SOUTH AFRICAN NATIONAL SURVEY OF RESEARCH AND EXPERIMENTAL DEVELOPMENT

MAIN REPORT 2017/18

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REVISIONS

The Department of Science and Innovation (DSI), Statistics South Africa (Stats SA) and the Human Sciences Research Council's Centre for Science, Technology and Innovation Indicators (HSRC-CeSTII) jointly reserve the right to revise the data, indicators and analysis contained in this report. Such revisions may result from revisions by Stats SA of socio-economic indicators such as the gross domestic product (GDP), or population or employment numbers. Revision may also arise from amendments in response to internal data quality and consistency checks, or external data consistency monitoring, such as that provided by the Organisation for Economic Cooperation and Development (OECD), which provides the opportunity for quality checks through global comparative analysis, time series analyses and other methods. Explanations of any revisions will be made available and accessible on the DSI and HSRC websites.

FOREWORD

The National Survey of Research and Experimental Development (R&D Survey) is published annually to update South Africa's science, technology and innovation (STI) statistics. These statistics measure the size, growth and composition of R&D expenditure, R&D funding and R&D personnel.

The Department of Science and innovation (DSI), as a partner within the National Statistics System (NSS), oversees the production of the R&D survey. R&D statistics are key to informing government's STI policy implementation, and are used by the private sector, the international community, the media, and researchers.

The 2017/18 R&D data collection was in line with the Frascati Manual 2002, an international guideline for R&D statistics that is published by the Organization for Economic Cooperation and Development (OECD). A phased approach is being followed to adopt the revisions proposed by the Frascati Manual 2015 edition (OECD, 2015). Starting with the 2016/17 survey, some concepts and definitions were refined and some new sub-categories on R&D personnel data were introduced, but without changing the historical data series. Further Frascati Manual 2015 revisions will be introduced in the 2019/20 R&D survey.

The Statistics Act (No. 6 of 1999) mandates the Statistician-General (SG) to coordinate statistical production in the country, even beyond the confines of Statistics South Africa (Stats SA). Therefore, each R&D survey is subjected to a quality assessment process, before the results can be approved for publication. A clearance committee oversees this process, in accordance with the South African Statistical Quality Assessment Framework (SASQAF), to ensure that the survey remains at a high standard in terms of producing quality statistics. In August 2019, new members were appointed to the clearance committee in order to boost its capacity, representing the survey respondents and user groups, such as the higher education sector, the business sector, policy researchers and other relevant actors from government institutions.

The quality indicators used in the 2017/18 Statistical Report indicate that there have been improvements in the way the survey is conducted, since the beginning of the clearance process. The assessment shows that there has been improvement on the following indicators over time: the adherence to the Statistical Value Chain phases, the collection rate, sampling frame duplication rate, range error rate, duplication error rate, the proportion of misclassified units, GERD responses, BERD responses, proportion of statistical unit deaths not reflected and proportion of births not reflected. Based on these improvements, the R&D survey is ready to undergo the SASQAF self-assessment process. The output of this process will indicate the readiness for the full assessment by the independent assessment unit.

Risenga Maluleke
STATISTICIAN-GENERAL, REPUBLIC OF SOUTH AFRICA

PREFACE

The 2019 White Paper on Science, Technology and Innovation highlights the importance of Research and Experimental Development (R&D) to innovation and advances in knowledge to prepare a society for the future that is fit for the fourth industrial revolution (4IR). All of these are crucial for the National Development Plan (NDP).

The National Survey of Research and Experimental Developmental (R&D Survey) is an important tool for monitoring the performance of the National System of Innovation (NSI). The R&D Survey is conducted annually by the Centre of Science, Technology and Innovation Indicators (CeSTII) based at the Human Science Research Council (HSRC), on behalf of the Department of Science and Innovation (DSI), and in partnership with Statistics South Africa (Stats SA). The survey produces key indicators for R&D performance that can be used to assess national progress in comparison with global peers, such as Gross Domestic Expenditure on Research and Development (GERD) and R&D personnel.

In 2017/18, South Africa's GERD amounted to R38.725 billion, which reflects a nominal increase of 8.5% from the R35.693 billion reported in 2016/17. R&D intensity, measured in terms of GERD as a percentage of gross domestic product (GDP), moved from 0.82% in 2016/17 to 0.83% in 2017/18, which is one basis point of increment.

