SOUTH AFRICAN SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS 2017

SYNTHESIS REPORT

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Department:
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REPUBLIC OF SOUTH AFRICA

NACI
NATIONAL ADVISORY COUNCIL ON INNOVATION

SOUTH AFRICAN SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS

SYNTHESIS REPORT
2017

innovation
for a better future

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ACRONYMS

ACRONYM	DEFINITION
AIDS	Acquired Immune Deficiency Syndrome
BERD	Business Expenditure on Research and Development
BRICS	Brazil, Russia, India, China and South Africa
CBTBR	Centre of Excellence for Biomedical Tuberculosis Research
DSBD	Department of Small Business Development
DST	Department of Science and Technology
EDD	Economic Development Department
ESTD	Early-stage Technology Development
FTE	Full-time Equivalent
GCI	Global Competitive Index
GCI	Global Cybersecurity Index
GDP	Gross Domestic Product
GEM	Global Entrepreneurship Monitor
GERD	Gross Expenditure on Research and Development
GII	Global Innovation Index
HCD	Human Capital Development
HDI	Historically Disadvantaged Institution
HEMIS	Higher Education Management Information System
HIV	Human Immunodeficiency Virus
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
IDC	Industrial Development Corporation
IPR	Intellectual Property Right
ITU	International Telecommunication Union
MTSF	Medium-term Strategic Framework
NACI	National Advisory Council on Innovation
NFF	New Funding Framework
NGO	Non-governmental Organisation
NPO	Non-profit Organisation
NRF	National Research Foundation

ACRONYM	DEFINITION
NSI	National System of Innovation
PCT	Patent Cooperation Treaty
PDI	Previously Disadvantaged Individual
PIC	Public Investment Corporation
PPP	Public-private Partnership
R&D	Research and Development
SAMRC	South African Medical Research Council
SANEDI	South African National Energy Development Institute
SARChI	South African Research Chairs Initiative
SEDA	Small Enterprise Development Agency
SET	Science, Engineering and Technology
SFP	Seed Fund Programme
SII	South African Innovation Index
SME	Small and Medium Enterprise
SMME	Small, Medium and Micro Enterprises
SPI	Social Progress Index
SPII	Support Programme for Industrial Innovation
STI	Science, Technology and Innovation
TB	Tuberculosis
TEA	Total Early-stage Entrepreneurial Activity
The dti	Department of Trade and Industry
THRIP	Technology and Human Resources for Industry Programme
TIA	Technology Innovation Agency
TIMSS	Trends in Mathematics and Science Study
UKIIF	UK Innovation Investment Fund
UNCTAD	United Nations Conference on Trade and Development
USPTO	United States Patent and Trademark Office
WHO	World Health Organisation
WRC	Water Research Commission

1. KEY HIGHLIGHTS

The *2017 South African Science, Technology and Innovation Indicators Report* uses the new South African Innovation Scorecard Framework to analyse the country's state of innovation. This framework categorises science, technology and innovation (STI) activities into three components: the public sector's enabling activities, firm-level innovation activities and the economic and social outputs of innovation. The following is a summary of the report's key highlights:

- It is encouraging to observe that there is a high proportion of female graduations for the university science, engineering and technology (SET) disciplines. However, this proportion is relatively low at the doctoral degree level (43% in 2015). In 2015, most of these degrees were awarded in the disciplines of health and related clinical sciences (58%), life sciences (58%), education (52%) and agricultural sciences (50%). There is a low supply of doctoral qualifications for females in disciplines like engineering, mathematics and statistics, and computer and information sciences.
- There are few black doctoral degree graduates in life sciences and engineering.
- South Africa ranks 18^{th} in the world for scientific publications in social sciences, arts and humanities.
- Government's contribution to business expenditure on research and development (BERD) is shown to be low and there is no appropriate coordination mechanism for a coherent response by various government entities.
- Government significantly contributes to the South African venture capital industry.
- High-technology exports remain low, thus there is much reliance on imported high-technology products.
- South Africa ranks high on the Social Progress Index (SPI)'s opportunity and foundations of wellbeing category.

In summary, the recommendations below have been derived from the *2017 South African STI Indicators Report.*

Recommendations targeted at STI human capital development (HCD): transformation and expansion of HCD

- **Representation of female students in SET disciplines at university:** It is recommended that the Department of Science and Technology (DST) and its agencies, especially the National Research Foundation (NRF), intensify targeted and purposeful interventions that are aimed at increasing the representation of female students in the key SET disciplines such as engineering, mathematics and statistics, and computer science. In this regard, established instruments such as the South African Research Chairs Initiative (SARChI) and centres of excellence can be upscaled to achieve this objective. It is also recommended that an analysis be conducted to improve an understanding of student choices of courses at the undergraduate level.
- **STI pipeline:** Over the past years, the National Advisory Council on Innovation (NACI) has emphasised the challenge of a constrained STI pipeline, as shown by the Trends in International Mathematics and Science Study (TIMSS) Report, Grade 12 Mathematics performance and other reports. There is a consensus that poor early childhood development is a major contributor to this challenge. A comprehensive evaluation study is therefore recommended to focus on the effectiveness and efficiency of the various interventions that are aimed at improving performance in Mathematics and Physical Science.

Recommendations targeted at the funding of research and development (R&D) and innovation

- **Government STI investment:** It is recommended that government accelerates the implementation of the STI budget coordination mechanisms. It is also recommended that government improves mechanisms to build capacity to prioritise STI funding areas, such as selected science and technology missions and emerging technologies to be developed and upscaled.
- **Business STI investment:** Recent data shows that the proportion of business expenditure on R&D over gross expenditure on R&D (GERD) has declined drastically since the beginning of the global economic recession, and there has not been any recovery so far. Since South Africa has an efficiency-driven economy, the business sector has an appetite for a relatively short-term planning horizon, especially during the periods of slow economic growth. This results in the business sector's low levels of R&D expenditure. In order to stimulate R&D and innovation in the business sector, it is recommended that government considers the use of public sector innovation and the revamping of government-supported venture capital funds, especially for small and medium enterprises (SMEs). NACI condones the decision of National Treasury and the Department of Performance Monitoring and Evaluation to evaluate all government incentives.

2. CURRENT TRENDS

An ideal framework for the analysis of the role and contribution of STI in South Africa is government's Medium-term Strategic Framework (MTSF) and its outcomes. There are several STI-related delivery actions on the MTSF. For Outcome 1 (quality basic education), NACI continuously monitors and comments on the percentage of Grade 12 learners who obtain 50% or more in Mathematics and Physical Science. For Mathematics, this percentage has been oscillating for over a decade between a high of 18.1% in 2008 and a low of 11.8% in 2015.

On the health front (Outcome 2), the country is showing some notable progress in making use of innovation and technology to improve health, although there is the persistent challenge of diseases such as Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS) and tuberculosis (TB). According to the 2017 Global Cybersecurity Index, the country's commitment to cybersecurity, which is related to safety (Outcome 3), is ranked 58th out of 193 International Telecommunication Union (ITU) member countries. South Africa is far behind some African countries, such as Mauritius (ranked 6th) and Egypt (ranked 14th).

Despite the introduction of the R&D Tax Incentive Programme, GERD remains low at 0.8% of the gross domestic product (GDP). There is consensus that most of the increase in R&D expenditure should come from the industry through instruments such as the Sector Innovation Fund. This is important for the country to achieve an outcome of decent employment through inclusive economic growth (Outcome 4).

Table 2.1 shows South Africa's ranking on the selected global indices. Although the country ranked relatively high on the Global Competitiveness Index (GCI) in comparison to the Global Innovation Index (GII) in recent years, a huge drop on its GCI ranking from 47th in 2016 to 61st in 2017 resulted in a relatively better ranking on the GII (57th in 2017). The main contributors to a huge decline in its GCI ranking in 2017 are financial market development (from 11th in 2016 to 44th in 2017) and goods market efficiency (from 28th in 2016 to 54th in 2017). The country's total early-stage entrepreneurship activity (TEA) is also declining from 22nd in 2012 to 46th in 2016. Overall, the country is experiencing a slight deterioration in innovation, competitiveness and entrepreneurship.

Table 2.1: *Trend in South Africa's ranking on selected global indices*

	2012	2013	2014	2015	2016	2017
GII ranking	54	58	53	60	54	57
Number of participating countries for GII	141	142	143	141	128	127
GCI ranking	52	53	56	49	47	61
Number of participating countries for GCI	141	148	144	140	138	137
TEA ranking	22	35	53	38	46	-
Number of participating countries in the Global Entrepreneurship Monitor (GEM)	69	67	70	60	65	-

However, South Africa's innovation and competitiveness are still the best among the African countries, most notably above those of Nigeria and Egypt (Table 2.2).

Brazil's low competitiveness ranking is in contrast to the highest TEA rate (19.6% in 2016) among the Brazil, Russia, India, China and South Africa (BRICS) member countries (see Table 2.3). This is due to the fact that only 4.0% of Brazil's new and established entrepreneurs innovate with technology less than five years old.

Table 2.2: *Benchmarking of South Africa's ranking on selected global indices in recent years*

	SOUTH AFRICA	BRAZIL	CHINA	INDIA	RUSSIA	EGYPT	NIGERIA
GII ranking (out of 127)	57	69	22	60	45	105	119
GCI ranking (out of 137)	61	80	27	40	38	100	125

For South Africa, 55.1% of new entrepreneurs and 53.2% of established entrepreneurs innovated with technology less than five years old in 2016. It turns out that the South African National System of Innovation (NSI) enables entrepreneurship and competitiveness for both new and established businesses. There is a high TEA rate for those with post-secondary education (11.9% in 2016) in comparison to those with low levels of education.

Table 2.3: *Benchmarking of South Africa's Entrepreneurial Activity Phases – 2016*

	SOUTH AFRICA	BRAZIL	CHINA	INDIA	RUSSIA
TEA rate	6.9	19.6	10.3	10.6	6.3
TEA rate with basic education	4.6	19.5	6.6	8.1	6.4
TEA rate with complete secondary education	7.4	20.5	11.2	11.3	2.8
TEA rate with post-secondary education	11.9	14.4	12.1	14.1	7.1
Percentage of new entrepreneurs who innovate with technology less than five years old	55.1	4.0	35.4	55.7	23.6
Established business ownership rate	2.5	16.9	2.5	7.5	5.3
Percentage of established entrepreneurs who innovate with technology less than five years old	53.2	4.0	38.5	40.4	24.0

Source: 2016/17 Brazil Report (Global Entrepreneurship Monitor)

3. SOUTH AFRICAN INNOVATION SCORECARD FRAMEWORK

The South African Innovation Scorecard is a measurement framework for the Innovation Union Scoreboard.

Innovation performance is measured with a composite indicator that summarises the performance of a range of different indicators. The South African Innovation Scorecard distinguishes between three main types of indicators (enablers, firm activities and outputs) and eight innovation dimensions (human resources, open excellent research system, finance and support, firm investments, linkages and entrepreneurship, intellectual assets, economic effects and social effects). A total of 20 indicators are used.

