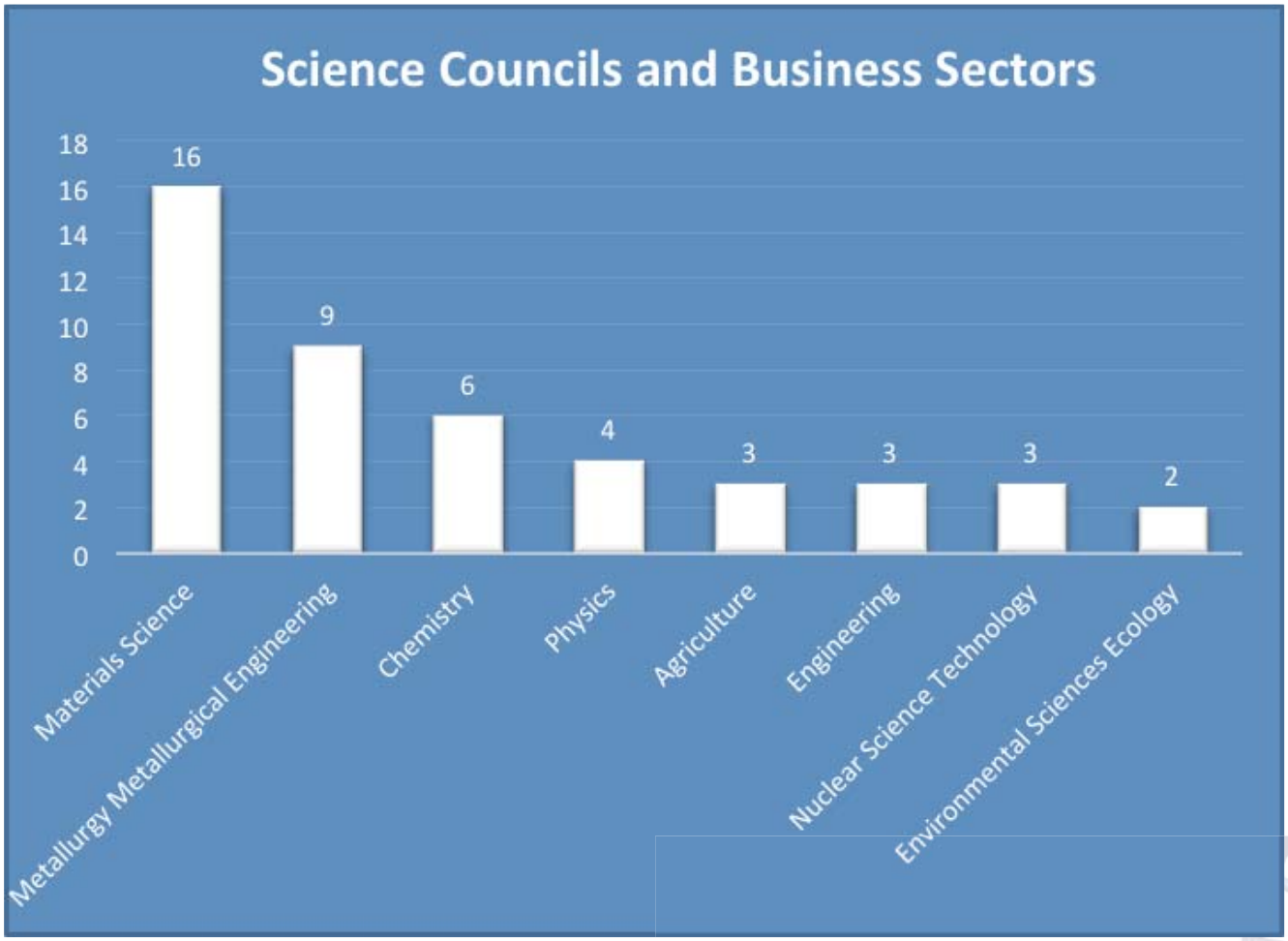


Figure 3.19: Research Areas Emphasised in Science Councils and Business Collaboration

4. Technical Progress (Improvement and Innovation)

The 1996 White Paper on Science and Technology acknowledged that, as the South African economy opens up to global market forces, niche markets need to be identified in which international competitiveness can be improved. This can be achieved through increased technology investment and increased productivity. Patents and revealed technological advantage, foreign direct investment (FDI) outflow and technology receipts data are presented in this chapter.

4.1 Patents

Patent analysis offers a number of advantages which can be exploited to facilitate their universal use as indicators of performance. They are highly reliable because they are well defined and unambiguous. They facilitate detailed categorisation and thereby enhance research in scientific and technological fields and sub-fields. Finally, they make international comparisons possible. The Organisation for Economic Co-operation and Development (OECD) provides guidelines for the use of patents in their relevant manual.[1]

The patents most often utilised internationally for this type of analysis are those awarded by the United States Patent and Trademark Office (USPTO). Although most countries in the world have their own patent authorities, the use of the USPTO provides a number of advantages. In the majority of patent offices, patents are not examined for originality, usefulness and novelty. Counting and comparing patents awarded by different patent offices in different countries may be misleading because of differences in the criteria used and the ease of awarding patents, bias towards local patents, etc. The obvious solution to avoid the above-mentioned shortcomings is to use a common denominator such as an external patent system with an objective approach to the awarding of patents (i.e. USPTO).

1 OECD. (1994). "The Measurement of Scientific and Technological Activities, Using Patent Data as Science and Technology Indicators – Patent Manual". OECD, Paris.

Figure 4.1 shows the number of patents granted to South African inventors during the period 2001-2014. During 2013, South African inventors were awarded 161 patents. This is the highest number during the period.

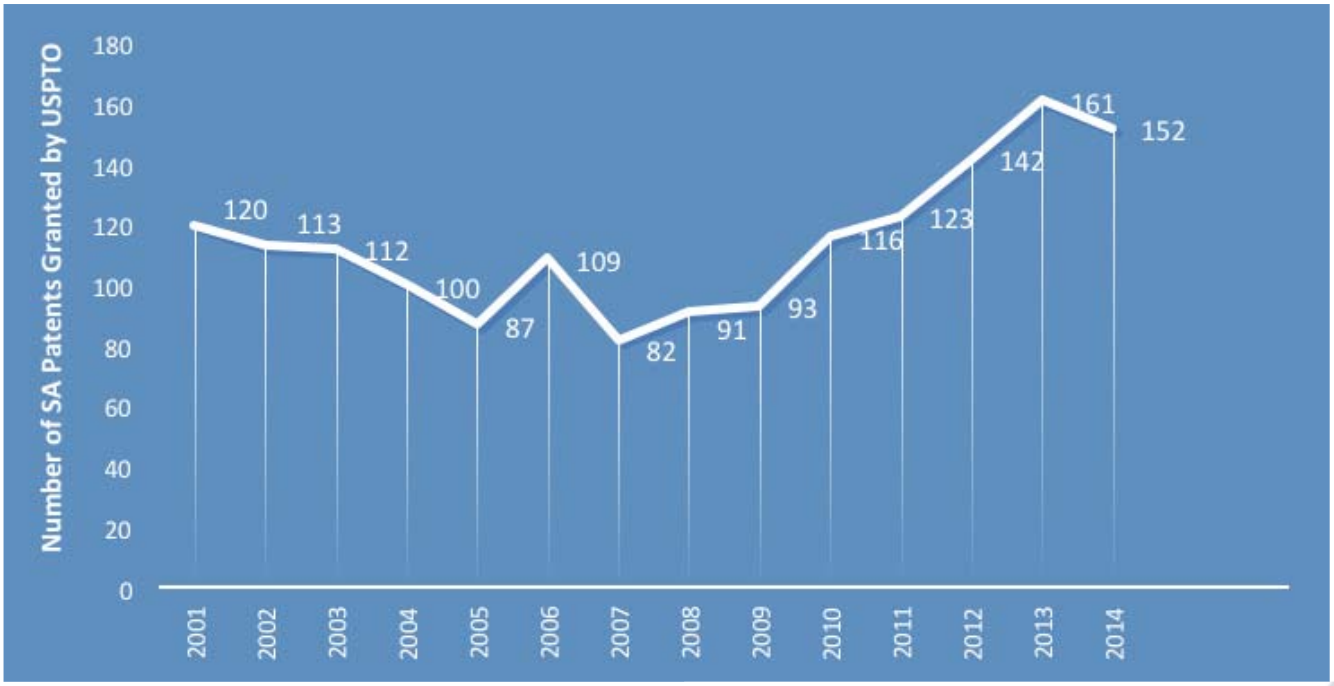


Figure 4.1: Patents Granted to South African Inventors at USPTO, 2001-2014

Figure 4.2 shows the share of South African patents awarded by the USPTO in the world total. The share declined from 0.07% during 2001 to 0.05% during 2014. It becomes apparent that even though the South African system of innovation increased the absolute number of patents during the period, the rest of the world increased their patenting activity more rapidly than South Africa.

Figure 4.2: Share of South African Patents in the World Total (USPTO 2001-2014)

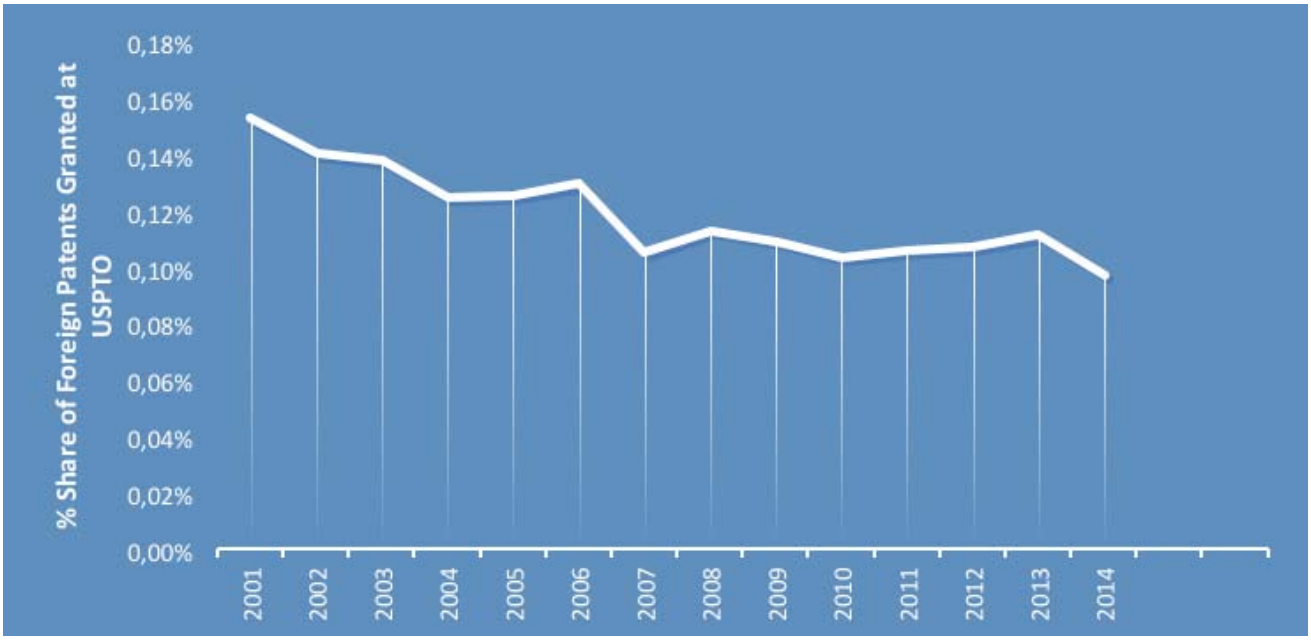


Figure 4.3: Share of South African Patents in Foreign Origin Patents Granted by USPTO 2001-2014

Table 4.1 identifies the technology classes to which the South Africa patents belong. The table shows the class number, the class title, the number of South African patents in the class during the period 2010-2014, the total number of patents granted in the particular class during the period and the South African share. South Africa produced 5.69% of the patents in the class Chemistry: Fischer-Tropsch Processes, 3.23% in Abrasive Tool Making Processes and 2.96% in Mining.