Total R&D personnel headcount increased to 84 262, from 80 029 in 2016/17, an increase of 5.3%. The highest increase in R&D personnel FTEs was noted in the higher education sector, with 6.1% growth from 22 061.4 FTEs in 2016/17 to 23 415.1 FTEs in 2017/18. In 2017/18, women researchers accounted for 44.9% of total (61 840) researchers. The country's human capital and research outputs need to increase so that our national system of innovation can contribute optimally to addressing South Africa's socio-economic challenges. Currently, our science system is improving at a slow rate and it remains small and fragmented.

The government sector is leading as the main source of funding. This is important as a countercyclical measure – for government to sustain the research and innovation system during tough economic periods. Government's interactions with the domestic private sector and international partners on R&D and technological innovation matters are positive and have over the years built important platforms for future growth. Following government as the main funder is the business sector and funding from other countries.

Government continues to provide public funding that benefit the private sector by supporting partnerships between business, higher education institutions and public research institutions, to stimulate R&D intensity in the country. Public-Private sector collaboration needs to be strengthened in order to take advantage of the country's researcher base and to overcome challenges of the decline of business R&D investment and the slow economic growth. The R&D tax incentive is in place to encourage companies to undertake R&D within the country.

A number of other initiatives require scientific research to achieve their aims and hold promise in expanding and transforming the local research enterprise. These include blue economy initiatives to drive sustainable use of ocean resources for economic activity, initiatives in health research, biological and food security as well as earth and environment, materials and manufacturing, astronomy and data sciences and energy. Aspects of these areas are identified as new sources of growth in the foresight exercise that will be used to identify priority areas for investment by government.

I wish to thank the Centre of Science, Technology and Innovation Indicators for their efforts in conducting this survey annually on behalf of Department of Science and Innovation, and to Statistics South Africa for facilitating the process of assessing the quality of the R&D Statistics.

The participation of respondents from the five key institutional sectors who participated in the R&D Survey is sincerely appreciated. Your efforts provide government with a critical evidence base for science, technology and innovation to play a transformative role in addressing our social, economic and environmental development challenges. I thank you for your time and effort and look forward to your continued support with future surveys and other efforts to strengthen the National System of Innovation.

Dr B E Nzimande, MP
MINISTER OF HIGHER EDUCATION AND SCIENCE AND INNOVATION

ACKNOWLEDGEMENTS

The South African National Survey of Research and Experimental Development (R&D Survey) is conducted annually by HSRC-CeSTII on behalf of the DSI.

The project team extends its appreciation to Dr Phil Mjwara, Director-General of the DSI, Mr Risenga Maluleke, Statistician-General, Prof. Crain Soudien, CEO of the HSRC, and Prof. Leickness Simbayi, Deputy CEO: Research of the HSRC, for their support of the R&D Survey.

The support and contributions of Dr Glenda Kruss, Executive Head of CeSTII, and of Imraan Patel, Godfrey Mashamba, Tshidi Lekala, Kgomotso Matlapeng and Thabo Manyaka of the DSI are appreciated.

Technical inputs and advice by the DSI and Statistics South Africa teams, as well as the Clearance Committee for Science, Technology and Innovation Statistical Reports, have helped to improve the quality of this publication and are appreciated.

Interactions with the OECD Working Party of National Experts on Science and Technology Indicators (NESTI) have provided invaluable assistance in maintaining the quality and standard of the South African R&D surveys and the analysis of their results.

The HSRC-CeSTII project team for the 2017/18 South African National Survey of Research and Experimental Development comprised: Curtis Bailey, Lindiwe Binda, Mario Clayford, Nozibele Gcora, Firdous Khan, Lwando Kondlo, Nhlanhla Malaza, Jerry Mathekga, Neo Molotja, Precious Mudavanhu, Nazeem Mustapha, Gerard Ralphs, Kgabo Ramoroka, Janine Senekal, Theodore Sass, Natasha Saunders, Moses Sithole, Anele Slater, Natalie Vlotman, Sibusiso Ziqubu, and Thembinkosi Zulu.

We further acknowledge the contributions and support of Maria Maluleke, Zinziswa Hlakula, and Vuyiseka Mpikwa.

We are most grateful for and acknowledge the cooperation of the respondents to the questionnaire.