The enablers capture the main drivers of innovation performance that are external to the firm and differentiate between three innovation dimensions: human resources, open, excellent and attractive research systems, and finance and support.

Human resources includes two indicators and measures the availability of a highly skilled and educated workforce. The indicators capture new doctoral graduates and the population aged 20 to 64 with completed tertiary education.

Open, excellent and attractive research systems includes two indicators and measures the international competitiveness of the science base by focusing on international scientific co-publications and most-cited publications.

Finance and support includes two indicators and measures the availability of finance for innovation projects by venture capital investments and the support of government for research and innovation activities (R&D expenditures) by universities and government research organisations.

Firm activities captures the innovation efforts at firm level and differentiates between three innovation dimensions: firm investments, linkages and entrepreneurship, and intellectual assets.

Firm investments includes two indicators of R&D and information and communication technology (ICT) investments that firms make to generate innovations.

Linkages and entrepreneurship includes two indicators that measure innovation capabilities by looking at collaboration efforts between public and private sector organisations and the support that business sector organisations offer to universities.

Intellectual assets captures different forms of intellectual property rights (IPRs) generated as a throughput in the innovation process, including Patent Cooperation Treaty (PCT) patent applications, patents related to societal challenges and trademarks.

Outputs capture the effects of firms' innovation activities (economic and social effects).

Economic effects includes four indicators and captures the economic success of innovation in the export of medium- and high-technology products, services, and licence and patent revenues from selling technologies abroad.

Social effects includes three indicators and captures life expectancy, internet users and energy efficiency in producing the country's GDP.

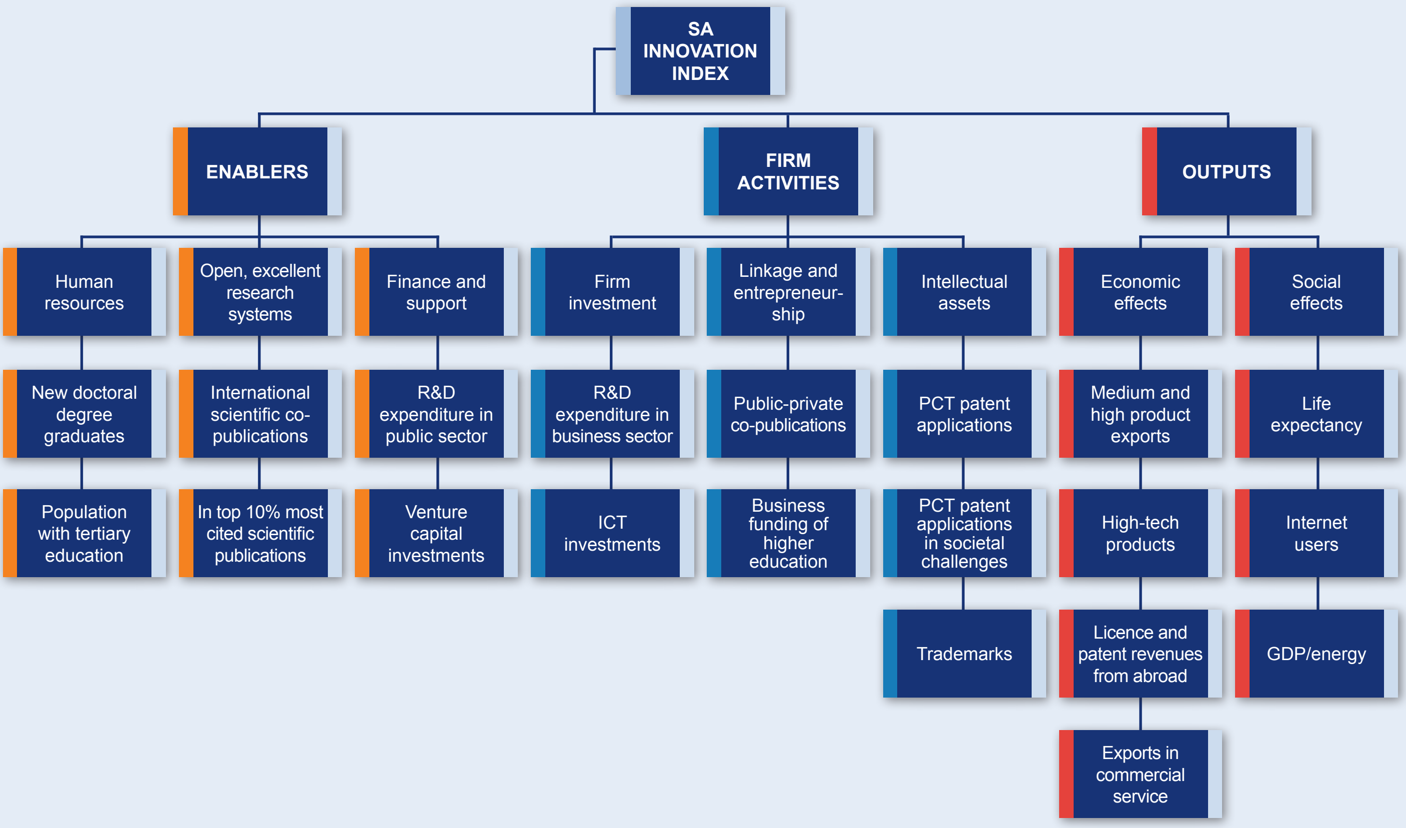


Figure 3.1: *South African Innovation Index (SII)*

4. ENABLERS: PUBLIC SECTOR ACTIVITIES

The public sector has a dual role of being the innovation performer and also the creator of the appropriate framework conditions for innovation in the private sector. Conducive framework conditions take on many forms, such as the enabling STI policy, appropriate strategies, establishing and maintaining strategic STI institutions to generate knowledge and de-risk technologies, the funding of R&D and innovation, developing STI human capital, establishing strategic partnerships and many more. As alluded to by the European Union, the innovation enablers are the basic building blocks that allow innovation to take place.[1]

4.1 SCIENCE, TECHNOLOGY AND INNOVATION HUMAN CAPITAL

The need to increase critical mass on STI is encapsulated in the 1996 White Paper on Science and Technology. The *2017 South African STI Indicators Report* shows some success in growing the SET base and promoting equity. Figure 4.1 shows that the proportion of female SET graduations remains high at approximately 50%, whereas that of previously disadvantaged individuals (PDIs) increased from 64.1% in 2007 to 74.0% in 2015.

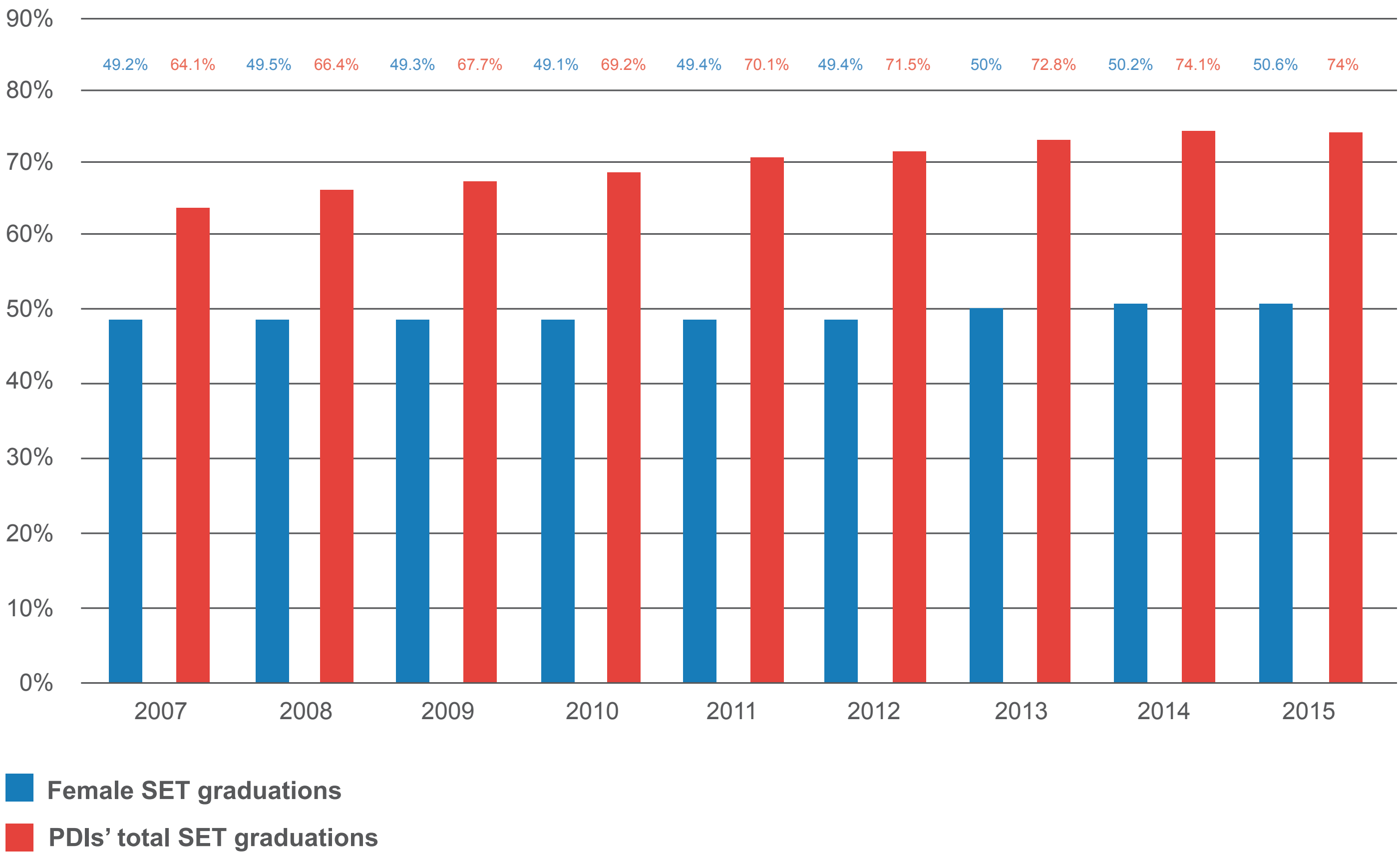


Figure 4.1: *Females and PDIs' SET graduation*

Source: Department of Higher Education and Training

1 europa.eu/rapid/press-release_MEMO-16-2487_en.pdf

This transformation is also evident at the doctoral degree level. As NACI previously reported, the number of Africans that obtain doctoral degrees is now the largest of all four races (Figure 4.2), as is the case with South Africa's demographics.