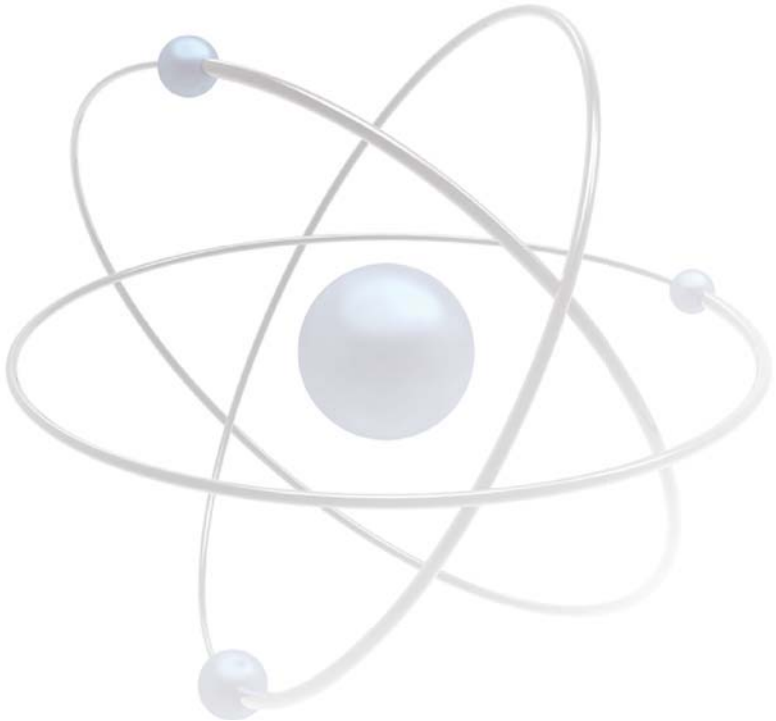


Table 4.1: SA Patents by Technology Class 2010-2014

Class	Class Title	SA grants	Class grants	SA Share
424	Drug, Bio-Affecting and Body Treating Compositions (includes Class 514)	39	47 211	0.08%
623	Prosthesis (i.e., Artificial Body Members), Parts Thereof, or Aids and Accessories Thereof	31	6 567	0.47%
705	DP. Financial, Business Practice, Management, or Cost/Price Determination (Data Processing)	31	23 676	0.13%
435	Chemistry: Molecular Biology and Microbiology	18	19 356	0.09%
463	Amusement Devices: Games	17	7 007	0.24%
518	Chemistry: Fischer-Tropsch Processes; or Purification or Recovery of Products Thereof	17	299	5.69%
175	Boring or Penetrating the Earth	15	1 894	0.79%
532	Organic Compounds (includes Classes 532-570)	15	18 337	0.08%
405	Hydraulic and Earth Engineering	13	1 618	0.80%
102	Ammunition and Explosives	12	1 016	1.18%
210	Liquid Purification or Separation	12	5 501	0.22%
015	Brushing, Scrubbing, and General Cleaning	11	3 291	0.33%
051	Abrasive Tool Making Process, Material, or Composition	11	341	3.23%
075	Specialised Metallurgical Processes, Compositions for Use Therein, Consolidated Metal Powder Compositions, and Loose Metal Particulate Mixtures	11	1 031	1.07%
299	Mining or In Situ Disintegration of Hard Material	11	371	2.96%
340	Communications: Electrical	10	13 021	0.08%
423	Chemistry of Inorganic Compounds	10	3 837	0.26%
585	Chemistry of Hydrocarbon Compounds	10	1 635	0.61%
089	Ordnance	8	1 219	0.66%
198	Conveyors: Power-Driven	8	2 223	0.36%
257	Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)	8	39 230	0.02%
264	Plastic and Non-metallic Article Shaping or Treating: Processes	8	5 195	0.15%
324	Electricity: Measuring and Testing	8	9 642	0.08%
502	Catalyst, Solid Sorbent, or Support There for: Product or Process of Making	8	2 341	0.34%

Table 4.2 shows the number of patents granted to company assignees during the 2010-2014 period. Patent ownership reflects ownership at the time of patent grant and does not include subsequent changes in ownership. When there is more than one assignee, the patent is attributed to the first named assignee. Origin is determined by the residence of the first named inventor. Sasol appears on top of the list, followed by the University of Cape Town and CSIR.

Table 4.2: Patents Granted to South African Assignees 2010-2014

Company Assignee	2010	2011	2012	2013	2014	Total
Sasol Technology	6	8	10	12	10	46
University of Cape Town	2	3	1	8	5	19
CSIR	4	4	2	5	1	16
University of the Witwatersrand	1	2	4	4	3	14
Discovery Holdings	0	3	5	3	1	12
Azoteq	3	3	1	2	1	10
North West University	2	1	3	3	1	10

4.2 Revealed Technological Advantage

According to the OECD, the revealed technology advantage (RTA) index provides an indication of the relative specialisation of a given country in selected technological domains and is based on patent applications filed. It is defined as a country's share of patents in a particular technology field divided by the country's share in all patent fields. The RTA index is equal to zero when the country holds no patent in a given sector, is equal to 1 when the country's share in the sector equals its share in all fields (no specialisation) and above 1 when a positive specialisation is observed.

Table 4.3 shows the trends in RTA for various South African technological inventions. These values were derived from the detailed data recorded in Appendix B. The technologies with the highest RTA are Environmental Technology (2.66 in 2014), followed by Semiconductors (2.29), Electrical Machinery (2.26), Mechanical Elements (2.11) and Thermal Processes and Apparatus (2.06). The other areas in which South Africa has potential for specialisation are Surface Technology/Coating, Materials/Metallurgy, Medical Technology, Machine Tools and Handling. The country has recently developed a specialisation in Micro-Structural and Nano-technology (from an RTA of 0.79 in 2013 to 1.41 in 2014).

Table 4.3: RTA of Various South African Technological Inventions

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Electrical machinery	1.15	2.31	0.96	0.98	1.50	1.23	2.00	0.84	1.19	2.26
Audio visual technology	0.49	0.57	0.61	0.55	0.71	0.81	0.59	0.78	0.47	0.60
Telecommunications	0.43	0.27	0.31	0.40	0.35	0.51	0.33	0.32	0.33	0.45
Digital communication	0.57	0.60	0.43	0.40	0.59	0.25	0.25	0.27	0.31	0.77
Basic communication	0.31	0.48	0.23	0.21	0.36	0.24	0.28	0.22	0.38	0.31
Computer technology	0.16	0.17	0.10	0.17	0.43	0.82	0.81	0.54	0.55	0.76
IT methods	0.51	0.32	0.28	0.42	0.38	0.48	0.50	0.62	0.44	0.33
Semiconductors	1.22	1.80	1.99	2.20	3.49	2.64	3.84	4.12	3.68	2.29
Optics	0.08	0.59	0.20	0.14	0.17	0.22	0.29	0.42	0.26	0.27
Measurement	0.04	0.04	0.05	0.11	0.05	0.06	0.05	0.19	0.08	0.39
Analysis of biological materials	0.73	0.62	0.55	0.46	0.54	0.59	0.77	0.54	0.41	0.65
Control	0.32	1.32	0.49	0.47	0.18	0.21	0.43	0.39	1.15	0.96
Medical technology	2.26	1.72	1.81	1.38	1.27	1.27	0.81	0.97	0.89	0.79
Organic fine chemistry	0.94	1.01	1.09	1.24	0.71	1.02	1.13	1.30	1.33	1.29
Biotechnology	0.51	0.66	1.04	0.52	0.85	0.72	1.34	1.52	1.07	1.19
Pharmaceuticals	0.67	0.46	0.82	0.59	1.16	0.86	1.20	0.95	1.18	0.90
Macromolecular chemistry, polymers	0.49	0.80	0.49	0.50	0.59	0.57	1.02	0.79	1.48	0.99
Food chemistry	0.45	0.35	0.23	0.29	0.41	0.55	0.27	0.38	0.36	0.39
Basic materials chemistry	1.06	1.76	1.15	1.25	0.95	0.80	1.28	0.76	0.61	1.41
Materials, metallurgy	1.65	2.01	2.78	2.49	1.97	2.09	1.57	2.11	1.76	1.48
Surface technology, coating	2.15	3.59	4.18	3.24	3.15	2.69	3.58	2.36	2.34	1.65
Micro-structural and nano-technology	0.38	0.59	0.85	0.72	0.66	0.62	0.56	0.65	0.79	1.41
Chemical engineering	0.00	0.00	0.34	0.28	0.25	0.27	0.00	0.85	1.71	1.82
Environmental technology	3.17	3.04	2.05	2.44	2.50	2.24	2.46	2.42	2.47	2.66
Handling	1.59	1.58	1.25	1.85	1.46	1.82	1.33	1.12	1.64	1.28
Machine tools	1.98	1.91	2.26	2.42	1.99	2.06	1.78	1.42	1.26	1.27
Engines, pumps, turbines	1.19	1.46	1.30	1.09	1.07	0.96	0.81	0.50	0.82	1.37
Textile and paper machines	1.65	0.89	0.99	0.88	1.10	0.80	1.17	0.71	0.75	0.72
Other special machines	0.60	0.23	0.25	0.33	0.35	0.41	0.61	0.33	0.24	0.22
Thermal processes and apparatus	1.73	1.62	1.63	1.83	1.29	1.77	1.38	1.57	2.07	2.06
Mechanical elements	0.86	0.84	1.75	1.35	1.58	1.72	0.65	0.57	1.23	2.11
Transport	1.48	1.45	1.21	1.19	1.13	0.99	0.80	1.01	1.13	1.07
Furniture, games	1.09	0.94	0.96	1.14	0.85	0.84	0.68	1.15	0.62	0.59
Other consumer goods	2.21	1.53	2.30	2.08	1.72	1.99	1.30	1.74	1.76	1.29
Civil engineering	1.14	0.84	1.52	1.55	1.72	2.05	1.48	1.99	1.76	1.22

Source: WIPO IP Statistics Data Center

Figure 4.4 shows a further analysis of the South African technology patents published by classifying them into four categories, namely, distinctive, background, marginal and niche technologies. It should be noted that these classifications are based on arbitrary cut-off points. The country's patent share is placed on the vertical axis with a cut-off point of 3% while on the horizontal axis the RTA is placed with a cut-off point of 1.50. The size of the bubbles indicates the number of patents for various technologies.

Distinct technologies such as Chemical Engineering represent the technological areas that have the largest country and global share. Although the background technologies (e.g. Electrical Machinery) have the highest portion of the country's share of patents, they do have a relatively low global share of patents. Marginal technologies (e.g. Textile and Paper Machineries) have low shares at both the country and global level. Niche technologies such as Micro and Nano-technology have a low country share of patents although they have a high global share of patents.

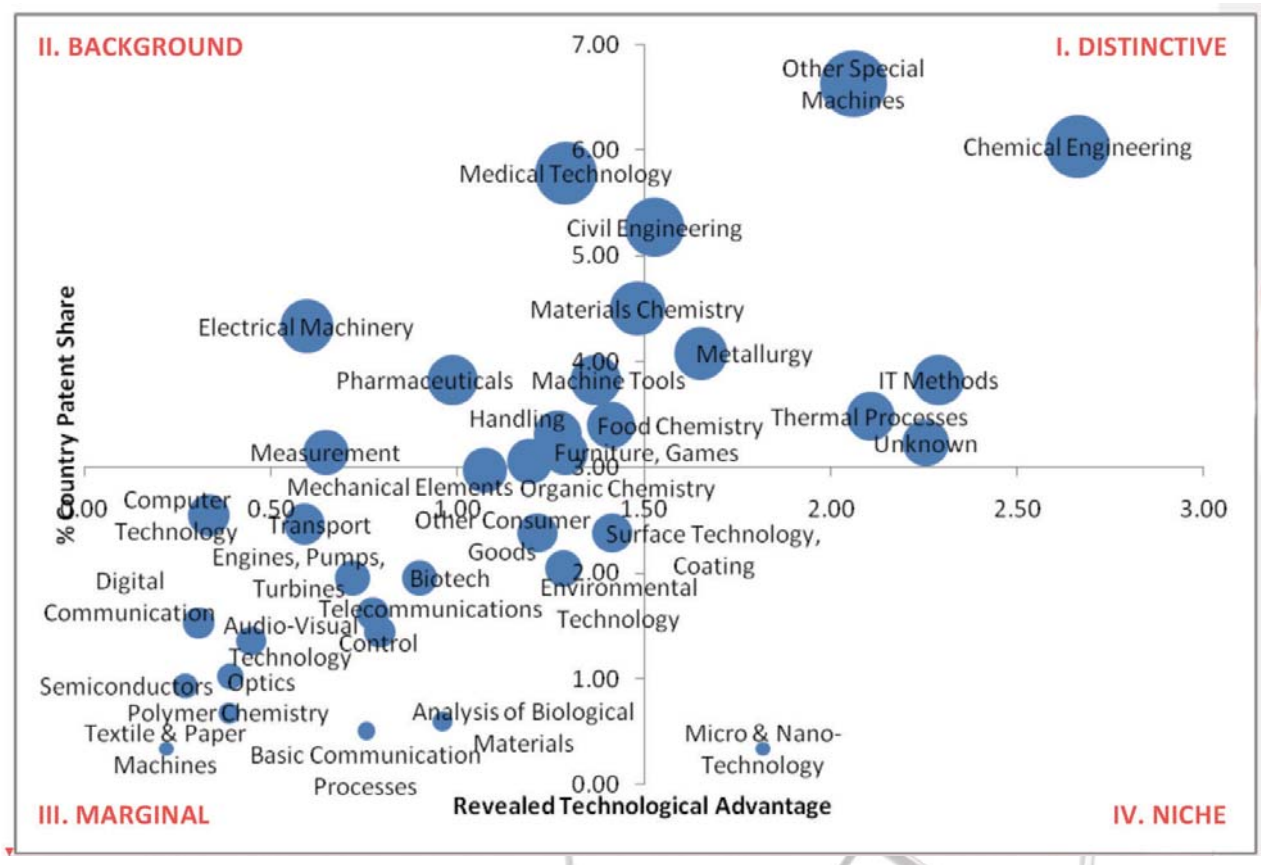


Figure 4.4: South African New Technologies Classification, 2014

4.3 Outflow of Foreign Direct Investment

The outflow of FDI is an important indicator of technology transfer between countries (OECD). South African FDI outflow increased from a low of R556 million in 2010 to R75 277 million in 2014. As a result, the country's world share of FDI outflow increased from 0.006% in 2010 to 0.512% in 2014 (table 4.4). As a percentage of its GDP, South African FDI was 0.36% in 2005 and 1.98% in 2014 with a low of 0.02% in 2010. FDI as percentage of GDP was highest in 2006 (2.23%) over the 2005-2014 period.