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
BERD	Business Expenditure on R&D
BRICS	Brazil, the Russian Federation, India, China and South Africa
CEO	Chief Executive Officer
CeSTII	Centre for Science, Technology and Innovation Indicators
DACST	Department of Arts, Culture, Science and Technology
DSI	Department of Science and Innovation
DST	Department of Science and Technology
FTE	Full-time Equivalent
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
HERD	Higher Education Expenditure on R&D
HIV	Human Immunodeficiency Virus
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
NESTI	National Experts on Science and Technology Indicators
NPO	Not-for-profit Organisation
NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing Power Parity
QMP	Quality Management Plan
R	Rand (South African currency)
R&D	Research and Experimental Development
RF	Research Field
SASQAF	South African Statistical Quality Assessment Framework
SEO	Socio-economic Objective
SIC	Standard Industrial Classification
Stats SA	Statistics South Africa
STI	Science, Technology and Innovation
SVC	Statistical Value Chain
TB	Tuberculosis
UIS	UNESCO Institute for Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization

DEFINITION OF TERMS

Applied research is original investigation undertaken in order to acquire new knowledge. It is directed primarily towards a specific practical aim or objective.

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

BERD refers to business expenditure on research and experimental development.

Biotechnology is an application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.

Capital expenditure is the annual gross expenditure on fixed assets used repeatedly or continuously in the performance of R&D programmes for more than one year. Such expenditure is reported in full in the period in which it took place and is not registered as an element of depreciation. Capital expenditure includes expenditure on land, buildings, instruments and equipment.

Current expenditure is composed of labour costs of R&D personnel and other current costs used in R&D. Services and items (including equipment) used and consumed within one year are current expenditures. Annual fees or rents for the use of fixed assets is included in current expenditures.

Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems or services, or to improving substantially those already produced or installed.

Full-time equivalent (FTE) refers to the number of hours (person-years of effort) spent on R&D activities.

FTE per 1 000 in total employment is the number of professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of these projects during a given year expressed as a proportion of 1,000 employed people. It is calculated by number of researchers during a given year divided by the total employed people and multiplied by 1 000.

Gross domestic product (GDP) is the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.

Gross domestic expenditure on research and experimental development (GERD) covers all expenditures for R&D performed on national territory in a given year. It thus includes domestically performed R&D that is financed from abroad but excludes R&D funds paid abroad, notably to international agencies.

Headcount refers to the actual number of people directly involved in or supporting R&D (i.e. the total number of R&D personnel).

HERD refers to higher education expenditure on research and experimental development.

In-house or intramural R&D refers to R&D performed by the unit or entity itself (i.e. by the personnel of the unit or entity). This is R&D performed within the borders of South Africa, even if funded by foreign sources.

Labour costs comprise annual wages and salaries and all associated costs or fringe benefits, such as bonus payments, holiday pay, contributions to pension funds and other social security payments, and payroll taxes. The labour costs of persons providing indirect services that are not included in the personnel data (such as security and maintenance personnel or the staff of central libraries, computer departments or head offices) are excluded from labour costs and included in other current expenditure.

Master's students refer to students doing a full research master's as well as those doing coursework plus thesis with a research component.

Non-South African personnel are classified as those that are not from South Africa but undertaking research for a period exceeding six months. This classification aligns with the South African System of National Accounts classification that classifies non-South Africans as temporary residents or permanent residents. R&D personnel may be permanent or temporary residents. The conditions are that they have to be involved in the R&D Survey during the survey period, and on contract of six months or longer.

New materials refer to the technology and R&D activities of high-technology companies particularly in the aerospace, construction, electronic, biomedical, renewable energy, environmental remediation, food and packaging, manufacturing and motorcar industries. New materials include multi-functional materials, advanced materials, nano-materials, nano-composites and nanotechnology.

Other current expenditure comprises non-capital purchases of materials, supplies and equipment to support R&D performed by the reporting unit in a given year.

Other support staff includes skilled and unskilled craftspeople, secretarial and clerical staff participating in R&D projects or directly associated with such projects.

Outsourced R&D refers to R&D done by another entity on behalf of the reporting unit and paid for by the reporting unit.

Research and experimental development (R&D) comprises creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.

Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned.

Research field (RF) refers to a branch of science, either natural or social and humanities sciences.

R&D intensity refers to gross expenditure on R&D as a percentage of GDP.

R&D personnel includes all persons (irrespective of nationality) employed directly on R&D activities, as well as those providing direct services, such as R&D managers, administrators, technicians and clerical staff. These include emeritus professors, honorary fellows and research fellows[1].

R&D-performing sectors comprise the government, science councils, higher education, business and not-for-profit institutional sectors.

Standard Industrial Classifications (SIC) are codes used by Statistics South Africa for all economic activities of industries.