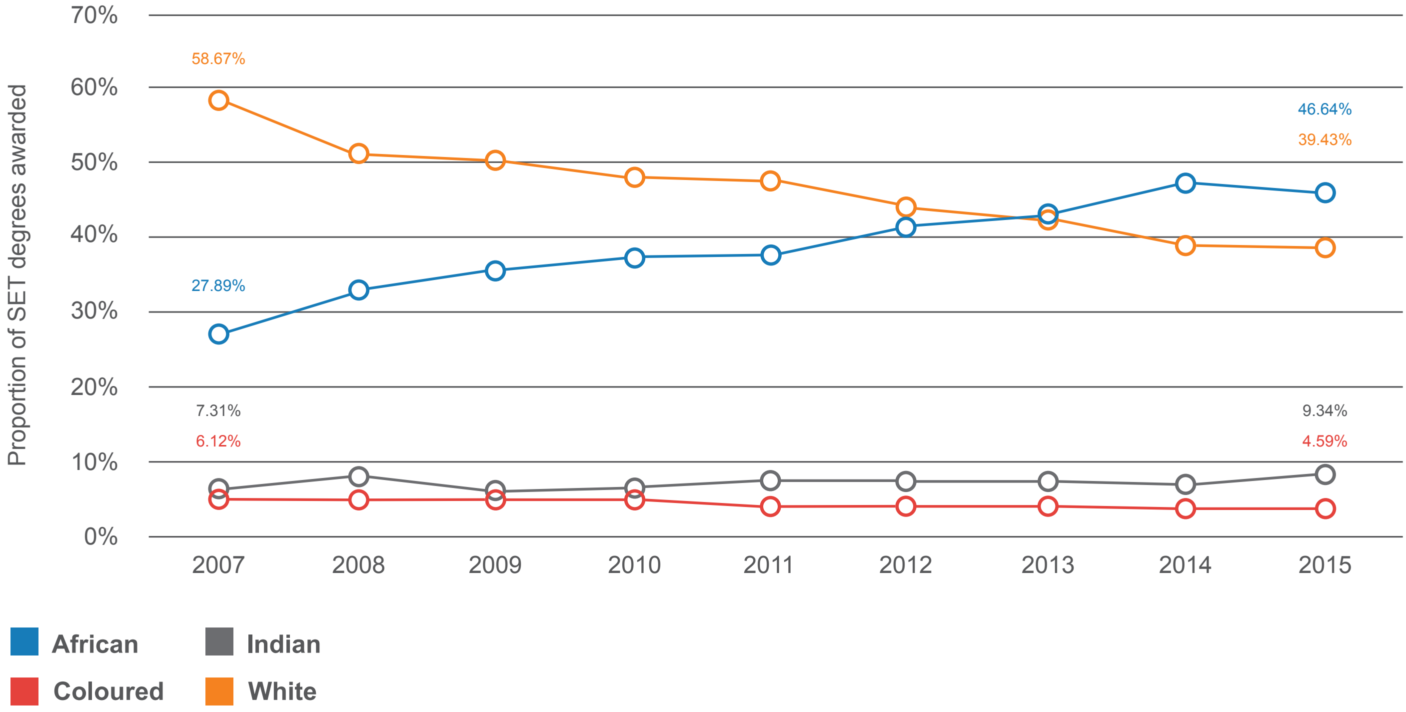


Figure 4.2: *Percentage distribution of SET doctoral degrees awarded by South African universities by race*

Source: Department of Higher Education and Training

The 1996 White Paper on Science and Technology outlined several guiding principles regarding the transformation of STI human capital in South Africa. Some of these principles include the need to address the consequences of deliberate policies and practices that promoted racial and gender discrimination in human resources development, the maximisation of ideas use, creativity, ingenuity and innovation from the entire population, the achievement of rapid and sustainable human resources development through equity, and the reversal of the apartheid policies and strategies that sought to relegate historically disadvantaged institutions (HDIs) to the sole mission of teaching.

The development of high-end skills should be matched with the demand conditions of various sectors. It is therefore important to understand the nature of doctoral degrees awarded. Table 4.1 shows that about 50% of doctoral degrees are awarded in SET disciplines.

Among the SET doctoral degrees awarded, most are in the life sciences (24%), followed by health and related clinical studies (20%), physical sciences (20%) and engineering (16%). There is a serious shortage of females with high-end skills in disciplines such as engineering, mathematics and statistics, and computer and information sciences. There is also a shortage of African graduates with doctoral degrees in life sciences (31% of total doctoral degree graduates in 2015) and engineering (37%).

To address these challenges, the DST's Human Capital Development Strategy for R&D, Innovation and Scholarship proposes a range of interventions to increase the number of doctoral degree graduates and improve the demographics of students enrolled for and graduating with master's and doctoral research degrees.

Table 4.1: Distribution of doctoral degrees awarded to Africans at South African universities by classification of educational subject matter, 2015

	PROPORTION OF DOCTORAL DEGREES AWARDED (%)	PROPORTION OF FEMALE DOCTORAL GRADUATES (%)	PROPORTION OF AFRICAN DOCTORAL GRADUATES (%)
SET	**50**	**43**	**45**
Agricultural sciences	5	50	67
Computer and information sciences	2	31	53
Engineering	8	18	37
Health and related clinical sciences	10	58	42
Family ecology and consumer sciences	0	–	–
Life sciences	12	58	31
Physical sciences	10	36	56
Mathematics and statistics	3	23	53
Business and commerce	**10**	**34**	**50**
Education	**12**	**52**	**62**
Other humanities	**28**	**46**	**49**
Total	**100**	**44**	**49**

Source: Higher Education Information Management System (HEMIS) (Department of Higher Education and Training)

The R&D survey data on employment of researchers provides a perspective on the demand conditions for researchers in various sectors (Figure 4.3). From 2008 to 2015, the business sector has shed the most researchers' jobs, while the most research jobs shifted towards the higher education sector, although government research laboratories and some non-governmental organisations (NGOs) also absorbed some of these researchers.

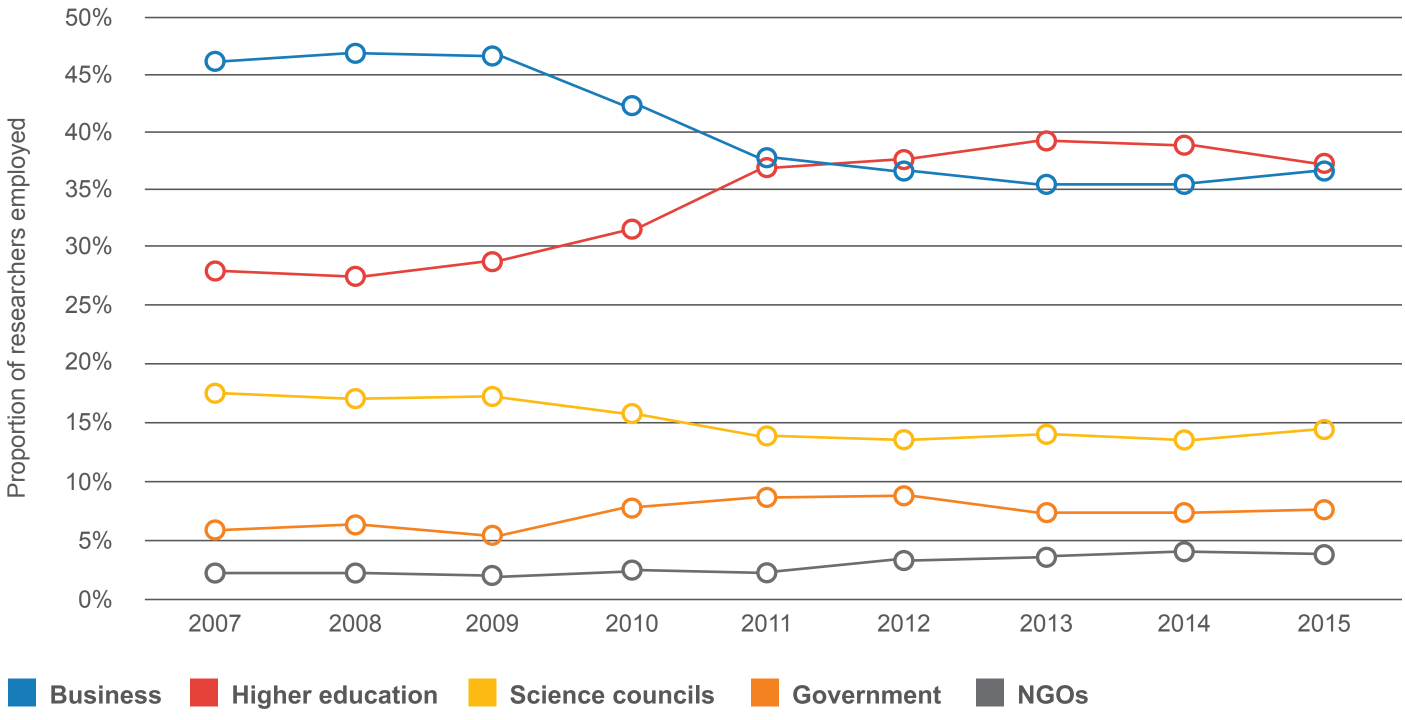


Figure 4.3: Employment of researchers by sector (full-time equivalent)

Source: National Survey of Research and Experimental Development (Human Sciences Research Council (HSRC) and DST)

4.2 KNOWLEDGE GENERATION

Indicators based on research publications are probably the most often used in the assessment of research activities. The philosophy underlying the use of research publications as a measure of performance has been summarised as "for those who are working at the research front, publication is not just an indicator but, in a very strong sense, the end product of their creative effort".[2]

Figure 4.4 shows the number of publications with at least one South African author during the period 1995–2016. It is apparent that the number of South African publications has been increasing since 2005. An investigation[3] has concluded that the New Funding Framework (NFF) for higher education institutions affects the number of publications. The NFF supports the higher education institutions (among others) financially according to their research outputs (number of publications and number of postgraduates). It is apparent that the incentive brought about the desirable effect.

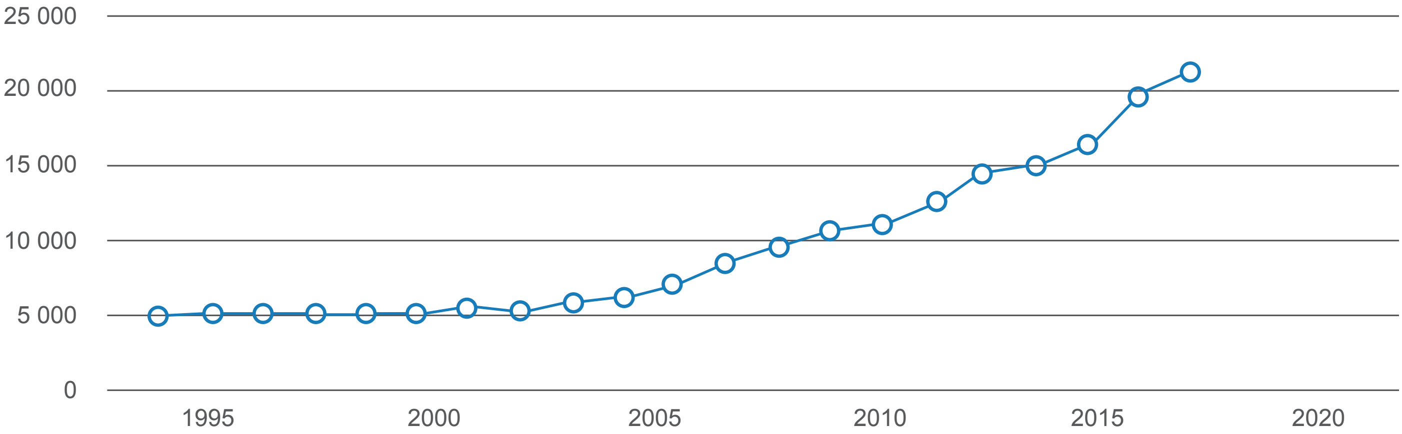


Figure 4.4: *South African publications, 1995–2016*

Table 4.2 shows the number of scientific publications with at least one South African author in each broad scientific field, the share of each discipline in the South African set of publications, the country's share of world publications in the particular field and the world ranking of South Africa in each field.