Table 4.4: Outward Flow of FDI

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
FDI Outflow (R million)	5 915	41 047	20 910	25 887	9 749	556	1 866	24 531	64 229	75 277
FDI Outflow as % of GDP	0.36	2.23	0.99	1.09	0.39	0.02	0.06	0.75	1.82	1.98
% Global Share of FDI Outflow	0.117	0.451	0.139	0.185	0.105	0.006	0.016	0.233	0.509	0.512

Source: United Nations Conference on Trade and Development "UNCTADstat"

As table 4.5 and figure 4.5 show, FDI outflow as a percentage of GDP for South Africa compares reasonably well with countries such as the United Kingdom (2.02%), United States (1.92%), South Korea (2.47%) and Japan (2.48%) but is higher than the average value for the BRIC group of countries (1.12%). Russia leads with 3.03%. South Africa's global percentage share of FDI outflow is low (0.512%) but it is not out of line with its small population and economy size.

Table 4.5: Benchmarking of FDI Outflow, 2014

	FDI Outflow (R million)	FDI Outflow as % of GDP	% World Share of FDI Outflow
South Africa	75 277	1.98	0.512
BRIC	2 016 212	1.12	13.720
Brazil	38 409	0.15	0.261
Russia	612 352	3.03	4.167
India	106 851	0.48	0.727
China	1 258 600	1.12	8.565
Japan	1 232 875	2.48	8.390
South Korea	331 554	2.47	2.256
United Kingdom	646 964	2.02	4.403
United States	3 655 832	1.92	24.879

Source: United Nations Conference on Trade and Development "UNCTADstat"

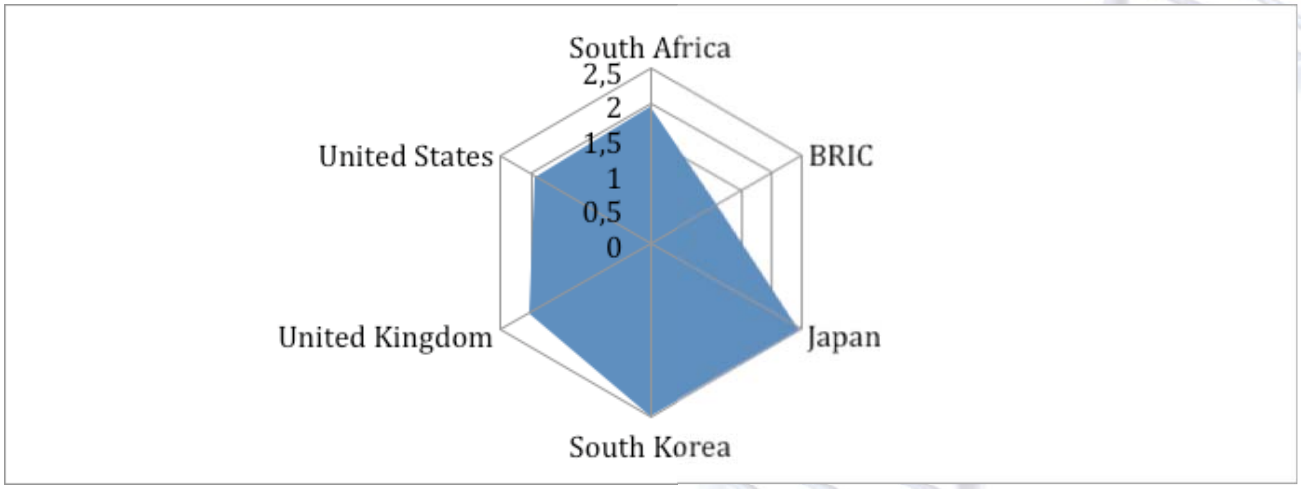


Figure 4.5: FDI as a Percentage of GDP

4.4 Technology Receipts

Technology receipts represent the revenue received for the use of intellectual property (disembodied technologies). There has been an increase in technology receipts since 2005 with the exception of the minor decline in 2009 (table 4.6). Technology receipts as a percentage of GDP increased from 0.018% in 2005 to 0.030% in 2010 and then to 0.033% in 2014.

Table 4.6: Charges for the Use of Intellectual Property: Receipts

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Technology Receipts (R million)	288	372	528	644	636	832	976	1 024	1 156	1 260
Technology Receipts as % of GDP	0.018	0.020	0.025	0.027	0.025	0.030	0.032	0.031	0.033	0.033

Source: South African Reserve Bank "Online Statistical Query"

The benchmarking of technology receipts (table 4.7 and figure 4.6) shows that South Africa has lower technology receipts as a percentage of GDP in comparison to Japan (0.8%), the United States (0.748%), United Kingdom (0.669%) and South Korea (0.365%). However, this is more than double that of the BRIC average (0.016%). The increase in technology receipts as a result of the increase in intellectual property stock is vital if the current account deficit is to be reduced.

Table 4.7: Benchmarking of Technology Receipts, 2014

	Technology Receipts (R million)	GDP (R million)	Technology Receipts as % of GDP
South Africa	1 260	3 797 067	0.033
BRIC	*28 069*	*180 218 750*	*0.016*
Brazil	4 069	25 454 925	0.016
Russia	7 226	20 187 488	0.036
India	7 150	22 226 409	0.032
China	9 624	112 349 927	0.009
Japan	399 638	49 925 852	0.800
South Korea	55 888	15 302 656	0.365
United Kingdom	217 033	32 429 489	0.669
United States	1 414 417	188 996 150	0.748

Source: World Development Indicators

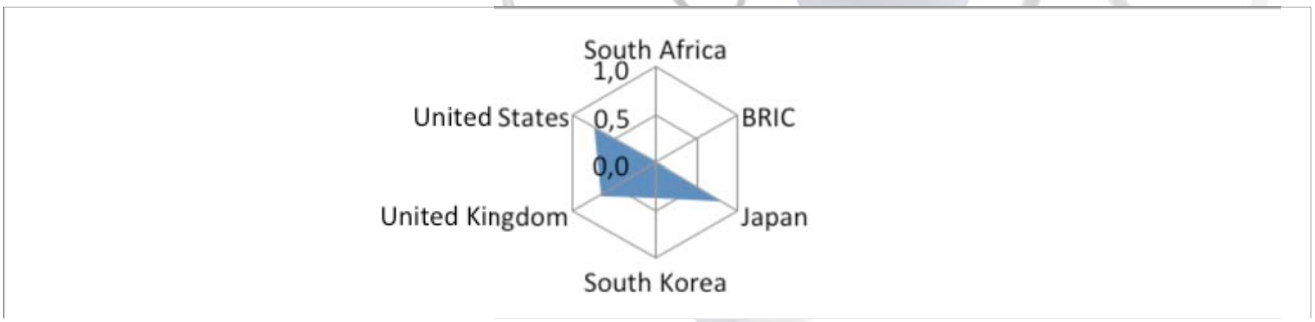


Figure 4.6: Technology Receipts as a Percentage of GDP

5. Imported Know-How

The NDP recognises the advantages of accelerated technological redundancy and reduced product lifecycles in creating opportunities for new industrial firms to enter new product segments. Imported technologies and know-how are therefore important in meeting ever-changing international and local customer needs. This chapter reviews the data on technology payments and inflows of FDI.

5.1 Technology Payments

Technology payments in this context represent the country's expenditure on the right to use intellectual property from other countries. Similar to the trend in technology receipts (table 4.6), technology payments have been increasing continually over the period 2005-2014 (table 5.1). However, the growth rate of technology payments is less than the growth rate of GDP for most years in this period. As a result, technology payments as a percentage of GDP declined from a high of 0.579% in 2008 to 0.495% in 2014.

Table 5.1: Charges for the Use of Intellectual Property: Payments

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Technology Payments (R million)	6 812	8 661	11 226	13 716	13 861	14 184	15 362	16 534	18 651	18 791
Technology Payments as % of GDP	0.416	0.471	0.532	0.579	0.553	0.516	0.508	0.507	0.528	0.495

Source: South African Reserve Bank "Online Statistical Query"

As table 5.2 and figure 5.1 show, South Africa imports more disembodied technologies (0.495% technology payments as a percentage of GDP in 2014) than countries within the BRIC group (0.215%), the United States (0.242%), United Kingdom (0.368%) and Japan (0.455%) but lower than that of South Korea (0.735%). As South Korea's innovation system is performing relatively well (technology receipts are ten-fold those of South Africa), high technology payments do not necessarily reflect a problematic situation. The ability of the country to absorb and diffuse such imported technological know-how is an important factor to consider here.

Table 5.2: Benchmarking of Technology Payments, 2014

	Technology Payments (R million)	GDP (R million)	Technology Payments as % of GDP
South Africa	18 791	3 797 067	0.495
BRIC	*386 651*	*180 218 750*	*0.215*
Brazil	18 803	25 454 925	0.074
Russia	87 028	20 187 488	0.431
India	52 612	22 226 409	0.237
China	228 208	112 349 927	0.203
Japan	227 134	49 925 852	0.455
South Korea	112 504	15 302 656	0.735
United Kingdom	119 274	32 429 489	0.368
United States	457 045	188 996 150	0.242

Source: World Development Indicators

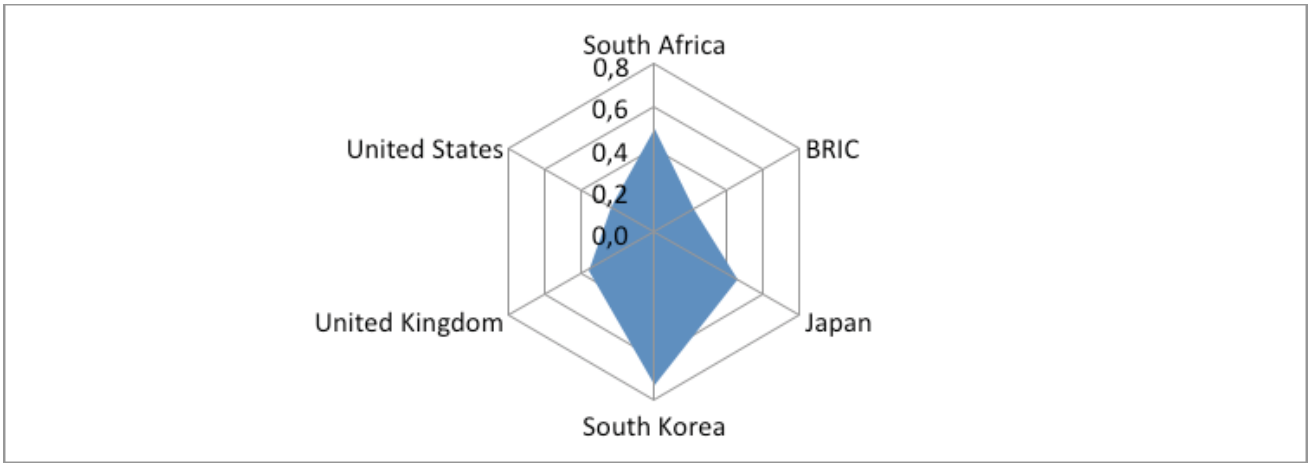


Figure 5.1: Technology Payments as a Percentage of GDP

5.2 Inflow of Foreign Direct Investment

As table 5.3 shows, the inflow of FDI into the country slowed down at the start of the economic recession between 2008 and 2009. However, good growth was observed between 2010 and 2013 (from R26 616 million to R80 178 million) before a 22.7% decline began in 2014. FDI as a percentage of GDP and a percentage of global share have trends that are similar to those of FDI. South Africa's share of global FDI peaked during this period in 2005 (0.717%).

Table 5.3: Inward Flow of FDI

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
FDI Inflow (R million)	42 275	2 105	46 093	76 066	63 542	26 616	30 804	37 429	80 178	61 975
FDI Inflow as % of GDP	2.58	0.11	2.18	3.21	2.54	0.97	1.02	1.15	2.27	1.63
% World Share of FDI Inflow	0.717	0.022	0.349	0.618	0.632	0.274	0.271	0.325	0.566	0.465

Source: United Nations Conference on Trade and Development "UNCTADstat"

As table 5.4 and figure 5.2 show, South Africa's FDI inflow as a percentage of its GDP was not as low as its global share of FDI inflow in 2014 (0.465%). It was higher than that of Japan (0.157%), despite its small population. The best scale-adjusted indicator is FDI inflow as a percentage of GDP for which South Africa's performance (1.63%) is clearly much high than that of the other countries listed in table 5.4, except for Brazil (2.66%), the United Kingdom (2.45%) and India (1.68%). There are opposing schools of thought with regard to FDI being the source of technological progress, with some in support and others against this view.