Socio-economic objectives (SEO) are classification codes providing an indication of the main beneficiaries of R&D activities.

Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences, or social sciences, humanities and the arts.

Total employment is the total employment in the economy. This statistic is obtained from the Statistics South Africa Labour Force Survey series P0211 (Stats SA, 2019a), where employed persons are those aged 15–64 years who, during the reference week, did any work for at least one hour, or had a job or business but were not at work (temporarily absent).

Year-on-year changes are calculated as follows: (current year's figure - previous year's figure) / previous year's figure × 100%.

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[1] Prior to 2016/17, emeritus professors, honorary fellows and research fellows were not required to be explicitly included in the estimates of R&D personnel.

EXECUTIVE SUMMARY

This report presents results from the sixteenth South African National Survey of Research and Experimental Development (R&D Survey) 2017/18 that the Centre for Science, Technology and Innovation Indicators (CeSTII) conducted on behalf of the Department of Science and Innovation (DSI).

R&D expenditure increased to R38.725 billion in 2017/18.

R&D expenditure has shown slow growth since 2013/14, peaking at R38.725 billion in 2017/18. This represents a nominal increase of 8.5% from the R35.693 billion recorded in 2016/17. At constant 2010 Rand values, gross domestic expenditure on R&D (GERD) amounted to R25.963 billion in 2017/18, which was a minimal increase of R0.772 million from R25.191 billion in 2016/17.

GERD as percentage of GDP grew marginally.

GERD as percentage of GDP rose by one basis point year-on-year to 0.83% in 2017/18, indicating a low level of R&D performance in South Africa compared to developed countries. This was an increase of one basis point from 0.82%, recorded in 2016/17. This indicator has been fluctuating over the years, peaking at 0.90% in 2006/07, and declining to 0.72% in 2013/14.

Business-led R&D performance continued in 2017/18.

The business sector remained the largest performer of R&D in 2017/18, with business expenditure on R&D (BERD) amounting to R15.859 billion or 41.0% of GERD. The higher education sector's expenditure on R&D increased from R11.659 billion in 2016/17 to R13.010 billion in 2017/18; while science council R&D expenditure in 2017/18 was similar to that recorded in 2016/17, notably R6.313 billion and R6.136 billion, respectively. The government sector's expenditure on R&D constituted 6.0% of GERD, increasing slightly in current Rand value from R2.099 billion in 2016/17 to R2.326 billion in 2017/18. Not-for-profit organisations showed a seventh consecutive increase in R&D, with expenditure rising from R1.018 billion in 2016/17 to R1.216 billion in 2017/18.

Firms in the financial intermediation, real estate and business services sector accounted for almost half of all business sector R&D expenditure.

The industrial sector with the largest proportion of BERD in 2017/18 continued to be the financial, intermediation, real estate and business services industry, accounting for R7.744 billion worth of R&D or 49.0% of BERD. This has been the case for the past ten years (2008/09 to 2017/18). The manufacturing sector was second highest, accounting for R4.473 billion or equivalent to 28.2% of BERD. The manufacturing sector's share has been rising and falling since 2008/09 when it stood at 38.8% of BERD.

Foreign funding for R&D declined.

Government funding for R&D amounted to R18.082 billion in 2017/18, followed by the business sector's contribution of R16.067 billion. The bulk of business sector funding (93,1%) was allocated to R&D within the business sector itself, with small allocations to higher education and science councils, at R680 million (4.2%) and R355 million (2.2%) respectively.

Foreign funding represented the third-largest source of funding for R&D in 2017/18, but decreased from R4.172 billion recorded in 2016/17 to R3.937 billion in 2017/18. While foreign funding decreased overall, the higher education, science council and not-for-profit sectors experienced a slight increase in funds from abroad, viewed in nominal terms.

R&D personnel continued to grow year-on-year.

Growth in South Africa's R&D personnel headcount and full-time equivalents (FTEs) continued in 2017/18. The R&D personnel headcount (including doctoral students and post-doctoral fellows) increased from 80 029 in 2016/17 to 84 262 in 2017/18 and from 42 533.0 FTEs in 2016/17 to 44 259.3 FTEs in 2017/18. Researcher FTEs increased by 6.7%, while the proportion of female researchers decreased by 0.2 of a percentage point. The number of researcher FTE per 1 000 employed increased slightly from 1.7% in 2016/17 to 1.8% in 2017/18.