Table 4.2: *Disciplinary performance of South Africa 1996–2016*

	NUMBER OF PUBLICATIONS	SOUTH AFRICA'S SHARE (%)	WORLD SHARE (%)	SOUTH AFRICAN WORLD RANKING
Social sciences	31 651	13.9	0.80	18
Arts and humanities	8 842	3.9	0.33	18
Life sciences	103 441	45.4	0.63	33
Physical sciences	46 119	20.2	0.50	38
Technology	37 847	16.6	0.37	40

South Africa is ranked 18th in the world in social sciences, and arts and humanities, 33rd in life sciences, 38th in physical sciences and 40th in technology. South Africa is ranked best in social sciences, and arts and humanities, although these disciplines have a low country share of publications.

2 De Solla Price, D. (1975) "The productivity of research scientists", *Yearbook of Science and the Future,* Encyclopaedia Britannica, University of Chicago, Chicago, IL
3 Pouris, A. (2012) "Scientometric research in South Africa and successful policy instruments", *Scientometrics* 91: 317–325

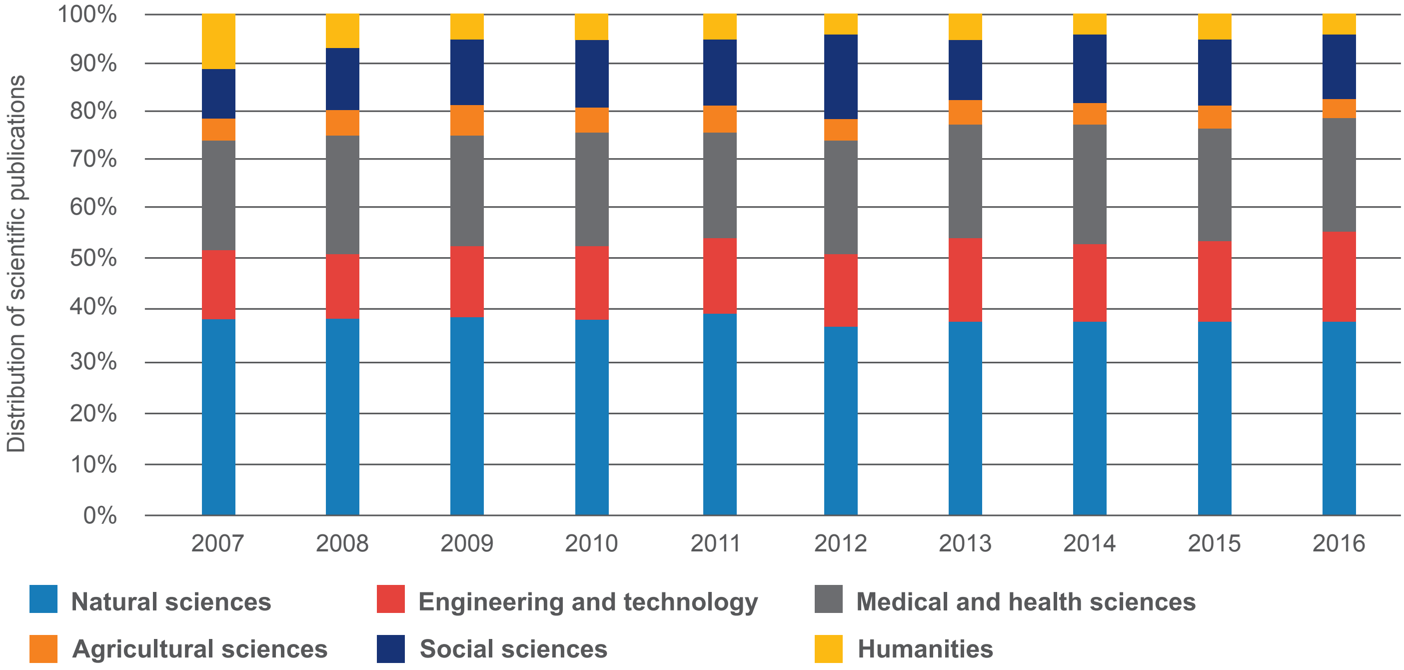


Figure 4.5: *Distribution of scientific publications per major research field*

Source: Incites 2.0 (Clarivate Analytics)

Figure 4.5 shows that the distribution of South African scientific publications per major research field remained almost the same between 2007 and 2016. A notable downward trend, albeit small, is that of the humanities disciplines.

Figure 4.6 shows that most university publications originate from the traditional universities (80.4% in 2016). The top five universities (University of Cape Town, University of the Witwatersrand, University of Pretoria, University of KwaZulu-Natal and University of Stellenbosch) contributed to 78.2% of the publications from traditional universities. The comprehensive universities contributed to 14.7% of publications in 2015, while the universities of technology contributed to only 4.8% of university publications.

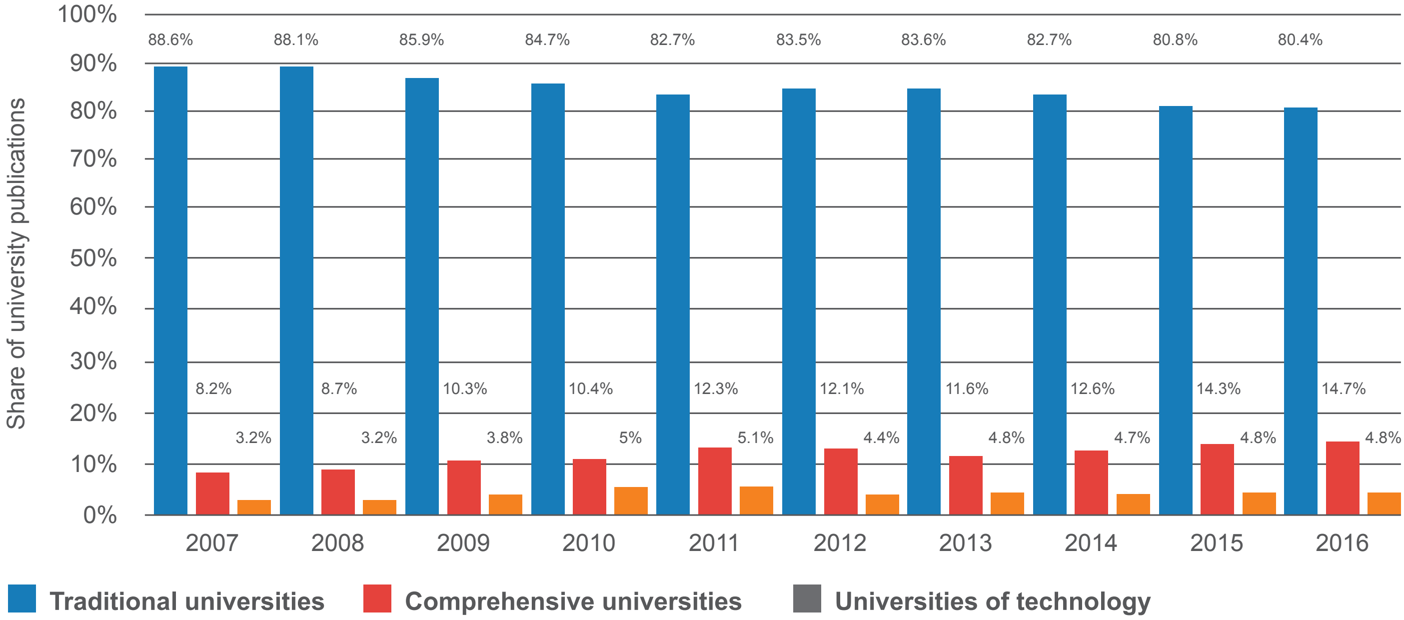


Figure 4.6: *Distribution of scientific publications per type of university*

Source: Incites 2.0 (Clarivate Analytics)

4.3 SCIENCE, TECHNOLOGY AND INNOVATION FUNDING AND SUPPORT

Figure 4.7 shows the major organisations and instruments involved in funding R&D and innovation in the country. These are categorised according to various stages of the innovation value chain: basic research, proof of concept or innovation (which includes applied research and experimental development), early-stage technology development (ESTD) (pre-commercialisation stage), product development, and production or marketing. The major types of funding shown are those open, typically through a call, to a range of individuals and organisations in different sectors, such as higher education, science councils, small, medium and micro enterprises (SMMEs), and large companies and industries. This list is not exhaustive, but indicates some of the vast range of funds that are provided.

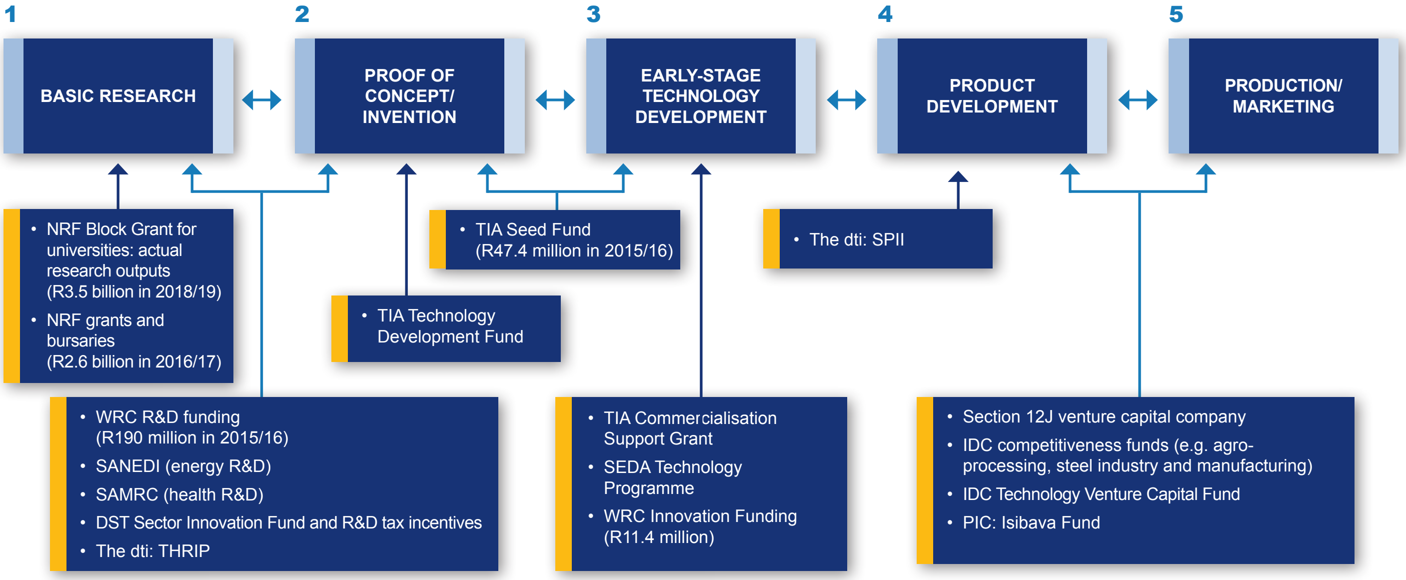


Figure 4.7: *Major funders of research, development and innovation in South Africa*

Basic research at universities is funded mainly through the NFF's line item of the actual research outputs. The NRF provides funding through grants and bursaries. It is important to note that, during 2015/16, of the R30.3 billion budget for the higher education sector, only R3 billion was allocated for research outputs. The research allocation was reduced from approximately 10% during 2015/16 to approximately 7.6% during 2018/19.