Table 5.4: Benchmarking of FDI Inflow, 2014

	FDI Inflow (R million)	FDI Inflow as % of GDP	% World Share of FDI Inflow
South Africa	61 975	1.63	0.465
BRIC	2 673 115	1.48	18.042
Brazil	678 071	2.66	5.088
Russia	227 394	1.13	1.706
India	373 424	1.68	2.802
China	1 394 225	1.24	8.446
Japan	22 677	0.05	0.157
South Korea	103 032	0.7	0.87
United Kingdom	783 815	2.45	5.881
United States	1 002 507	0.53	14.688

Source: United Nations Conference on Trade and Development "UNCTADstat"

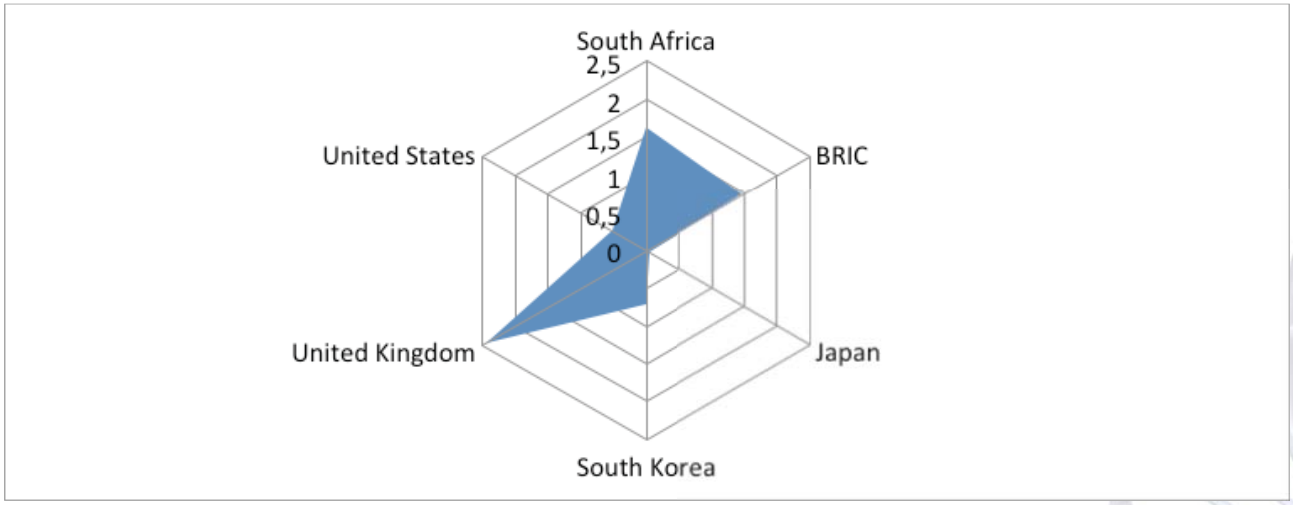


Figure 5.2: Inflow of FDI as a Percentage of GDP

6. Business Performance and Key Industrial Sectors

The NDP seeks to ensure that there is a rising share of South Africa's diversified exports outside of the minerals cluster through non-mineral manufacturing and services. It is anticipated that this diversified trade will reduce a strong link to commodity cycles and vulnerability to the associated volatility in exchange rate earnings. In this chapter the analysis is focused on trends in the export of goods as well as revealed comparative advantage (RCA) of various sectors, as classified by technological intensity.

6.1 Export of Goods

Table 6.1 shows South Africa's export performance trends classified according to technological intensity (Appendix C). In 2014, exports from high technology manufacturers were significantly lower than the total merchandise exports for that year (<0.001%) whereas, during the same year, medium technology manufacturers' exports were 0.5% of global exports in the same category. In order to position South Africa as a knowledge-based economy, the Ten-Year Innovation Plan has set a target of 55% of high- and medium technology exports as a percentage of all exports, up from the 32% share in 2014. Medium technology manufacturing exports accounted for 28.7% of South Africa's total exports, compared with just 3.9% in the case of high technology manufacturing exports (at just 0.1% of global exports).

Table 6.1: Export Performance of Various South African Merchandise by Technological Intensity

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Primary Products	Exports (R billion)	89	117	153	184	144	169	203	192	228	230
	% World Share	0.83	0.83	0.91	0.72	0.79	0.85	0.78	0.64	0.65	0.61
	% Country Share	29.83	32.81	33.89	30.15	31.57	28.01	25.85	23.69	24.78	23.42
Resource-Based Manufactures	Exports (R billion)	77	87	91	160	129	177	225	236	282	296
	% World Share	0.74	0.69	0.59	0.73	0.76	0.94	0.95	0.89	0.87	0.84
	% Country Share	25.63	24.53	20.18	26.26	28.29	29.33	28.65	29.13	30.69	30.14
Low Technology Manufactures	Exports (R billion)	31	35	42	44	35	53	53	58	62	71
	% World Share	0.33	0.31	0.31	0.25	0.24	0.37	0.31	0.30	0.26	0.25
	% Country Share	10.32	9.78	9.31	7.28	7.70	8.76	6.80	7.20	6.75	7.27
Medium Technology Manufactures	Exports (R billion)	87	99	129	196	128	177	196	216	241	282
	% World Share	0.44	0.42	0.45	0.52	0.44	0.58	0.55	0.53	0.50	0.50
	% Country Share	29.07	27.93	28.63	32.14	28.08	29.22	25.04	26.62	26.27	28.72

High Technology Manufactures	Exports (R billion)	12	14	17	21	16	21	24	27	30	38
	% World Share	0.09	0.09	0.09	0.09	0.08	0.10	0.10	0.10	0.09	0.10
	% Country Share	4.03	4.05	3.76	3.42	3.58	3.41	3.01	3.36	3.27	3.89
Unclassified Products	Exports (R billion)	3	3	5	5	4	8	83	81	76	65
	% World Share	0.12	0.10	0.11	0.07	0.06	0.13	1.20	1.05	0.80	0.63
	% Country Share	1.12	0.90	1.10	0.75	0.78	1.27	10.65	10.00	8.24	6.56

Source: United Nations Conference on Trade and Development "UNCTADstat"

As tables 6.1 and 6.2 and figure 6.1 show, the highest share of South Africa's merchandise exports is accounted for by resource-based manufacturers (30.14% in 2014), followed by medium technology manufacturers (28.72%), primary products (23.42%), low technology manufactures (7.27%) and high technology manufacturers (3.89%). About 6.56% of the merchandise exports could not be classified under Lall's framework (Appendix C). In service-based economies such as Japan, the United Kingdom and the United States, the share of high technology exports is about 18% to 19% of their total exports.

South African merchandise exports as a percentage of world exports are very low as figure 6.1 shows. The highest percentage of the global share of exports for the different product groups relates to resource-based manufacturers (0.84% in 2014) while the lowest global share of exports is in respect of high technology manufacturers (0.10%).

Table 6.2: Benchmarking of Export Performance by Technology Intensiveness, 2014

		South Africa	BRIC	Japan	South Korea	United Kingdom	United States
Primary Products	Exports (R billion)	230	4 984	170	150	626	1 993
	% World Share	0.61	13.20	0.45	0.40	1.66	5.28
	% Country Share	23.42	13.58	2.29	2.41	11.28	11.34
Resource-Based Manufactures	Exports (R billion)	296	5 791	710	1 015	788	3 296
	% World Share	0.84	16.46	2.02	2.89	2.24	9.37
	% Country Share	30.14	15.78	9.57	16.32	14.21	18.76
Low Technology Manufactures	Exports (R billion)	71	9 308	629	608	550	1 410
	% World Share	0.25	33.14	2.24	2.16	1.96	5.02
	% Country Share	7.27	25.36	8.47	9.77	9.92	8.02

Medium Technology Manufactures	Exports (R billion)	282	7 599	4 039	2 653	1 842	5 626
	% World Share	0.50	13.514	7.182	4.717	3.276	10.005
	% Country Share	28.72	20.70	54.43	42.66	33.22	32.01
High Technology Manufactures	Exports (R billion)	38	8 631	1 425	1 776	1 040	3 132
	% World Share	0.10	22.65	3.74	4.66	2.73	8.22
	% Country Share	3.89	23.52	19.20	28.56	18.75	17.82
Unclassified Products	Exports (R billion)	65	65	391	448	17	700
	% World Share	0.63	3.79	4.34	0.17	6.78	20.51
	% Country Share	6.56	1.06	6.04	0.28	12.62	12.04

Source: United Nations Conference on Trade and Development "UNCTADstat"

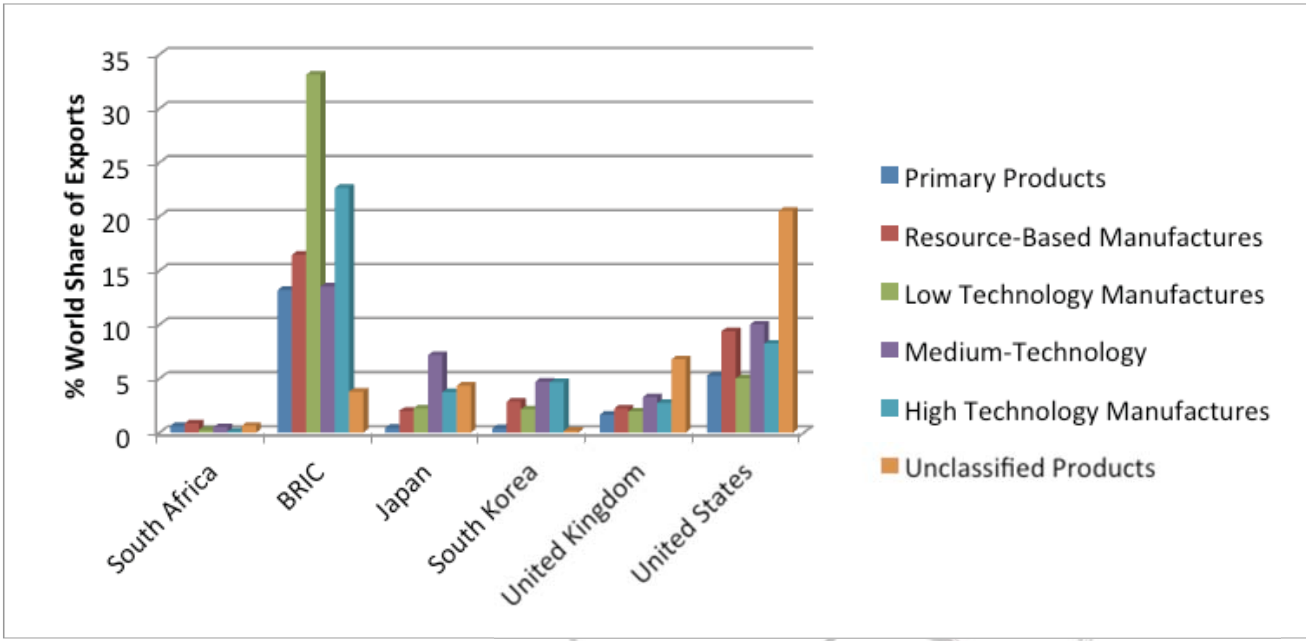


Figure 6.1: Benchmarking of World Share of Products Export by Technology Intensiveness

6.2 Revealed Comparative Advantage

RCA is an index similar to the RTA although it measures the comparative advantage of merchandise exports. The latter is measured by the country's share of exports in the specific product group divided by a country's share of exports for all the products. The RCA index is equal to zero when the country has no exports for a given product group, is equal to 1 when the country's share in exports for the product group equals its share of all merchandise exports (no specialisation) and above 1 when a positive specialisation is observed.

As table 6.3 and figure 6.2 show, the country has positive specialisation in resource-based manufactures (1.76), primary products (1.28) and medium technology manufacturers (1.05). On the other hand, low technology and high technology manufacturers have low RCA values (0.53 and 0.21 respectively). The similarities between RCA and RTA structures with regard to low and high technologies, confirms the relationship between technical progress and business performance.

Table 6.3: Benchmarking of South Africa's RCA, 2014

	South Africa	BRIC	Japan	South Korea	United Kingdom	United States
Primary Products	1.28	0.74	0.12	0.13	0.61	0.62
Resource-Based Manufactures	1.76	0.92	0.56	0.95	0.83	1.10
Low Technology Manufactures	0.53	1.86	0.62	0.72	0.73	0.59
Medium Technology Manufactures	1.05	0.76	1.99	1.56	1.22	1.17
High Technology Manufactures	0.21	1.27	1.04	1.54	1.01	0.96
Unclassified Products	1.31	0.21	1.20	0.06	2.52	2.40

Source: United Nations Conference on Trade and Development "UNCTADstat"

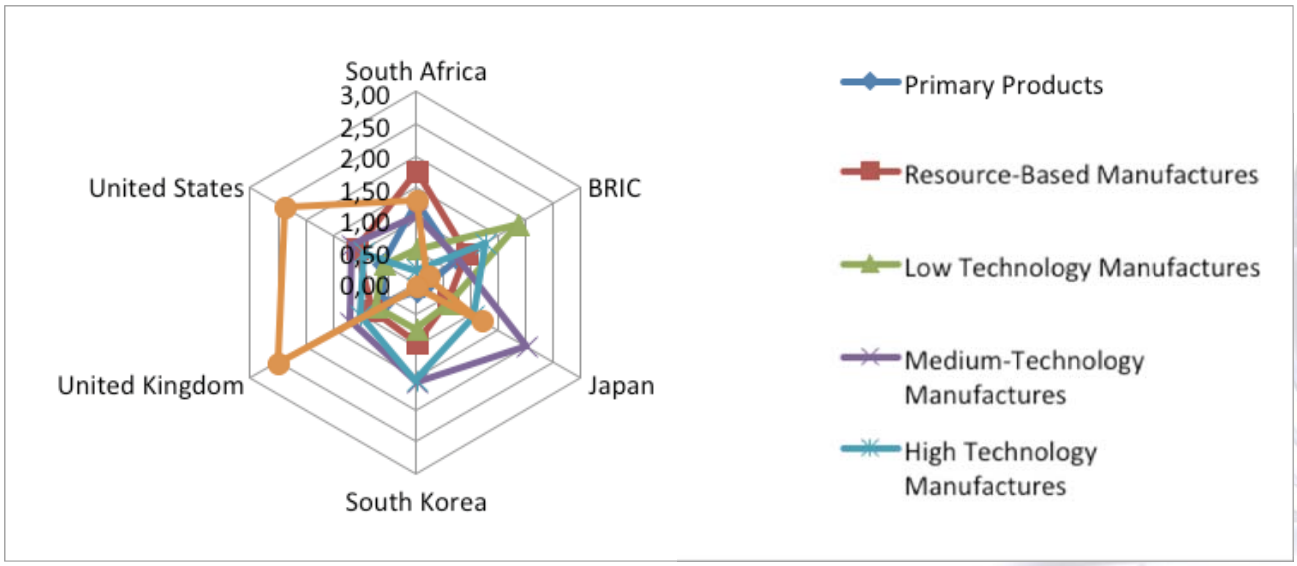


Figure 6.2: Illustration of RCA, 2014

7. Wealth Creation

Economic growth and wealth creation are key ingredients in achieving a decent standard of living for a country's inhabitants. Technological innovation contributes towards high levels of business performance that translates into higher wages and profits. GDP and employment statistics are indicators of a country's aggregate value added across different economic sectors and are analysed to monitor progress towards wealth creation in eradicating poverty and reducing inequality.

7.1 Gross Domestic Production

As table 7.1 and figure 7.1 show, South Africa's manufacturing economic activity is mainly concentrated in Gauteng (40.8%), followed by KwaZulu-Natal (21.7%) and the Western Cape (14.7%).

Table 7.1: Regional Distribution of Economic Activity, 2013

	Eastern Cape	Free State	Gauteng	KwaZu-lu- Natal	Limpopo	Mpuma langa	North West	Northern Cape	Western Cape	SA
Agriculture, forestry and fishing	5.4	10.5	5.9	26.4	8.4	8.5	6.2	6.1	22.6	100
Mining and quarrying	0.2	7.8	12.9	3.4	23.7	20.0	24.7	6.9	0.3	100
Manufacturing	7.9	3.8	40.8	21.7	1.4	7.3	2.2	0.2	14.7	100
Electricity and water	3.8	6.0	34.2	15.6	8.1	15.4	3.4	2.5	10.9	100
Construction	4.7	3.0	43.3	13.5	5.3	6.7	4.7	1.2	17.6	100
Wholesale, retail and motor trade; catering and accommodation	8.3	4.7	35.4	17.7	5.4	5.3	4.5	1.5	17.3	100
Transport, storage and communication	7.2	4.4	34.4	22.5	4.7	4.7	4.6	2.1	15.6	100
Finance, real estate and business services	7.0	4.0	41.9	13.5	5.2	4.2	4.0	1.4	18.9	100
General government services	11.0	4.9	39.6	14.9	7.9	5.0	5.1	2.0	9.6	100
Personal services	12.9	9.9	23.8	17.2	5.0	5.5	8.4	3.5	13.8	100

Source: Statistics South Africa "Gross Domestic Product, P0441"

Gauteng is also the hub for economic sectors other than agriculture and mining. Agriculture (including forestry and fishing) is relatively prominent in KwaZulu-Natal (26.4% of total agriculture value added), followed by the Western Cape (22.6%). Mining activities are prominent in the North West (24.7%), followed by Limpopo (23.7%) and Mpumalanga (20.0%).

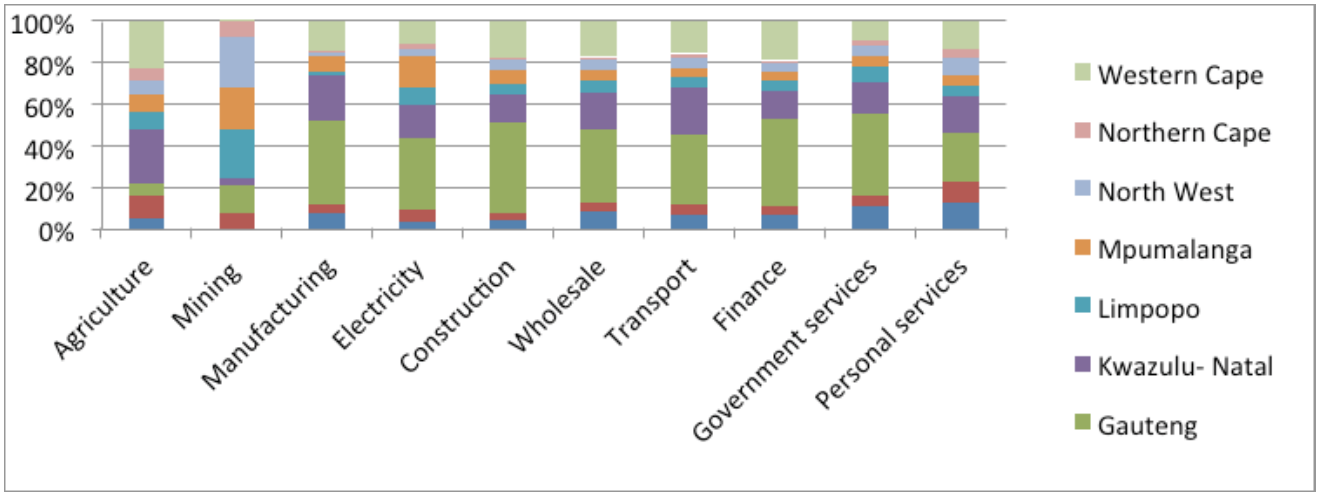


Figure 7.1: Provincial Share of Economic Activity, 2013

As was previously stated, South Africa is principally a services driven economy with services accounting for 68.9% of value added. Within BRICS, the other similarly structured economy is Brazil (with value-added of services accounting for 71.0% of its GDP). Many developed economies are services driven with the top three being the United Kingdom (78.4%), the United States (78.1%) and Japan (72.6%). As table 7.2 and figure 7.2 show, the countries with the lowest services value-added as a percentage of GDP show the highest values of manufacturing value-added as a percentage of GDP (35.9% for China and 30.3% for South Korea) except for India where agriculture accounts for a relatively high share of value-added (17.8%).

Table 7.2: Benchmarking of Contributions of Different Sectors to the Economy, 2014

	South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Agriculture Value-Added (as % of GDP)	2.6	5.6	4.2	17.8	9.2	1.2	2.3	0.7	1.4
Industry Value-Added (as % of GDP)	14.6	12.5	20.2	13.0	6.8	7.7	7.9	10.4	8.1
Manufacturing Value-Added, Excl. Manufacturing (as % of GDP)	13.9	10.9	15.6	17.1	35.9	18.5	30.3	10.6	12.4
Services Value-Added (as % of GDP)	68.9	71.0	60.0	52.1	48.1	72.6	59.4	78.4	78.1

Source: World Development Indicators

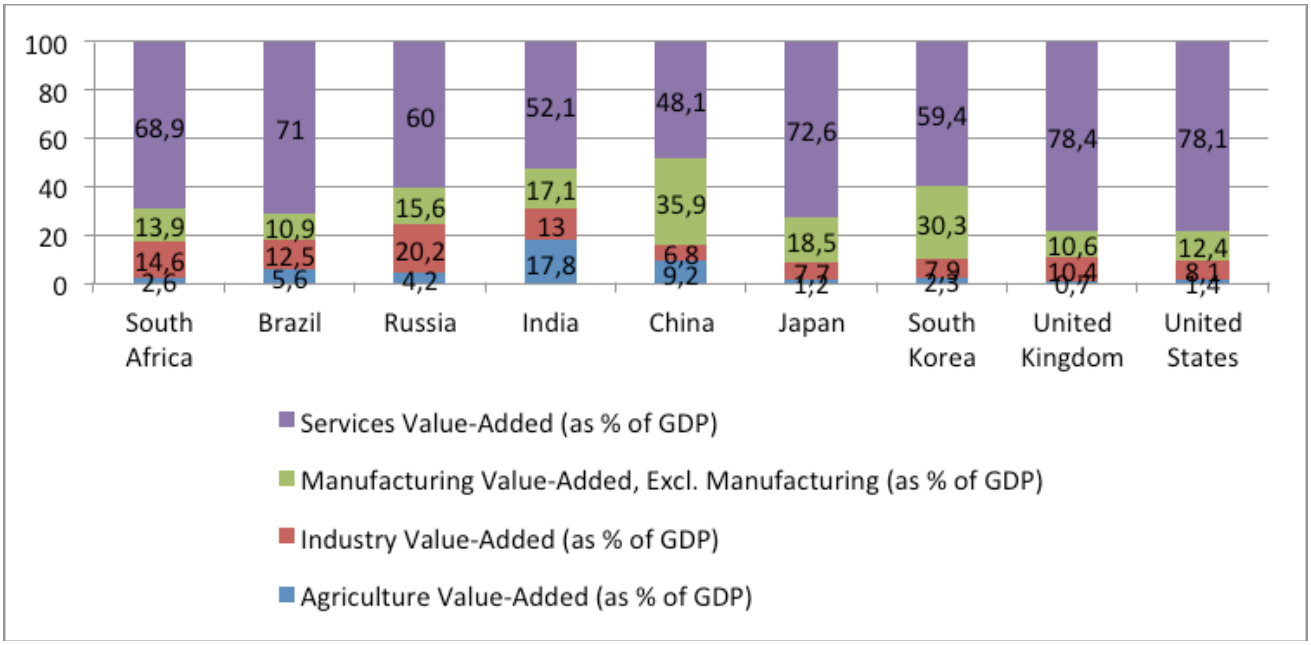


Figure 7.2: Illustration of Sector Contribution to GDP for Selected Countries, 2014

7.2 Employment

As table 7.3 and figure 7.3 show, the Gauteng province has the highest share of total employment in the country (31.9% in 2014), followed by KwaZulu-Natal (16.4%) and the Western Cape (14.5%). Northern Cape has the lowest share of the country's employment (2.0%). The labour force participation rate is also highest in Gauteng (68.8%), followed by the Western Cape (67.8%) and the Free State (61.2%).

Table 7.3: Labour Force Characteristics by Province, 2014

	Labour Force ('000)	Employed ('000)	Country Share of Employment (%)	Unemployed ('000)	Unemployment Rate (%)	Labour Force Participation Rate (%)
Eastern Cape	7 673	5 400	8.9	2 273	29.6	47.1
Free State	4 546	2 996	4.9	1 551	34.1	61.2
Gauteng	25 692	19 298	31.9	6 396	24.9	68.8
KwaZulu-Natal	12 805	9 946	16.4	2 859	22.3	48.4
Limpopo	5 740	4 791	7.9	949	16.5	40.9
Mpumalanga	6 373	4 527	7.5	1 846	29.0	58.9
North West	4 917	3 618	6.0	1 300	26.4	51.6
Northern Cape	1 753	1 227	2.0	525	29.9	57.9
Western Cape	11 366	8 781	14.5	2 586	22.8	67.8
Total for Country	80 866	60 586	100	20 281	25.1	57.1

Source: Statistics South Africa "Quarterly Labour Force Survey, P0211"

Although Limpopo had the lowest unemployment rate in 2014 (16.5%), it also had the lowest labour force participation rate (40.9%). Similar circumstances prevail in KwaZulu-Natal.

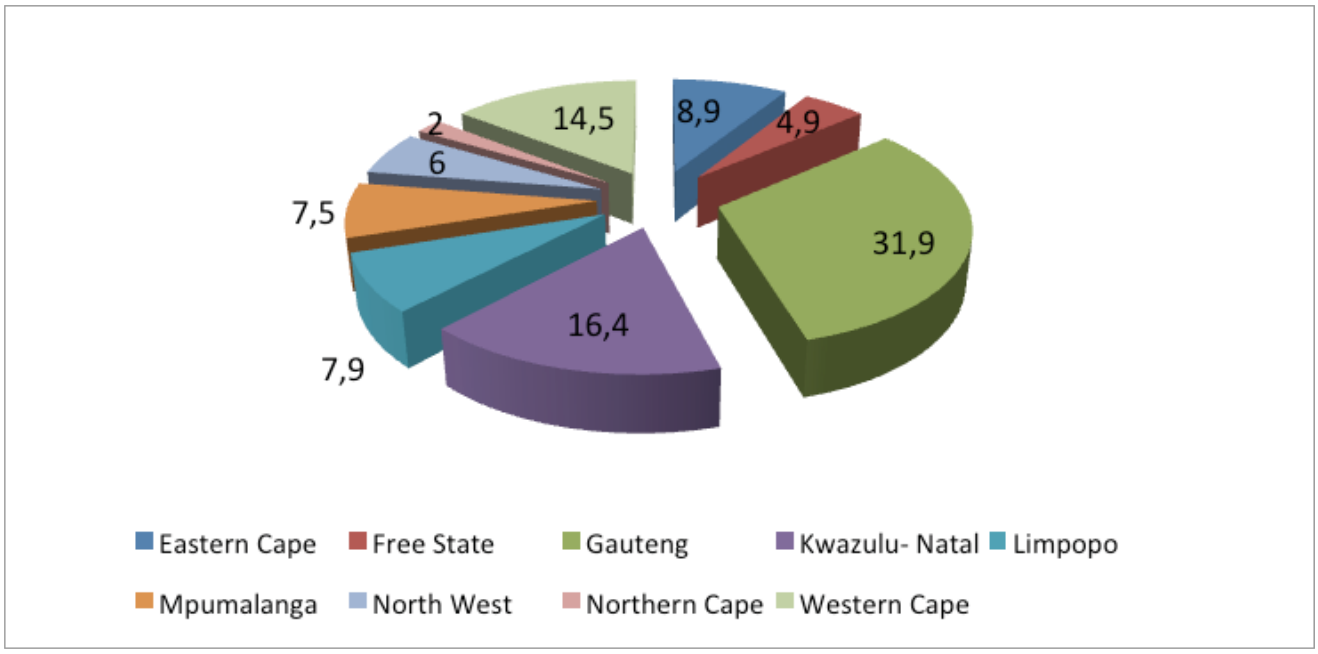


Figure 7.3: Country Share of Employment by Province, 2014

An analysis of labour force characteristics by population group (table 7.4) shows that whites have by far the lowest unemployment rate (7.4% in 2014) and the highest labour force participation rate (67.6%). Indians have a low share of the country's employment (3.3%) although the unemployment rate for this population group is also low (12.0%). Africans have the highest country share of employment (73.1%) but also the highest unemployment rate (28.1%) and the lowest labour force participation rate (54.9%). The second highest unemployment rate is for coloureds (24.0%), although this group's labour force participation rate is high (65.0%).