Basic research is also funded through a range of other instruments that support proof of concept or invention. These are the Water Research Commission (WRC), the South African National Energy Development Institute (SANEDI), the South African Medical Research Council (SAMRC), the DST's Sector Innovation Fund and the R&D Tax Incentive and Department of Trade and Industry (the dti)'s Technology and Human Resources for Industry Programme (THRIP). Proof of concept development or invention is also funded by programmes such as the Technology Development Fund and Seed Fund Programme (SFP) of the Technology Innovation Agency (TIA).

The SFP, which also funds ESTD, was launched during 2013/14 with the objective of providing access to early-stage funding and support services. More specifically, the programme's objective is to assist higher education institutions and SMMEs to advance their research outputs and ideas to develop prototypes, proof of concept and business cases that could be used for further development. Other funding programmes for ESTD are the TIA Commercialisation Support Grant, the Small Enterprise Development Agency (SEDA)'s Technology Programme and Water Resources Department's water innovation funding.

The dti's Support Programme for Industrial Innovation (SPII) provides financial assistance to the South African industry for the development of innovative products and/or processes. Other funding programmes that support the development of innovative products and/or processes, as well as production or marketing, are the Industrial Development Corporation (IDC)'s various competitiveness and venture capital funds, as well as the Public Investment Corporation (PIC) and Section 12J venture capital company incentive.

Generally, the country has a range of funding programmes that covers the whole spectrum of R&D and innovation activities. However, a concern has been raised about the lack of coordination among these funding instruments and the small size of some. An example is the TIA Seed Fund (R47.4 million in 2015/16).

5. FIRM ACTIVITIES ON SCIENCE, TECHNOLOGY AND INNOVATION

There are various models of firm-level innovation, each with its own successes and failures. The model of innovation that is adopted by the firm needs to reflect the country's framework conditions, as well as the other competitive drivers. The pillars adopted by NACI for firm-level innovation activities are firm investments, linkages and entrepreneurship, and intellectual assets.

5.1 STI INVESTMENTS

In pursuit of market competitiveness through technological innovation, businesses invest in R&D, technological development, products or process development, production and marketing. BERD is a widely used input indicator for the extent to which the business sector considers technological innovation as its major source of competitiveness. Figure 5.1 shows that BERD has been in recovery mode since 2011, albeit at a relatively slower pace.

The R13.8 billion BERD in 2015/16 represents 42.7% of GERD (the ratio that is on the decline). At the beginning of the global economic recession in 2008/09, BERD, as a percentage of GERD, was 58.6%. During 2013/14 and 2014/15, this ratio was 45.9% and 45.3% respectively.

Although the business sector remains the largest R&D-performing sector in South Africa, the higher education sector is increasing its R&D expenditure at a higher rate in comparison to the business sector. Its share of R&D expenditure, as a percentage of GERD, increased from 19.4% in 2007/08 to 30.5% in 2015/16. The relatively low level of BERD is clearly demonstrated by the reduced BERD as a percentage of GDP, This places a huge strain on the country's ability to achieve the target of 1.5% R&D expenditure as a percentage of GDP.

Table 5.1, which analyses BERD according to various research fields, reveals some linkages between BERD by research field, employment of researchers by the business sector and supply of doctoral graduates. The distribution of BERD by research field can be used as a reflection of the type of research areas that are in demand in the business sector. Since it has been shown that there is a low proportion of female doctoral graduates in disciplines such as engineering (18% in 2015), computer and information sciences (31%) and physical sciences (36%), a shortage of female researchers can be expected in disciplines such as engineering sciences, ICT and chemical sciences. This can explain the low proportion of female researchers in the business sector (38.7%, 39.6% and 39.3% in 2015/16, 2014/15 and 2013/14 respectively).

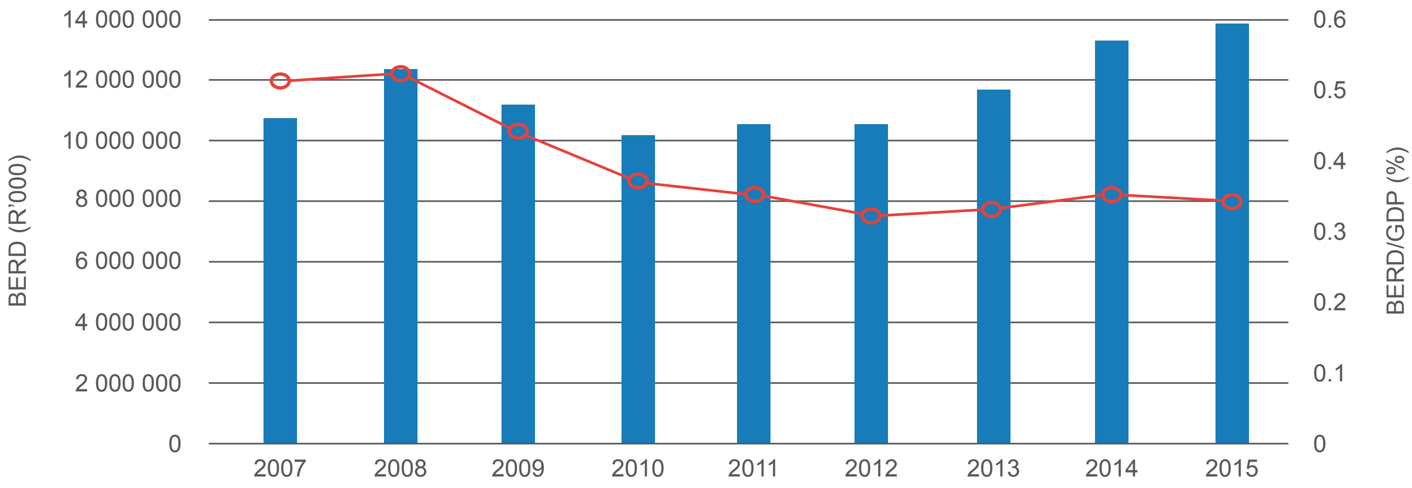


Figure 5.1: *The trend in business sector R&D expenditure*

Source: National Survey of Research and Experimental Development (HSRC and DST)

Government has put various direct and indirect support programmes in place for business research and innovation in order to accelerate the level of technological innovation in the business sector. Due to a relative decline in the flow of government funding of R&D to BERD, from 27.3% in 2007/08 (R2.3 billion) to 3.6% in 2015/16 (R0.5 billion), there is evidence of a lack of coordination between these support programmes.

Table 5.1: *The proportion of BERD by research field*

	2007	2008	2009	2010	2011	2012	2013	2014	2015
	PERCENTAGE								
Division 1: Natural sciences, technology and engineering	**96.5**	**96.5**	**96.4**	**95.6**	**95.5**	**86.3**	**82.9**	**82.6**	**82.9**
Mathematical sciences	1.6	1.5	1.6	1.1	2.0	1.4	1.8	1.6	0.9
Physical sciences	4.7	5.3	1.7	0.3	0.3	0.5	0.4	0.4	0.3
Chemical sciences	5.4	7.0	5.6	6.8	8.9	9.3	8.3	6.4	7.0
Earth sciences	0.9	0.8	0.8	1.1	0.9	1.0	0.9	0.9	0.7
Biological sciences	1.5	1.3	1.7	2.1	2.0	2.0	1.8	1.9	1.8
Information, computer and communication technologies	20.3	19.6	25.6	24.9	23.7	14.9	13.7	14.4	18.6
Applied sciences and technologies	14.7	13.6	11.4	11.3	8.6	8.2	6.9	7.2	6.5
Engineering sciences	30.1	31.7	29.7	27.5	26.3	26.8	26.3	26.7	24.8
Biological sciences	1.5	1.3	1.7	2.1	2.0	2.0	1.8	1.9	1.8
Agricultural sciences	2.9	2.4	2.9	3.7	4.5	4.2	5.0	5.0	4.9
Medical and health sciences	11.8	12.2	14.1	16.1	17.6	17.1	16.8	16.3	16.7
Environmental sciences	0.6	0.5	0.4	0.1	0.0	0.4	0.4	0.6	0.2
Material sciences	1.7	0.7	0.6	0.6	0.6	0.5	0.5	1.2	0.5
Marine sciences	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0
Division 2: social sciences and humanities	**3.5**	**3.5**	**3.6**	**4.4**	**4.5**	**13.7**	**17.1**	**17.4**	**17.1**
Social sciences	3.5	3.5	3.5	4.4	4.5	13.7	17.1	17.4	17.1
Humanities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: National Survey of Research and Experimental Development (DST)

However, there are pockets of excellence, such as the venture capital industry. Government plays a significant role in the South African venture capital industry as it funded 39% of active funds under management in 2016, followed by independent fund managers (35%), corporate (15%), angel investors (6%) and other sources (5%).

5.2 LINKAGES AND ENTREPRENEURSHIP

As innovation does not take place in isolation, appropriate linkages need to be established between different sectors in order to facilitate knowledge and technology transfer. One type of innovation linkage is the public-private partnership (PPP). It is a useful risk-sharing and resource-pooling mechanism on projects that have a long-term benefit to one or more stakeholders from the public and private sectors. The three significant words that describe PPPs are risk, resources and benefit. Large infrastructure-type innovation projects involve some higher level of risk and uncertainty on issues such as capital availability, social acceptance, political support and policy certainty.

While the wealth of technical and industry knowledge brought in by the reputable industry partner is undisputed, there are typically different perspectives of the project's benefit among the public-sector and private-sector partners. The public-sector partner's objectives in the PPP are aimed at an improved service delivery, whereas the private-sector partner seeks a financial return.