Table 7.4: Labour Force Characteristics by Population Group, 2014

	Labour Force ('000)	Employed ('000)	Country Share of Employment (%)	Unemployed ('000)	Unemploy-ment Rate (%)	Labour Force Participation Rate (%)
Black African	61 651	44 313	73.1	17 339	28.1	54.9
Coloured	8 541	6 494	10.7	2 048	24.0	65.0
Indian/Asian	2 262	1 991	3.3	272	12.0	58.7
White	8 411	7 788	12.9	624	7.4	67.6
Total for Country	80 866	60 586	100	20 281	25.1	57.1

Source: Statistics South Africa "Quarterly Labour Force Survey, P0211"

In terms of gender (table 7.5), females have a lower share of the country's employment (43.8% in 2014), a lower labour force participation rate (50.7%) and a higher unemployment rate (27.2%) than is the case for males.

Table 7.5: Labour Force Characteristics by Gender, 2014

	Labour Force ('000)	Employed ('000)	Country Share of Employment (%)	Unemployed ('000)	Unemployment Rate (%)	Labour Force Participation Rate (%)
Females	36 461	26 535	43.8	9 926	27.2	50.7
Males	44 404	34 050	56.2	10 354	23.3	63.7
Total for Country	80 866	60 586	100	20 281	25.1	57.1

Source: Statistics South Africa "Quarterly Labour Force Survey, P0211"

Although South Africa's labour force participation rate, at 57.1%, is higher than that of India (52.5%) and Brazil (56.0%), and not much lower than that of Japan (59.5%), South Korea (62.4%), the United Kingdom (62.7%) and the United States (62.9%), its unemployment rate is significantly higher than it is in all of these countries (table 7.6).

Table 7.6: Benchmarking of South African Employment Statistics, 2014

	South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Labour Force Participation Rate (%)	57.1	56.0	68.9	52.5	70.7	59.5	62.4	62.7	62.9
Female Labour Force Participation Rate (%)	50.7	48.2	63.3	25.8	-	49.2	51.3	57.0	57.0
Male Labour Force Participation Rate (%)	63.7	65.2	75.1	74.4	-	70.4	74.0	68.6	69.2
Unemployment Rate (%)	25.1	4.8	5.1	3.6	4.7	3.7	3.5	6.3	6.2
Female Unemployment Rate (%)	27.2	8.7	4.8	4.0	3.9	3.4	3.1	5.8	6.0
Male Unemployment Rate (%)	23.3	5.2	5.4	3.5	5.4	3.9	3.9	6.7	6.4

Source:World Development Indicators

8. Quality of Life

The notion of quality of life extends beyond the financial position of individuals, families, organisations or the country; it also includes a range of social issues such as health, the environment, knowledge, ecosystem vitality and a wide range of other basic human necessities. Developments (incremental or radical) in STI do have a significant impact on quality of life. Several international indices are used in this chapter to benchmark various components of quality of life against key priorities such as human development as well as environmental and social performance.

8.1 Human Development Index

The ranking of South African human development, as measured through components of health, education and individual wealth, is very low when compared to other BRIC countries except for India (table 8.1). At the indicators level in this framework (figure 8.1), a low comparative value is that of life expectancy at birth (57.4 years), even if the trend of this indicator may have been improving and continues to improve on the back of a successful rollout of antiretroviral drugs to combat the spread of HIV/AIDS.

Table 8.1: Benchmarking of Human Development, 2014

		South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Component	Indicator									
Long and Healthy Life	Life Expectancy at Birth (years)	57.4	74.5	70.1	68.0	75.8	83.5	81.9	80.7	79.1
Knowledge	Mean Years of Schooling (years)	9.9	7.7	12.0	5.4	7.5	11.5	11.9	13.1	12.9
	Expected Years of Schooling (years)	13.6	15.2	14.7	11.7	13.1	15.3	16.9	16.2	16.5
A Decent Standard of Living	GNI per Capita (2011 PPP $)	12 122	15 175	22 352	5 497	12 547	36 927	33 890	39 267	52 947
Human Development Index (HDI)		0.666	0.755	0.798	0.609	0.727	0.891	0.898	0.907	0.915
HDI World Ranking		116	75	50	130	90	20	17	14	8

Source: United Nations Human Development Programme "2015 Human Development Report"

In contrast with the low result for life expectancy, the mean number of schooling years (13.6 years) is higher than the corresponding figure for India (5.4 years), China (7.5 years) and Brazil (7.7 years) and on a par with countries such as the United Kingdom (13.1 years) and the United States (12.9 years).

On the other hand, the Gross National Income (GNI) per capita is much lower than that of the industrialised economies, which is also the case for most BRICS countries.

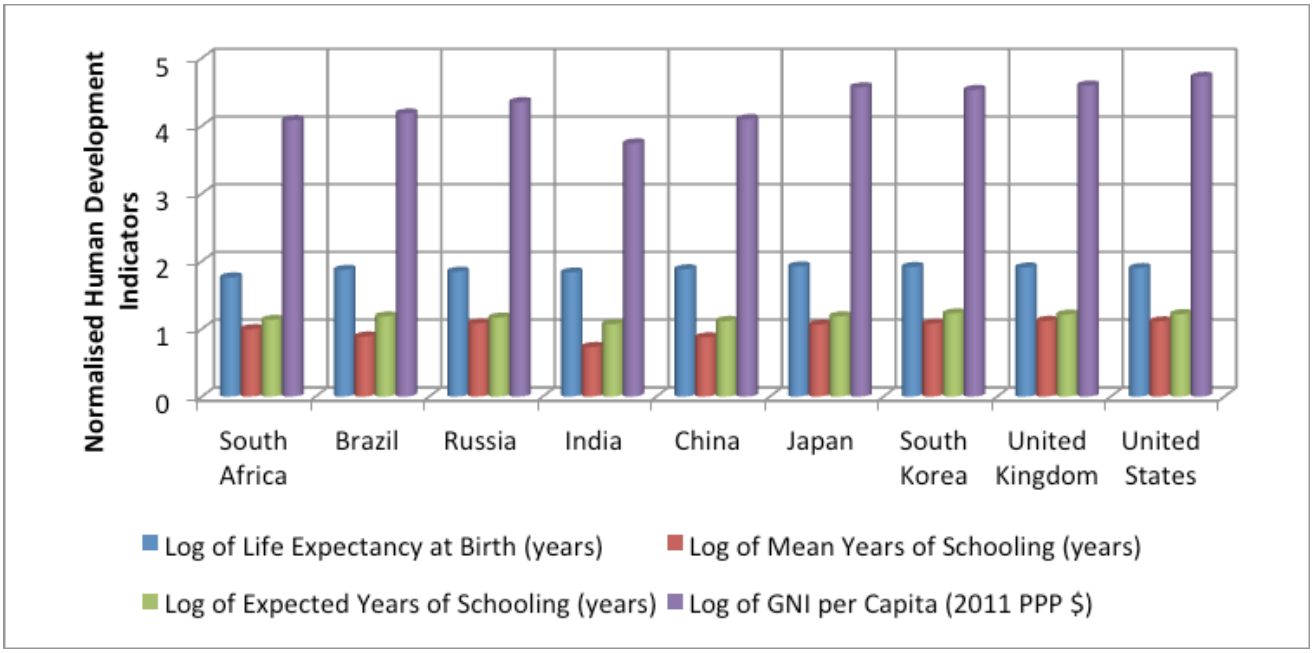


Figure 8.1: HDI Comparison, 2014

8.2 Environmental Performance Index

Table 8.2 partly explains the low life expectancy at birth for South Africans as it is also ranked low (130th) for environmental impact on health. Water and sanitation are challenges that need to be addressed for environmental health to be improved as the country is ranked 107th. The fishing ecosystem vitality also need to improve as South Africa is the lowest in terms of this world ranking among the BRICS group of countries (97th), followed by Russia (92nd), China (89th) and India (67th) and Brazil (53rd).

Table 8.2: World Rankings on Environmental Performance, 2014

		South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Component	Sub-Component									
Environmental Health	Health Impacts	130	95	64	127	80	24	29	1	35
	Air Quality	48	29	49	174	176	70	166	45	38
	Water and Sanitation	107	84	92	124	109	1	37	1	36
Ecosystem Vitality	Water Resources	56	86	62	87	67	26	18	3	32
	Agriculture	66	70	171	117	166	160	158	87	109
	Forests	1	115	57	57	80	35	62	50	107
	Fisheries	97	53	92	67	89	48	69	98	96
	Biodiversity and Habitat	84	75	106	125	76	62	108	70	86
	Climate and Energy	65	57	38	104	21	86	93	56	49

Source: Yale Center for Environmental Law and Policy "The 2014 Environmental Performance Index"

8.3 Social Progress Index

As table 8.3 shows, South Africa is doing comparatively well on social progress (63rd ranking) relative to its BRIC counterparts India (101st), China (92nd) and Russia (71st). The distinct area that contributes to this moderate social progress is the availability of opportunities, especially in terms of personal rights (33rd), personal freedom and choice (35th) and tolerance and inclusion (48th) although access to advanced education is ranked relatively low (72nd). STI can be used to improve social services such as nutrition and basic medical care, water and sanitation, shelter, personal safety, health and wellness, as well as ecosystem sustainability.

Table 8.3: World Rankings on Social Progress Performance, 2015

		South Africa	Brazil	Russia	India	China	Japan	South Korea	United Kingdom	United States
Component	Sub-Component									
Basic Human Needs	Nutrition and Basic Medical Care	89	61	45	95	73	17	36	27	39
	Water and Sanitation	72	62	66	98	84	21	49	17	28
	Shelter	82	69	65	99	58	4	27	18	6
	Personal Safety	129	122	107	99	76	10	22	20	30
	Sub-Component Ranking	92	74	70	101	71	5	26	19	21
Foundations of Wellbeing	Access to Basic Knowledge	61	38	34	94	49	1	16	18	45
	Access to Information and Communication	44	54	57	108	105	18	20	15	23
	Health and Wellness	114	34	131	120	103	19	39	27	68
	Ecosystem Sustainability	75	38	51	108	71	67	103	60	74
	Sub-Component Ranking	64	30	77	113	88	20	34	15	35
Opportunity	Personal Rights	33	33	122	70	132	5	45	2	24
	Personal Freedom and Choice	35	36	90	84	40	21	33	12	15
	Tolerance and Inclusion	48	24	114	128	116	42	40	21	15
	Access to advanced Education	72	62	2	87	73	19	10	4	1
	Sub-Component Ranking	37	32	70	91	110	19	28	6	8
Social Progress Ranking		63	42	71	101	92	15	29	11	16

Source: Social Progress Imperative "Social Progress Index 2015"

9. Appendices

Appendix A: Research Collaborations for Selected Higher Education Institutions

Tables 9.1 to 9.13 show the countries with which the individual universities collaborate and the number of co-authored articles during the 2005-2014 period. The USA is the major collaborating country for all South African universities. England appears second in the list for seven universities and Germany for two institutions. France, Australia and Netherlands follow in third to sixth position.

Table 9.1 Countries Collaborating with the University of Cape Town 2005-2014

Countries	Record Count	%
USA	3 427	23.39%
England	2 738	18.69%
France	1 292	8.82%
Germany	1 256	8.57%
Australia	111	7.58%
Netherlands	978	6.66%
Canada	904	6.17%
Switzerland	822	5.33%
Italy	780	5.33%
Sweden	695	4.74%
Spain	693	4.73%
Norway	607	4.14%
Scotland	606	4.14%
Japan	575	3.93%
Brazil	559	3.82%
Peoples R China	518	3.54%
Denmark	509	3.48%
Poland	443	3.02%
India	417	2.85%
Russia	407	2.78%
Austria	398	2.72%
Romania	378	2.58%
Greece	373	2.55%
Czech Republic	369	2.52%

Table 9.2: Countries Collaborating with the University of the Witwatersrand 2005-2014

Countries	Record Count	%
USA	2 597	23.05%
England	1 539	13.66%
Australia	1 003	8.90%
Germany	874	7.76%
France	740	6.57%
Switzerland	631	5.60%
Sweden	630	5.59%
Peoples R China	624	5.54%
Canada	622	5.52%
Netherland	593	5.26%
Italy	537	4.77%
Spain	530	4.70%
Brazil	500	4.44%
Norway	495	4.39%
Japan	476	4.23%
Scotland	471	4.18%
Denmark	435	3.86%
Austria	432	3.84%
Poland	423	3.76%
Israel	416	3.69%
Russia	405	3.60%
Czech Republic	404	3.59%
Taiwan	400	3.55%
Argentina	392	3.48%

Table 9.3: Countries Collaborating with the University of Pretoria 2005-2014

Countries	Record Count	%
USA	1 326	12.70%
England	627	6.01%
Netherlands	496	4.75%
Australia	453	4.34%
Germany	384	3.68%
France	286	2.74%
Belgium	276	2.64%
Canada	237	2.27%
Scotland	198	1.90%
Spain	191	1.83%

Peoples R China	172	1.63%
Nigeria	143	1.37%
Sweden	143	1.37%
Kenya	142	1.36%
Switzerland	142	1.36%
Italy	127	1.22%
India	122	1.17%
Norway	109	1.04%
Japan	104	1.00%
Zimbabwe	97	0.93%
Portugal	90	0.86%
Brazil	88	0.84%
Denmark	84	0.80%
Argentina	83	0.80%

Table 9.4: Countries Collaborating with the University of Stellenbosch 2005-2014

Countries	Record Count	%
USA	1 348	13.19%
England	884	8.65%
Germany	727	7.11%
Australia	502	4.91%
Netherlands	462	4.52%
France	456	4.46%
Canada	333	3.26%
Belgium	280	2.74%
Peoples R China	259	2.53%
Switzerland	230	2.25%
Italy	214	2.09%
Sweden	198	1.94%
Spain	177	1.73%
Denmark	148	1.45%
Scotland	122	1.19%
Norway	118	1.15%
India	113	1.11%
Japan	101	0.99%
Brazil	99	0.97%
Austria	86	0.84%
Czech Republic	84	0.82%
Russia	83	0.81%
Israel	74	0.72%
Uganda	73	0.71%

Table 9.5: Countries Collaborating with the University of KwaZulu-Natal 2005-2014

Countries	Record Count	%
USA	1 789	17.64%
England	1267	12.49%
France	637	6.28%
Germany	611	6.02%
Canada	543	5.35%
Australia	470	4.63%
India	452	4.46%
Switzerland	402	3.96%
Sweden	399	3.93%
Netherlands	377	3.72%
Spain	377	3.72%
Italy	365	3.60%
Scotland	350	3.45%
Poland	330	3.25%
Denmark	323	3.18%
Portugal	273	2.69%
Peoples R China	271	2.67%
Norway	264	2.60%
Japan	257	2.53%
Chile	255	2.51%
Russia	254	2.50%
Brazil	252	2.48%
Czech Republic	241	2.38%
Taiwan	228	2.25%

Table 9.6: Countries Collaborating with the University of Johannesburg 2005-2014

Countries	Record Count	%
USA	735	19.01%
England	555	14.36%
Germany	515	13.32%
Australia	474	12.26%
France	458	11.85%
Canada	441	11.41%
Japan	437	11.30%
Italy	433	11.20%
Netherlands	432	11.17%
Russia	411	10.63%

Peoples R China	399	10.32%
Sweden	396	10.24%
Switzerland	395	10.22%
Austria	388	10.04%
Scotland	383	9.91%
Spain	380	9.83%
Denmark	373	9.65%
Norway	367	9.49%
Poland	367	9.49%
Brazil	363	9.39%
Israel	362	9.36%
Portugal	358	9.26%
Turkey	357	9.23%
Argentina	355	9.18%

Table 9.7: Countries Collaborating with North-West University 2005-2014

Countries	Record Count	%
USA	447	11.73%
Germany	336	8.82%
England	310	8.14%
Netherlands	266	6.98%
France	250	6.56%
Australia	248	6.51%
Ireland	144	3.78%
Czech Republic	134	3.52%
Sweden	133	3.49%
Namibia	129	3.39%
Armenia	125	3.28%
Belgium	116	3.05%
Poland	108	2.84%
India	105	2.76%
Austria	96	2.52%
Canada	91	2.39%
Nigeria	91	2.39%
Peoples R China	87	2.28%
Italy	82	2.15%
Finland	76	2.00%
Spain	76	2.00%
Japan	68	1.79%
Denmark	57	1.50%
Switzerland	50	1.31%

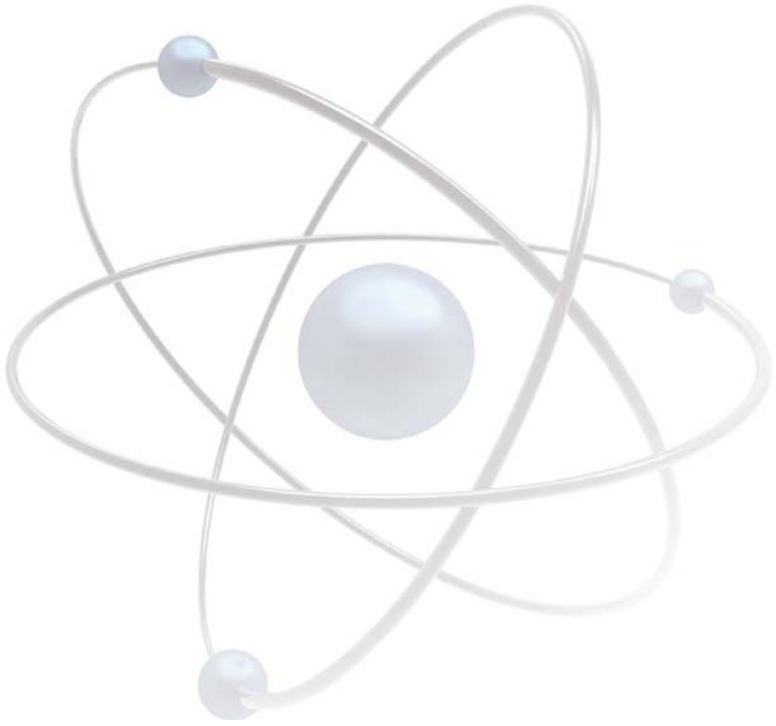
Table 9.8: Countries Collaborating with the University of the Free State 2005-2014

Countries	Record Count	%
USA	279	8.67%
Germany	187	5.81%
England	179	5.56%
Australia	100	3.11%
Belgium	99	3.08%
Netherlands	84	2.61%
Norway	73	2.27%
Canada	72	2.24%
India	70	2.18%
France	67	2.08%
South Korea	49	1.52%
Sweden	48	1.49%
Italy	45	1.40%
Ethiopia	42	1.31%
Poland	42	1.31%
Japan	41	1.27%
Spain	41	1.27%
Austria	39	1.21%
Switzerland	31	0.96%
Kenya	30	0.93%
New Zealand	30	0.93%
Scotland	29	0.90%
Zimbabwe	26	0.81%
Denmark	25	0.78%

Table 9.9: Countries Collaborating with Rhodes University 2005-2014

Countries	Record Count	%
USA	261	8.50%
England	218	7.10%
Australia	178	5.80%
Germany	170	5.54%
Peoples R China	123	4.01%
France	104	3.39%
Canada	96	3.13%
Switzerland	77	2.51%
Nigeria	68	2.21%
Turkey	65	2.12%
Netherlands	59	1.92%
Sweden	57	1.86%

Scotland	44	1.43%
Belgium	41	1.34%
Japan	38	1.24%
Spain	37	1.21%
India	34	1.11%
New Zealand	33	1.08%
Russia	30	0.98%
Brazil	29	0.94%
Italy	29	0.94%
Zimbabwe	26	0.85%
Norway	25	0.81%
Botswana	21	0.68%



Appendix B

Table 9.10: Number of South African Patents Published by Technology

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unknown	32	145	46	50	68	44	49	16	24	38
Electrical machinery, apparatus, energy	63	74	73	79	101	107	53	67	43	51
Audio-visual technology	53	34	33	47	36	44	17	14	14	16
Telecommunications	49	54	34	37	45	16	9	8	9	19
Digital communication	24	38	17	20	34	21	17	12	22	18
Basic communication processes	4	4	2	4	9	15	9	5	5	6
Computer technology	76	50	40	75	62	69	47	54	41	30
IT methods for management	31	48	48	67	110	70	66	69	70	45
Semiconductors	7	55	17	14	16	18	16	20	12	11
Optics	4	4	4	11	4	4	2	7	3	12
Measurement	65	54	45	47	55	54	45	31	25	37
Analysis of biological materials	6	21	7	8	3	3	4	3	9	7
Control	87	64	61	56	48	43	17	19	19	17
Medical technology	94	97	101	139	74	96	69	71	74	68
Organic fine chemistry	43	55	75	45	66	50	58	54	37	36
Biotechnology	38	23	36	32	61	42	40	26	33	23
Pharmaceuticals	53	88	48	58	62	52	59	38	72	45
Macromolecular chemistry, polymers	18	13	8	12	16	19	6	8	8	8
Food chemistry	35	52	31	43	35	27	30	16	15	40
Basic materials chemistry	94	109	142	156	118	116	57	71	64	53
Materials, metallurgy	91	145	159	161	149	121	107	69	72	48
Surface technology, coating	15	23	30	31	28	24	14	15	18	28
Microstructural and nano-technology			1	1	1	1		2	4	4
Chemical engineering	157	143	88	128	124	102	74	67	72	71
Environmental technology	48	46	34	61	48	57	27	22	33	24
Handling	126	115	122	153	117	108	62	45	42	39
Machine tools	62	73	58	59	57	49	28	17	29	45
Engines, pumps, turbines	100	50	52	56	72	47	44	25	28	23
Textile and paper machines	33	12	11	16	15	15	14	7	5	4
Other special machines	118	102	90	123	83	106	55	59	81	78
Thermal processes and apparatus	30	29	55	50	58	61	15	12	26	41
Mechanical elements	93	88	67	83	73	56	29	34	40	35
Transport	106	86	79	113	81	69	35	56	33	29
Furniture, games	133	91	123	131	97	99	41	50	53	37
Other consumer goods	55	38	60	72	75	81	38	48	43	28
Civil engineering	253	172	164	238	219	165	87	79	86	62

Table 9.11: Total Number of World Patents Published by Technology

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unknown	20 260	47 075	40 786	37 350	35 639	31 571	34 130	32 800	35 586	33 617
Electrical machinery, apparatus, energy	92 726	97 626	101 562	105 979	112 237	116 478	124 365	147 589	163 275	170 643
Audio-visual technology	88 962	93 513	90 440	86 711	80 590	75 818	72 504	74 805	74 659	71 258
Telecommunications	62 753	68 048	66 856	67 310	60 175	56 102	50 613	51 500	50 814	49 128
Digital communication	55 576	59 679	64 225	70 359	73 874	78 271	83 014	92 753	102 818	117 179
Basic communication processes	18 022	17 252	17 170	17 129	16 440	16 076	15 419	15 923	16 030	15 833
Computer technology	107 557	117 623	122 109	131 371	128 548	125 155	130 358	147 970	164 199	179 016
IT methods for management	18 518	20 031	20 606	22 326	24 834	23 296	23 898	28 661	33 734	39 240
Semiconductors	67 162	70 539	73 193	75 733	74 163	73 431	76 734	82 115	82 575	81 055
Optics	70 118	72 849	73 920	71 800	66 941	61 926	60 495	63 526	64 827	61 347
Measurement	64 890	65 831	69 499	75 493	79 718	80 514	81 272	98 000	107 570	114 072
Analysis of biological materials	13 503	11 906	12 102	12 417	12 807	12 525	13 025	13 279	13 862	14 562
Control	28 053	27 867	28 830	29 702	29 887	29 692	29 033	33 461	37 793	42 902
Medical technology	72 932	72 344	78 932	82 427	82 763	82 894	85 172	93 623	98 400	105 089
Organic fine chemistry	61 934	62 390	61 799	63 473	61 501	61 088	60 000	60 654	61 478	60 244
Biotechnology	41 059	37 132	37 641	39 940	41 390	42 917	46 310	46 819	49 655	51 048
Pharmaceuticals	78 945	83 046	83 775	85 746	83 133	79 631	80 615	82 098	86 312	91 002
Macromolecular chemistry, polymers	29 349	28 133	29 975	30 464	30 980	30 580	30 865	35 675	39 745	41 226
Food chemistry	24 097	22 175	23 111	25 287	28 992	29 633	32 633	36 263	43 583	56 586
Basic materials chemistry	41 473	40 639	43 652	46 081	47 154	48 831	50 417	57 720	64 317	71 310
Materials, metallurgy	30 753	30 292	32 508	36 522	37 350	39 576	41 480	50 067	54 540	58 007
Surface technology, coating	28 688	29 382	30 130	31 708	33 594	33 818	34 671	39 752	40 184	39 533
Micro-structural and nano-technology	2 148	2 167	2 505	2 659	3 115	3 318	3 411	4 015	4 138	4 386
Chemical engineering	36 030	35 319	36 655	38 563	39 073	40 094	41 719	47 399	51 735	53 223
Environmental technology	21 946	21 903	23 177	24 183	25 999	27 491	28 198	33 533	35 627	37 291
Handling	46 436	45 192	46 094	46 331	46 250	46 065	48 269	54 297	58 831	61 322
Machine tools	38 040	37 418	37 995	39 713	42 004	44 858	48 056	57 795	62 648	65 547
Engines, pumps, turbines	44 163	42 394	44 968	46 844	51 765	51 863	52 397	60 036	66 456	63 870
Textile and paper machines	39 972	38 431	37 442	35 408	33 916	32 203	31 845	35 851	36 824	36 188
Other special machines	49 546	47 276	47 136	49 326	50 825	52 660	55 185	64 393	69 245	75 488
Thermal processes and apparatus	25 531	25 919	26 813	27 256	28 936	31 188	32 069	36 068	37 549	38 844
Mechanical elements	45 804	45 605	47 221	51 358	50 937	49 787	50 241	57 533	62 450	65 100
Transport	70 783	68 372	70 136	72 823	75 461	71 984	71 035	83 494	93 741	98 008
Furniture, games	43 877	44 643	45 678	46 276	44 543	43 843	43 855	49 336	53 295	57 278
Other consumer goods	35 175	34 111	33 668	34 078	34 293	34 679	35 789	41 225	43 277	45 992
Civil engineering	55 150	58 120	57 394	58 030	59 482	61 328	63 007	71 778	77 736	80 979