National Treasury maintains a database of PPP projects. Table 5.2 shows the active South African innovation-related PPPs for energy, waste, water and IT infrastructure projects. There are seven active energy PPP projects in the energy sector, of which two are at the inception stage, three are at the feasibility study phase and three are at the procurement stage. The two energy PPPs that are at the inception stage are the Free State Provincial Government's waste-to-energy processing plant and the Midvaal Local Municipality's electricity services project. The energy projects at the feasibility study phase are the City of Cape Town's Alternative Service Delivery Mechanisms for Council's Composting Plants Project in Cape Town and Drakenstein Municipality's waste-to-energy project. In the IT sector, the PPP that is at the inception stage is the Western Cape Provincial Government's Broadband Initiative Project.

The active waste-sector PPP projects are the Ditsobotla Local Municipality's waste water treatment project (at the inception stage), Eden District Municipality's Mossel Bay and Oudtshoorn regional waste landfill project (at the feasibility study stage) and the eThekwini Municipality's reclamation and re-use of treated sewage effluent for potable water (at the feasibility study stage). Lastly, the four water-sector PPP projects are the Department of Water and Sanitation's Pongolapoort Dam development (at the feasibility study stage), Lephalale Municipality's bulk water reticulation and sanitation project (at the feasibility study stage), eThekwini Municipality's Kwa-Mashu waste water treatment project (at the feasibility study stage) and Sedibeng Municipality's waste water treatment project (at the procurement stage).

Table 5.2: *Active innovation-related PPPs*

	NUMBER OF PROJECTS	PROJECT STAGE
Energy	7	2 x inception; 2 x feasibility study; 3 x procurement
IT	1	1 x inception
Waste	3	1 x inception; 2 x feasibility study
Water	4	3 x feasibility study; 1 x procurement

Source: National Treasury

There are several other innovation-related PPP that are being conceptualised, such as the Sovereign Innovation Fund. The Sovereign Innovation Fund PPP is aimed at commercialising innovations from ideas from the public and the private sectors. In the 2017/18 financial year, the DST was planning to develop its business case in consultation with other government departments, such as the dti, the Economic Development Department (EDD) and the Department of Small Business Development (DSBD). Various governments around the world have initiated such Fund of Funds in support of innovation commercialisation for start-ups and seed capital. A notable example is the UK Innovation Investment Fund (UKIIF), which supports the creation of viable investment funds that target high-growth, technology-based businesses in the UK. It has invested through two underlying Funds of Funds – the UK Future Technology Fund and the Hermes Environmental Impact Fund.

5.3 INTELLECTUAL PROPERTY RIGHTS REGIME: RECENT DEVELOPMENTS

Intellectual property rights refer to rights conferred by law for creations of the mind, both artistic and commercial. Industrial intellectual property rights are protected by patents, registered trademarks, registered industrial designs and integrated circuits, and geographical indications (appellations). The benefits of the patent system arise from its dual mission, that is, to encourage invention and the diffusion of technology. However, patents have a number of deficiencies that can stifle innovation, such as the creation of monopolies.

Figure 5.2 shows the number of patents awarded to South African inventors by the United States Patent and Trademark Office (USPTO) during the period 2000–2015. The most recent years exhibit an increase in the number of patents awarded to South Africans. It should be noted that the granting of 160 patents to South African inventors is an all-time high. South Africa was ranked 32nd during 2015 according to the number of patents granted by USPTO. However, South Africa, in general, gets very few patents from USPTO. Japan is granted more than 50 000 patents a year, and companies like IBM are granted more than 3 000 patents a year.

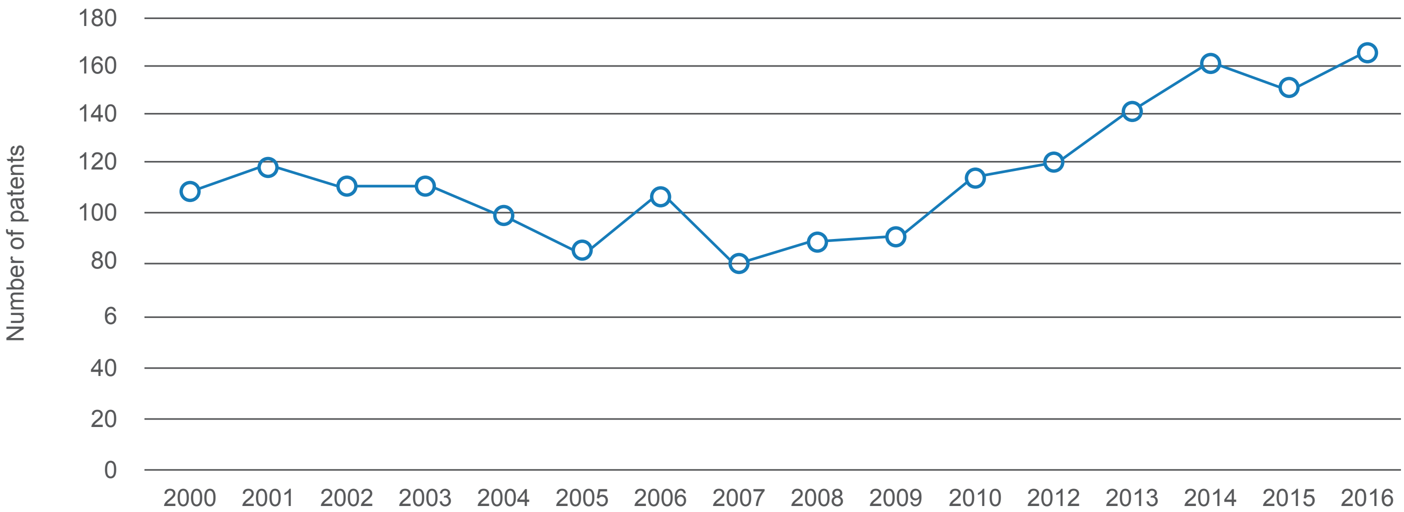


Figure 5.2: *Patents granted to South African inventors*

Source: USPTO

Table 5.3 identifies the most prolific South African organisations that were awarded utility patents by USPTO between 2011 and 2015.

Table 5.3: *Patent grants of the most prolific assignees in South Africa*

FIRST NAME ASSIGNEE	PATENT GRANTS (2011–2015)	PATENT GRANTS (2015)
Individually owned	134	16
Sasol Technology	48	10
Amazon Technologies	29	12
Council for Scientific and Industrial Research	23	11
University of the Witwatersrand	22	8
Spinalmotion	20	1
University Cape Town	15	1
Cork Group Trading	14	4
Element Six Abrasives	14	6
Joy MM Delaware	12	3

Source: USPTO

Patent origin is determined by the residence of the first-named inventor. Individually owned patents were the majority. Sasol Technology was at the top of the list with 48 patents during the period.

6. INNOVATION OUTPUTS

The process of innovation is not complete if it does not include the desired economic and social impacts. There are several accounts of the strong links between the level of innovation and economic performance of various countries. The variety of innovations has also been useful in tackling societal challenges that are related to issues such as food security, safety and peace, mobility, health, energy, environmental protection and shelter. This section shows the state of STI in addressing economic and societal needs.

6.1 INNOVATION FOR ECONOMIC IMPACT

Table 6.1 shows the balanced exports and imports for the medium-technology sector to which the automotive industry contributes positively to the balance of payments, whereas the engineering industries are experiencing a narrowing trade deficit. The high-technology sector's exports represented only 22.6% of its imports in 2016: a slight increase from 19.2% in 2007. Electronic and electrical products contributed to this high trade deficit (18.1% in 2016).

Table 6.1: *Merchandise exports as a percentage of imports*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	PERCENTAGE									
High technology	**19.2**	**18.2**	**16.9**	**19.1**	**19.2**	**20.8**	**18.7**	**22.5**	**20.5**	**22.6**
Electronic and electrical	15.5	14.9	15.6	17.0	17.6	19.5	15.9	19.5	16.5	18.1
Other	27.5	25.0	19.5	23.1	21.9	23.1	25.7	29.7	30.7	31.9
Medium technology	**70.8**	**90.7**	**82.3**	**100.1**	**89.1**	**85.3**	**81.3**	**92.0**	**89.2**	**102.7**
Automotive	64.4	120.1	114.3	109.8	95.8	96.7	90.6	110.1	123.8	161.2
Process	128.2	160.2	131.3	160.2	138.8	129.1	125.4	131.9	109.1	128.7
Engineering	50.4	48.9	45.8	63.5	60.2	56.9	53.6	58.5	55.9	57.3
Low technology	**77.9**	**67.5**	**62.0**	**81.5**	**68.2**	**68.1**	**59.6**	**65.2**	**56.3**	**59.9**
Textile, garment and footwear	22.4	20.7	16.5	30.9	29.9	29.8	30.2	32.1	28.9	29.0
Other products	108.1	90.7	89.7	115.9	94.0	93.7	79.4	88.8	76.8	83.7
Resource-based	**118.1**	**146.3**	**160.5**	**179.9**	**175.2**	**161.3**	**161.9**	**165.9**	**149.8**	**165.4**
Agro	88.0	94.1	108.0	123.2	112.3	100.0	104.3	114.1	120.4	111.8
Other	132.0	169.9	192.1	211.1	205.6	193.5	190.0	191.7	164.0	200.5
Primary products	**146.2**	**112.3**	**123.3**	**146.5**	**137.5**	**106.4**	**114.9**	**95.7**	**138.1**	**150.5**
Unclassified products	**11.3**	**8.8**	**10.5**	**17.8**	**171.9**	**141.8**	**115.7**	**83.0**	**42.4**	**78.8**
Total	**80.2**	**84.4**	**84.5**	**99.6**	**105.1**	**94.9**	**91.9**	**90.7**	**87.5**	**99.2**

Source: United Nations Conference on Trade and Development (UNCTAD)

Overall, there was a good improvement in South Africa's merchandise trade balance of payment in 2016 as the exports, as a percentage of imports, reached 99.2%. This was largely driven by the increase in exports and the reduction of imported products in 2016. Table 6.2 provides an in-depth analysis of the contribution of high-technology industries to the South African economic competitiveness in terms of exports, as a percentage of imports.

Table 6.2: *High-technology exports as percentage of imports*

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	PERCENTAGE									
Electronic and electrical	**15.5**	**14.9**	**15.6**	**17.0**	**17.6**	**19.5**	**15.9**	**19.5**	**16.5**	**18.1**
Power-generating machinery and equipment	51.8	39.3	34.4	35.2	31.1	37.0	37.4	41.0	32.7	39.0
Office machines and automatic data-processing machines	8.3	8.9	8.8	11.4	11.2	13.5	11.8	13.0	11.9	14.8
Parts and components for electrical and electronic goods	13.5	15.1	14.9	16.7	17.1	18.4	16.2	20.4	18.3	17.7
Telecommunication and sound-recording apparatus	12.8	10.8	11.1	10.6	11.9	16.1	16.6	22.9	15.1	15.4
Electrical machinery, apparatus and appliances not elsewhere specified	27.2	29.0	28.0	38.1	40.2	37.8	29.5	34.0	34.1	34.0
Other	**27.5**	**25.0**	**19.5**	**23.1**	**21.9**	**23.1**	**25.7**	**29.7**	**30.7**	**31.9**
Medicinal and pharmaceutical products	10.1	11.8	11.5	18.9	21.3	18.5	19.2	20.5	18.9	22.6
Other transport equipment	43.8	35.4	29.7	39.3	35.8	44.0	69.7	54.9	44.2	45.6
Professional and scientific instruments	19.2	22.8	23.3	28.5	28.8	26.9	26.9	34.1	33.4	34.8
Photo apparatus, optical goods, watches and clocks	15.0	16.2	15.2	20.4	18.4	17.0	16.0	17.5	19.3	18.3
Total	**19.2**	**18.2**	**16.9**	**19.1**	**19.2**	**20.8**	**18.7**	**22.5**	**20.5**	**22.6**

Source: UNCTAD

As shown, the trade deficit on the electronic and electrical products is caused mainly by the office machinery and automatic data-processing machines (14.8% in 2016), telecommunication and sound-recording apparatus (15.4%), and parts and components for electrical and electronic goods (17.7%) industries. A trade deficit is also high in respect of precision, as well as medicinal and pharmaceutical products. However, the trade deficit for medicinal and pharmaceutical products is decreasing according to Business Monitor International Research, as "several multinational drug-makers choose to manufacture medicines locally in South Africa, designating the market as their production hub for sub-Saharan Africa".[4] South Africa's local pharmaceutical industry is more developed in terms of local drug-makers' manufacturing capabilities compared with other sub-Saharan African drug-makers. To this end, they have become increasingly competitive in terms of medicine production. Pharmaceutical imports are predicted to remain high as the country is still heavily reliant on imported products, particularly with regard to the more advanced pharmaceuticals.

From 2007 to 2008, there was a notable sharp decline of exports, as a percentage of imports, for the power-generating machinery and equipment products. This is probably due to a R340 billion Eskom Build Programme, which commenced in 2005, with the objective of adding an additional 17 GW of electricity-generating capacity to the national grid by 2018/19.

Another notable improvement in reducing the trade deficit is in respect of professional and scientific instruments. This category includes optical instruments and apparatuses, medical instruments and appliances, meters and counters, and measuring, analysing and controlling apparatuses.

6.2 INNOVATION FOR INCLUSIVENESS AND SOCIAL IMPACT

The Social Progress Index addresses three key issues: does a country provide for its people's essential needs (basic human needs), are the building blocks in place for people to improve their lives (foundations of wellbeing) and is there opportunity for people to improve their position in society (opportunity)?

4 http://www.pharmaceuticalsinsight.com/industry-trend-analysis-pharmaceutical-imports-will-continue-dominate-nov-2017

Table 6.3 shows the ranking of South Africa on the SPI for the past four years. In 2017, the country was ranked 66th out of 128 countries.

Table 6.3: *World ranking of South Africa on the SPI*

COMPONENT	SUB-COMPONENT	2014	2015	2016	2017
		OUT OF 132	OUT OF 133	OUT OF 133	OUT OF 128
Basic human needs	Nutrition and basic medical care	95	89	87	83
	Water and sanitation	85	72	84	80
	Shelter	71	82	86	88
	Personal safety	128	129	129	123
	Sub-component ranking	**94**	**92**	**92**	**90**
Foundations of wellbeing	Access to basic knowledge	59	61	84	84
	Access to information and communication	41	44	44	44
	Health and wellness	129	114	126	110
	Environmental quality	92	75	70	77
	Sub-component ranking	**71**	**64**	**81**	**78**
Opportunity	Personal rights	32	33	36	37
	Personal freedom and choice	50	35	27	33
	Tolerance and inclusion	42	48	25	36
	Access to advanced education	71	72	49	55
	Sub-component ranking	**40**	**37**	**31**	**34**
Social progress ranking		**69**	**63**	**59**	**66**

Source: Social Progress Index (Social Progress Imperative)

According to Maslow's theory, most of the basic needs should be fulfilled before other human needs of wellbeing and belonging can be fulfilled. The SPI shows the opposite for South Africa, as the country ranks better on opportunity (34th in 2017), followed by foundations of wellbeing (78th). Personal freedom and choice, tolerance and inclusion, as well as personal rights, are the key drivers behind a high ranking in opportunity. Access to advanced education, one of the components of the opportunity pillar, has indicators such as access to world-class universities. According to the 2017 academic ranking of world universities, the top five South African universities were in the top 500.

In foundations of wellbeing, access to information and communication is ranked high (44th). This is probably driven by the large number of mobile cellular subscriptions that was shown in the *2016 South African STI Indicators Report*. Health and wellness is the weakest link in foundations of wellbeing. This component has indicators such as the life expectancy at 60 years (107th in 2017), premature deaths from non-communicable diseases (110th) and suicide rate (100th). It should, however, be noted that the survival rate for South Africans is increasing, as reflected by a rise in life expectancy at birth from 54.7 years in 2007 to 64 years in 2017.

A component that is ranked poorly in basic human needs is personal safety (123rd). This includes indicators such as the homicide rate (124th in 2017), level of violent crime (119th), perceived criminality (89th), potential terror (73rd) and traffic deaths (99th). Nutrition and basic medical care is showing gradual improvements from 2014 to 2017, although the number of deaths from infectious diseases is still a major issue for this component. The leading underlying cause of natural death in South Africa is still TB (7.2% of deaths in 2015), although its contribution to South African deaths is declining. The higher rates of TB infections are in the mining industry, with an estimated 2 500 to 3 000 cases per 100 000 individuals.[5] According to The World Bank, "this incidence is 10 times the World Health Organisation (WHO) threshold for a health emergency, and is also nearly three times the incidence rate in the general population". Some STI initiatives that address TB infections are the NRF's Centre of Excellence for Biomedical Tuberculosis Research (CBTBR), which is co-hosted by the University of Cape Town, the University of Stellenbosch and the University of the Witwatersrand.

5 http://www.worldbank.org/en/programs/the-southern-africa-tb-in-the-mining-sector-initiative

7. SOUTH AFRICAN INNOVATION SCORECARD

The South African Innovation Scorecard was originally published for the period 2010–2014. In this report, the scorecard has been updated and presents the performance of the country's system of innovation for the period 2010–2015. All individual indicators are amended, and the base year has been appropriately re-adjusted. A number of variables, such as the GDP, change over time. Figure 7.1 provides a diagrammatic illustration of the performance of the three pillars.

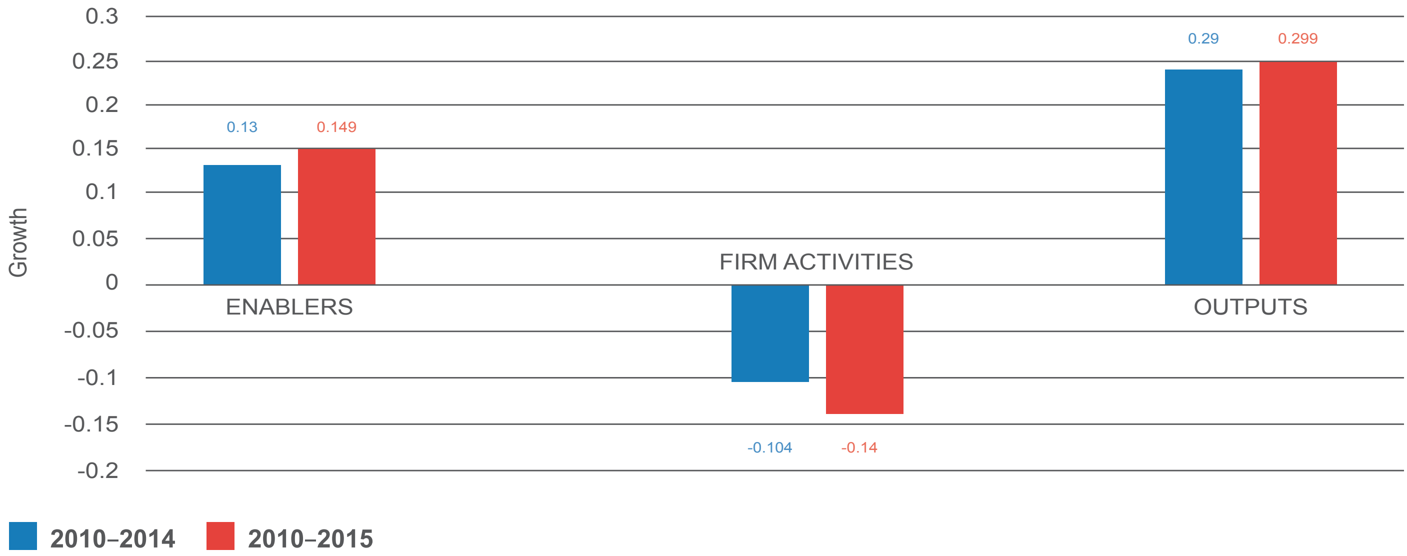


Figure 7.1: *Performance of innovation dimensions (2010–2014 and 2010–2015)*

During 2015, the overall composite indicator had a value of 0.136, indicating an overall improvement during the period since 2010. Table 7.1 shows the values of the pillars and the composite indicators for the periods 2010–2014 and 2010–2015. The summary indicator has improved from 0.105 to 0.136 (an improvement of almost 30%). Enablers and outputs have also improved, but the firm activities continue to decline.

Table 7.1: *Pillars and summary indicator for 2014 and 2015*

	2010–2014	2010–2015
Enablers	0.13	0.149
Firm activities	-0.104	-0.14
Outputs	0.29	0.299
Composite indicators	0.105	0.136

Table 7.2 shows the growth or decline of individual indicators for the periods 2010–2014 and 2010–2015. Among the enablers, venture capital, as a percentage of GDP, reversed its decline. Among the firm activities, only the public-private co-publications exhibited growth. PCT patent applications showed higher declines than in the previous period. Similarly, business finance to higher education institutions continued to decline. Among the outputs, the contribution of exports in commercial services to total exports also continued to decline.