Table 9.12: Percentage Country Share of South African Patents Published by Technology

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unknown	1.39	6.32	2.23	2.02	2.93	2.12	3.66	1.32	1.90	3.23
Electrical machinery, apparatus, energy	2.74	3.22	3.54	3.19	4.35	5.17	3.96	5.51	3.40	4.34
Audio-visual technology	2.31	1.48	1.60	1.90	1.55	2.12	1.27	1.15	1.11	1.36
Telecommunications	2.13	2.35	1.65	1.49	1.94	0.77	0.67	0.66	0.71	1.62
Digital communication	1.05	1.66	0.82	0.81	1.47	1.01	1.27	0.99	1.74	1.53
Basic communication processes	0.17	0.17	0.10	0.16	0.39	0.72	0.67	0.41	0.40	0.51
Computer technology	3.31	2.18	1.94	3.03	2.67	3.33	3.51	4.44	3.24	2.55
IT methods for management	1.35	2.09	2.33	2.71	4.74	3.38	4.93	5.67	5.54	3.83
Semiconductors	0.30	2.40	0.82	0.57	0.69	0.87	1.19	1.64	0.95	0.94
Optics	0.17	0.17	0.19	0.44	0.17	0.19	0.15	0.58	0.24	1.02
Measurement	2.83	2.35	2.18	1.90	2.37	2.61	3.36	2.55	1.98	3.15
Analysis of biological materials	0.26	0.92	0.34	0.32	0.13	0.14	0.30	0.25	0.71	0.60
Control	3.79	2.79	2.96	2.26	2.07	2.08	1.27	1.56	1.50	1.45
Medical technology	4.09	4.23	4.90	5.61	3.19	4.64	5.15	5.84	5.85	5.78
Organic fine chemistry	1.87	2.40	3.64	1.82	2.84	2.41	4.33	4.44	2.93	3.06
Biotechnology	1.66	1.00	1.75	1.29	2.63	2.03	2.99	2.14	2.61	1.96
Pharmaceuticals	2.31	3.83	2.33	2.34	2.67	2.51	4.40	3.13	5.70	3.83
Macromolecular chemistry, polymers	0.78	0.57	0.39	0.48	0.69	0.92	0.45	0.66	0.63	0.68
Food chemistry	1.52	2.27	1.50	1.74	1.51	1.30	2.24	1.32	1.19	3.40
Basic materials chemistry	4.09	4.75	6.89	6.30	5.09	5.60	4.25	5.84	5.06	4.51
Materials, metallurgy	3.96	6.32	7.71	6.50	6.42	5.84	7.99	5.67	5.70	4.08
Surface technology, coating	0.65	1.00	1.46	1.25	1.21	1.16	1.04	1.23	1.42	2.38
Micro-structural and nano-technology	0.00	0.00	0.05	0.04	0.04	0.05	0.00	0.16	0.32	0.34
Chemical engineering	6.84	6.23	4.27	5.17	5.34	4.93	5.52	5.51	5.70	6.04
Environmental technology	2.09	2.00	1.65	2.46	2.07	2.75	2.01	1.81	2.61	2.04
Handling	5.49	5.01	5.92	6.18	5.04	5.21	4.63	3.70	3.32	3.32
Machine tools	2.70	3.18	2.81	2.38	2.46	2.37	2.09	1.40	2.29	3.83
Engines, pumps, turbines	4.36	2.18	2.52	2.26	3.10	2.27	3.28	2.06	2.22	1.96
Textile and paper machines	1.44	0.52	0.53	0.65	0.65	0.72	1.04	0.58	0.40	0.34
Other special machines	5.14	4.44	4.37	4.97	3.58	5.12	4.10	4.85	6.41	6.63
Thermal processes and apparatus	1.31	1.26	2.67	2.02	2.50	2.95	1.12	0.99	2.06	3.49
Mechanical elements	4.05	3.83	3.25	3.35	3.15	2.70	2.16	2.80	3.16	2.98
Transport	4.62	3.75	3.83	4.56	3.49	3.33	2.61	4.61	2.61	2.47
Furniture, games	5.79	3.97	5.97	5.29	4.18	4.78	3.06	4.11	4.19	3.15
Other consumer goods	2.40	1.66	2.91	2.91	3.23	3.91	2.84	3.95	3.40	2.38
Civil engineering	11.02	7.49	7.96	9.61	9.44	7.97	6.49	6.50	6.80	5.27

Table 9.13: Percentage World Share of South African Patents Published by Technology

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unknown	0.16	0.31	0.11	0.13	0.19	0.14	0.14	0.05	0.07	0.11
Electrical machinery, apparatus, energy	0.07	0.08	0.07	0.07	0.09	0.09	0.04	0.05	0.03	0.03
Audio-visual technology	0.06	0.04	0.04	0.05	0.04	0.06	0.02	0.02	0.02	0.02
Telecommunications	0.08	0.08	0.05	0.05	0.07	0.03	0.02	0.02	0.02	0.04
Digital communication	0.04	0.06	0.03	0.03	0.05	0.03	0.02	0.01	0.02	0.02
Basic communication processes	0.02	0.02	0.01	0.02	0.05	0.09	0.06	0.03	0.03	0.04
Computer technology	0.07	0.04	0.03	0.06	0.05	0.06	0.04	0.04	0.02	0.02
IT methods for management	0.17	0.24	0.23	0.30	0.44	0.30	0.28	0.24	0.21	0.11
Semiconductors	0.01	0.08	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Optics	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.02
Measurement	0.10	0.08	0.06	0.06	0.07	0.07	0.06	0.03	0.02	0.03
Analysis of biological materials	0.04	0.18	0.06	0.06	0.02	0.02	0.03	0.02	0.06	0.05
Control	0.31	0.23	0.21	0.19	0.16	0.14	0.06	0.06	0.05	0.04
Medical technology	0.13	0.13	0.13	0.17	0.09	0.12	0.08	0.08	0.08	0.06
Organic fine chemistry	0.07	0.09	0.12	0.07	0.11	0.08	0.10	0.09	0.06	0.06
Biotechnology	0.09	0.06	0.10	0.08	0.15	0.10	0.09	0.06	0.07	0.05
Pharmaceuticals	0.07	0.11	0.06	0.07	0.07	0.07	0.07	0.05	0.08	0.05
Macromolecular chemistry, polymers	0.06	0.05	0.03	0.04	0.05	0.06	0.02	0.02	0.02	0.02
Food chemistry	0.15	0.23	0.13	0.17	0.12	0.09	0.09	0.04	0.03	0.07
Basic materials chemistry	0.23	0.27	0.33	0.34	0.25	0.24	0.11	0.12	0.10	0.07
Materials, metallurgy	0.30	0.48	0.49	0.44	0.40	0.31	0.26	0.14	0.13	0.08
Surface technology, coating	0.05	0.08	0.10	0.10	0.08	0.07	0.04	0.04	0.04	0.07
Micro-structural and nano-technology	0.00	0.00	0.04	0.04	0.03	0.03	0.00	0.05	0.10	0.09
Chemical engineering	0.44	0.40	0.24	0.33	0.32	0.25	0.18	0.14	0.14	0.13
Environmental technology	0.22	0.21	0.15	0.25	0.18	0.21	0.10	0.07	0.09	0.06
Handling	0.27	0.25	0.26	0.33	0.25	0.23	0.13	0.08	0.07	0.06
Machine tools	0.16	0.20	0.15	0.15	0.14	0.11	0.06	0.03	0.05	0.07
Engines, pumps, turbines	0.23	0.12	0.12	0.12	0.14	0.09	0.08	0.04	0.04	0.04
Textile and paper machines	0.08	0.03	0.03	0.05	0.04	0.05	0.04	0.02	0.01	0.01
Other special machines	0.24	0.22	0.19	0.25	0.16	0.20	0.10	0.09	0.12	0.10
Thermal processes and apparatus	0.12	0.11	0.21	0.18	0.20	0.20	0.05	0.03	0.07	0.11
Mechanical elements	0.20	0.19	0.14	0.16	0.14	0.11	0.06	0.06	0.06	0.05
Transport	0.15	0.13	0.11	0.16	0.11	0.10	0.05	0.07	0.04	0.03
Furniture, games	0.30	0.20	0.27	0.28	0.22	0.23	0.09	0.10	0.10	0.06
Other consumer goods	0.16	0.11	0.18	0.21	0.22	0.23	0.11	0.12	0.10	0.06
Civil engineering	0.46	0.30	0.29	0.41	0.37	0.27	0.14	0.11	0.11	0.08

Appendix C: Lall[1] Classification of Product Groups

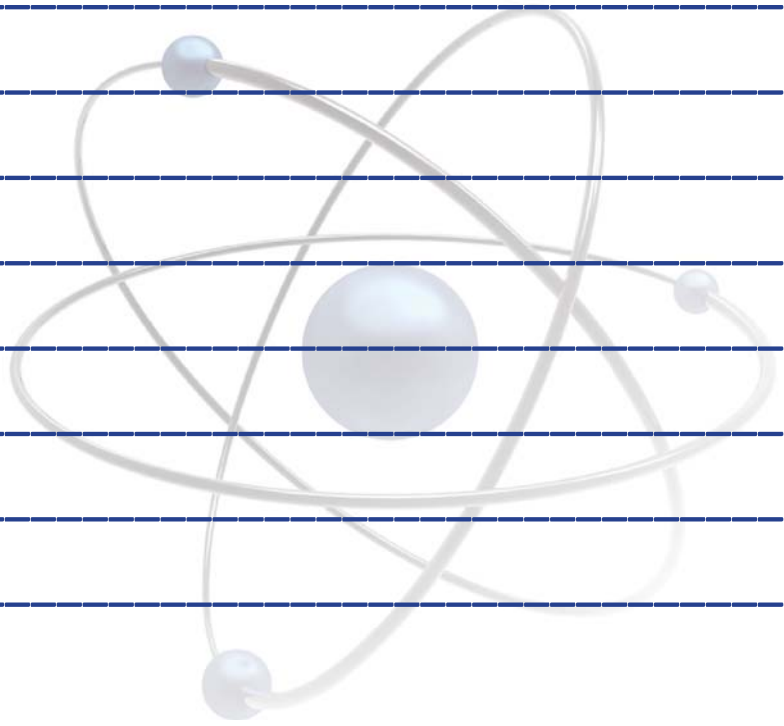
Table 9.14: Lall Classification of Products by Technology Intensiveness

CATEGORY	EXAMPLES	SITC
A. COMMODITIES		
	Fresh fruit, meat, rice, cocoa, tea, coffee, timber, coal, crude petroleum, gas, ore concentrates and scrap.	001, 011, 022, 025, 034, 036, 041, 042, 043, 044, 045, 054, 057, 071, 072, 074, 075, 081, 091, 121, 211, 212, 222, 223, 232, 244, 245, 246, 261, 263, 268, 271, 273, 274, 277, 278, 281, 286, 287, 289, 291, 292, 322, 333, 341.
B. MANUFACTURE		
	Prepared meats/fruits, beverages, wood products, vegetable oils, base metals (except steel), petroleum products, cement, gems, glass.	012, 014, 023, 024, 035, 037, 046, 047, 048, 056, 058, 061, 062, 073, 098, 111, 112, 122, 233, 247, 248, 251, 264, 265, 269, 423, 424, 431, 621, 625, 628, 633, 634, 635, 641, 282, 288, 323, 334, 335, 411, 511, 514, 515, 516, 522, 523, 531, 532, 551, 592, 661, 662, 663, 664, 667, 681, 682, 683, 684, 685, 686, 687, 688, 689.
	Textile fabrics, clothing, footwear, leather manufactures, travel goods pottery, simple metal structures, furniture, jewellery, toys, plastic products.	611, 612, 613, 651, 652, 654, 655, 656, 657, 658, 659, 831, 842, 843, 844, 845, 846, 847, 848, 851, 642, 665, 666, 673, 674, 675, 676, 677, 679, 691, 692, 693, 694, 695, 696, 697, 699, 821, 893, 894, 895, 897, 898, 899.
	Passenger vehicles and parts, commercial vehicles, motorcycles and parts, synthetic fibres, chemicals and paints, fertilizers, plastics, iron and steel, pipes and tubes, engines, motors, industrial machinery, pumps, ships, watches.	781, 782, 783, 784, 785, 266, 267, 512, 513, 533, 553, 554, 562, 572, 582, 583, 584, 585, 591, 598, 653, 671, 672, 678, 786, 791, 882, 711, 713, 714, 721, 722, 723, 724, 725, 726, 727, 728, 736, 737, 741, 742, 743, 744, 745, 749, 762, 763, 772, 773, 775, 793, 812, 872, 873, 884, 885, 951. 716, 718, 751, 752, 759, 761, 764, 771, 774, 776, 778, 524, 541, 712, 792, 871, 874, 881.
	Data processing and telecommunications equipment, television sets, transistors, turbines, power generating equipment, pharmaceuticals, aerospace, optical and instruments, cameras.	
C. OTHER TRANSACTIONS		
	Electricity, cinematographics film, printed matter, special transactions, gold, coins, pets, works of art.	351, 883, 892, 896, 911, 931, 941, 961, 971.

(Endnotes)

1 S. Lall. The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-1998, QEH Working Papers Series.

Notes



National Advisory Council on Innovation

Suite L2, Enterprise Building
Mark Shuttleworth Street
The Innovation Hub
Lynnwood
Pretoria
0087

Tel: 012 844 0252
Email: naci@dst.gov.za
Web: www.naci.org.za