Table 7.2: *Performance score per indicator for 2010–2014 and 2010–2015*

TYPE OR INDICATORS	GROWTH OR DECLINE (2010–2014)	GROWTH OR DECLINE (2010–2015)
Enablers		
New doctorates per 1 000 of the population aged 25 to 34	0.43	0.25
Percentage of the population aged 25 to 64 having completed tertiary education	0.15	0.24
International scientific co-publications per million of the population	0.52	0.52
Scientific publications among the top 10% most cited publications worldwide as a percentage of the total scientific publications in the country	0.16	0.16
R&D expenditure in the public sector (as a percentage of GDP)	0.027	0.16
Venture capital (as a percentage of GDP)	-0.49	0.168
Firm activities		
R&D expenditure in the business sector (as a percentage of GDP)	-0.108	-0.08
Public-private co-publications per million of the population	0.27	0.42
Business finance to higher education institutions	-0.25	-0.27
PCT patent applications per billion of GDP	-0.16	-0.3
PCT patent applications in societal challenges per billion of GDP	-0.06	-0.53
Trademarks per billion of GDP	-0.33	-0.14
ICT investments as a percentage of GDP	-0.09	-0.09
Outputs		
Licence and patent revenues from abroad as a percentage of GDP	0.51	0.38
Contribution of high-technology product exports to total exports	0.32	0.176
Medium high-technology product exports to total exports	0.009	0.009
Contribution of exports in commercial services to total exports	-0.038	-0.05
Life expectancy at birth	0.0073	0.29
Internet users as a percentage of the population	1.10	1.16
GDP per energy use	0.14	0.13

The above-mentioned findings highlight directions for further research, such as patents, and areas for incentives provision, such as business support to universities. Table 7.3 shows the values of the individual indicators for 2010 and 2015 and the growth or decline during the period. It should be mentioned that the list of indicators needs to be assessed for timeliness, sensitivity to policy changes, double counting, neglected areas, etc. As discussed in previous documents, most of the individual indicators are reactive and a separate list of leading indicators is needed for policy development.

Table 7.3: *Score per indicator – 2010 and 2015*

TYPE OR INDICATORS	2010	2015	GROWTH OR DECLINE
Enablers			
New doctorates per 1 000 of the population aged 25 to 34	0.16	0.20	0.25
Percentage of the population aged 25 to 64 having completed tertiary education	11.73	14.6	0.24
International scientific co-publications per million of the population	95.78	146.08	0.52
Scientific publications among the top 10% most cited publications worldwide as a percentage of total scientific publications in the country	1.2	1.4	0.16
R&D expenditure in the public sector (as a percentage of GDP)	0.37	0.43	0.16
Venture capital (as a percentage of GDP)	0.008	0.0215	0.168
Firm activities			
R&D expenditure in the business sector (as a percentage of GDP)	0.37	0.34	-0.08
Public-private co-publications per million of the population	2.76	3.92	0.42
Business finance to higher education institutions	10.8	7.8	-0.27
PCT patent applications per billion of GDP	0.10	0.07	-0.3
PCT patent applications in societal challenges per billion of GDP	0.03	0.014	-0.53
Trademarks per billion of GDP	8.69	7.46	-0.14
ICT investments as a percentage of GDP	3.2	2.9	-0.09
Outputs			
Licence and patent revenues from abroad as a percentage of GDP	0.31	0.43	0.38
Contribution of high-technology product exports to total exports	0.034	0.040	0.176
Medium high-technology product exports to total exports	0.0249	0.251	0.009
Contribution of exports in commercial services to total exports	0.171	0.180	-0.05
Life expectancy at birth	49.20	63.8	0.29
Internet users as a percentage of the population	24	52	1.16
GDP per energy use	4.238	4.825	0.13

8. KEY THEMES ON SOUTH AFRICAN STI POLICY: LOCAL INNOVATION SYSTEMS

South Africa is a developing country, comprising nine provinces. It is a resource-intensive economy, with a diversity of natural resources that contribute remarkably to its economic growth through mining, agricultural activities, manufacturing and other services. Each province has its own strengths. These are mainly influenced by the geography of the region. It is therefore imperative that regional and local innovation strategies should be based on these strengths and relative advantages. The provincial R&D expenditure data in Table 8.1 shows the innovation system structure for each province. The top three provinces in terms of contribution to GERD in 2015/16 are Gauteng (45.4%), Western Cape (22.0%) and KwaZulu-Natal (10.3%).

Table 8.1: *Provincial R&D expenditure, 2015/16*

	GAUTENG	WESTERN CAPE	LIMPOPO	KWAZULU-NATAL	FREE STATE	NORTH WEST	NORTHERN CAPE	MPUMALANGA	EASTERN CAPE
R&D expenditure (million R)	16 666	5 814	629	3 335	1 778	1 403	576	859	2 143
Gauteng expenditure on R&D as a percentage of GERD	45.4	22.0	1.9	10.3	5.5	3.7	2.0	2.4	6.6
BERD (million R)	7 184	2 275	146	1 437	1 124	452	207	340	652
Percentage of business R&D expenditure	52.0	12.7	1.1	10.4	8.1	3.3	1.5	2.5	4.7
Percentage of state-owned entities' R&D expenditure	79.0	6.0	0.2	0.2	0.5	8.6	0.1	0.7	0.2
Percentage of NPOs' R&D expenditure	38.8	11.3	6.3	26.1	1.8	11.0	0.2	2.9	2.4
Percentage of government R&D expenditure	41.4	18.8	4.2	9.3	3.1	3.1	3.4	5.6	11.2
Percentage of science councils' R&D expenditure	52.2	21.5	1.9	10.0	1.0	2.7	3.8	2.1	4.7
Percentage of higher education R&D expenditure	33.5	31.8	2.3	9.1	5.3	4.5	1.7	1.9	9.9

Source: National Survey of Research and Experimental Development (HSRC and DST)

Gauteng's innovation system is driven by its Innovation and Knowledge Economy Strategy. This strategy seeks to accelerate innovation in all its forms in order to bolster and support the broader strategic objectives of sustainable social and economic development, and sustainable employment. It is implemented through three main objectives: economic competitiveness, public sector efficiency and community-led innovation.

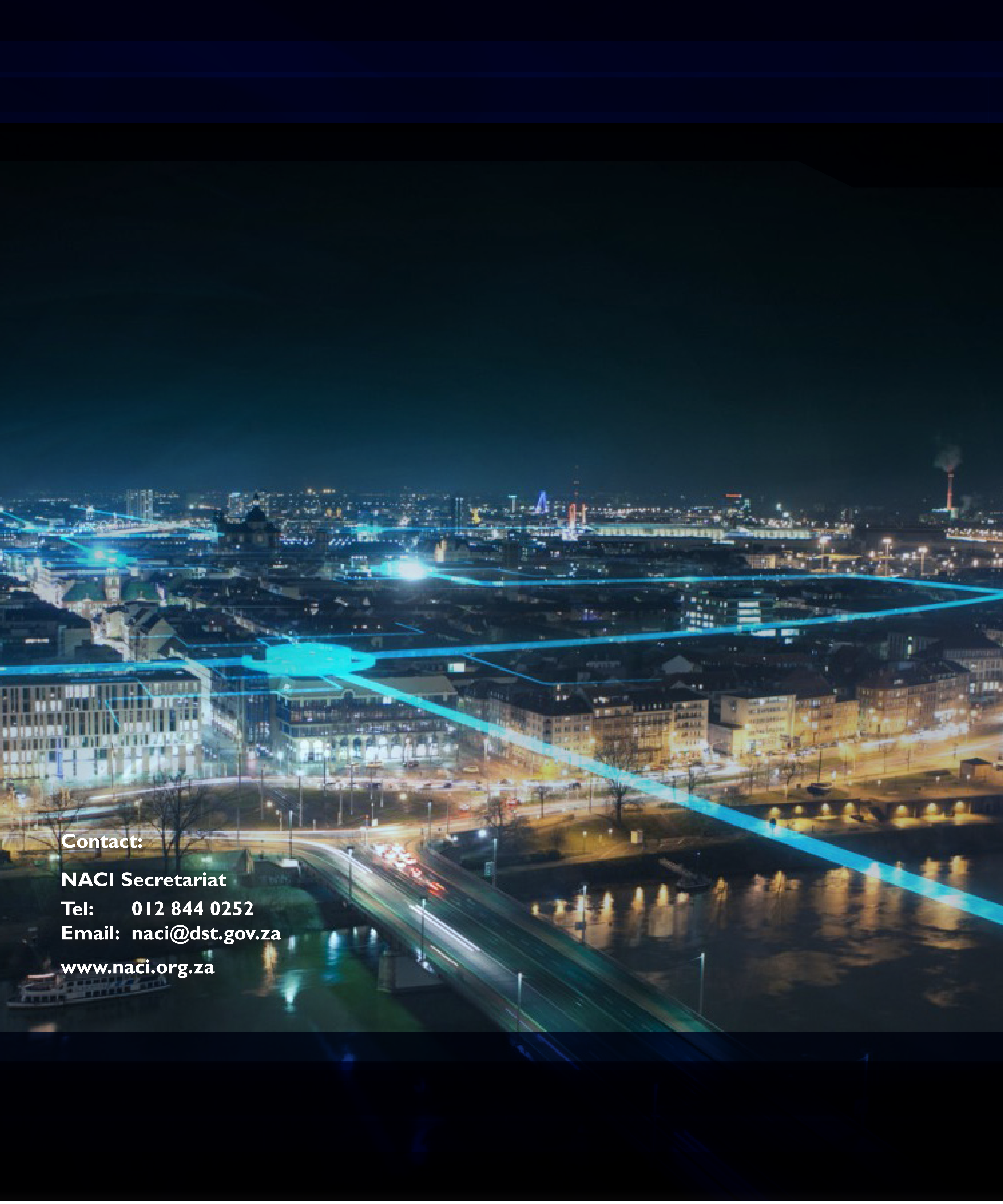
The Western Cape Innovation Strategy is focused on maintaining the balance between the top-down and bottom-up participatory approaches, and emphasis has been placed on the need to create models for innovation sustainability, to develop strong leadership or champions that will drive and coordinate broad-based innovation, to develop and define innovation in the South African context, to promote collaboration at both regional and national levels, to develop a national innovation strategy that will also acknowledge the cultural diversity and values of our country, to diversify the economic markets through a novel manufacturing sector using social innovation, to build knowledge capacity, not only through academic qualifications, but in a form that includes existing indigenous knowledge, and to balance the social and technological elements of innovation.

The KwaZulu-Natal Growth and Development Strategy maps a way to achieve the province's 2035 vision of a prosperous province with a healthy, secure and skilled population, living in dignity and harmony, acting as a gateway to Africa and the world. This vision is further articulated through seven strategic goals: inclusive economic growth, human resource development, human and community development, strategic infrastructure, environmental sustainability, governance and policy, and spatial equity.

Although the Western Cape's BERD, as a proportion of its total R&D expenditure (39.1% in 2015/16), is slightly lower than that of Gauteng (43.1%), it has a strong focus on technology transfer and the growth of high-technology start-ups. According to the 2017 Venture Capital Survey, investors operating from Gauteng and the Western Cape dominate the Southern African venture capital asset class. Furthermore, this survey found that the Western Cape represents the largest number of deals in the active venture capital portfolio, with Gauteng recording the greatest value of venture capital fund managers invested in active venture capital portfolios.

Much still need to be done to uplift the innovation systems of provinces such as Mpumalanga and the Northern Cape. These two provinces have universities that are still new (Mpumalanga University and Sol Platjie University) and are not yet fully capacitated (not yet providing master's and doctoral degrees). These universities are expected to add value to the innovation systems of these two provinces.

NOTES



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