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INTRODUCTION

South Africa has come a long way in the measurement of science, technology and innovation (STI) indicators. Over the past twenty-five years, since 1994, there have been several attempts to understand the science, technology and research landscape of South Africa, and to develop indicators of progress in implementing policy initiatives. Information gleaned from the annual R&D surveys assists in responding to and monitoring policy progress.

This report provides descriptive analysis and commentary on the results of the 2017/18 R&D Survey. It is accompanied by the *Statistical Report*, which presents data tables for 2017/18 in the form of trend data for the past ten years, as well as key findings and commentary placing the results in context. Together, these reports provide R&D data and indicators that enable the reader to raise policy issues and research questions for further exploration.

The R&D Survey covers the main institutional sectors that perform R&D in South Africa, namely the business, not-for-profit, government, science council and higher education sectors. This approach is followed to satisfy national data needs and, at the same time, maintain consistency with the international sector categorisation for measuring R&D recommended by the Organisation for Economic Co-operation and Development (OECD) in *The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys on Research and Experimental Development*, commonly known as the Frascati Manual (OECD, 2002, 2015).

The analysis in this report is presented in terms of globally standard categories of statistics:

- Gross domestic expenditure on research and experimental development (GERD);
- GERD by R&D-performing sectors;
- Sources and flows of funding for R&D;
- R&D expenditure by economic sector, field of research and socio-economic objective;
- R&D expenditure by province;
- R&D personnel by occupation (researchers, technicians and support staff) and full-time equivalents (FTEs).

In addition, R&D expenditure in multidisciplinary and selected areas of policy interest in South Africa is analysed, namely biotechnology, nanotechnology, environment-related, open-source software, new materials, and tuberculosis (TB), HIV/AIDS and malaria research.

The report is structured as follows: Section 1 provides a contextual overview of the current policy challenges in terms of which the reader should interrogate the survey data reported, as well as a summary of key indicators. Sections 2, 3 and 4 analyse expenditure on R&D, differentiating by a range of variables, such as institutional sector, type of research, research fields, sources of funding and geographical distribution. Section 5 outlines trends and shifts in the people employed in R&D. Section 6 compares the performance of R&D in selected countries, as a baseline against which to assess South Africa's performance. The concluding remarks in Section 7 highlight issues for further research and policy attention. The detailed description of the survey methodology, measurement and classification issues is documented in the accompanying *Statistical Report 2017/18*.

A new feature of this report is the inclusion of a text box at the beginning of each section that summarises key results in that section. We hope that readers will find this new feature helps to flag relevant data points as well as encourages a closer reading of the analysis presented in each section.

1. THE POLICY CONTEXT AND CURRENT CHALLENGES: REACHING GERD/GDP TARGETS

In brief

- South Africa's R&D expenditure as a proportion of GDP in 2017/18 (0.83%) fell below the national target of 1.5%.
- The Department of Science and Innovation is modelling the required R&D investment by sector that would allow the country to meet its target.
- Detailed interrogation of R&D trend data, by stakeholders across the National System of Innovation, remains essential to inform future planning and policy implementation by the Department.

To measure policy progress in the National System of Innovation, South Africa has adopted international science, technology and innovation (STI) measurement standards. One key high-level indicator is gross domestic R&D expenditure as a percentage of the gross domestic product of a country (GERD/GDP). That is, does a country spend a large enough portion of its total GDP on formal R&D?

Significantly, the United Nations now links high levels of R&D spending to efforts to achieve the Sustainable Development Goals (SDGs), noting that 'to evaluate a country's commitment to R&D, look at spending as a percentage of GDP' (UNESCO, 2020).

In South Africa after 1994, STI policies and strategies aimed to improve national R&D investment in order to contribute to dual policy goals: to promote economic growth and human development (DACST, 1996a). The stark inequality in South Africa, characterised by persistent and increasingly high levels of poverty and unemployment (World Bank, 2018; Stats SA, 2019a) informs new policy commitments to orient STI to support economic growth, but also, environmental sustainability, inclusive development, and improved government performance (DST, 2019).

R&D is defined as 'creative and systematic work undertaken on a systematic basis in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge the use of this stock of knowledge to devise new applications' (OECD, 2015).

In this context, the National R&D Strategy (DST, 2002) first set a target of 1% of GERD/GDP by 2019, which which was revised upwards to 1.5%, to be achieved over the coming decade. The Medium Term Strategic Framework (MTSF), which guides government spending in five-year periods, projects an interim GERD/GDP target of 1.1% by 2024.

The latest R&D Survey data, which is based on a multi-sectoral study of expenditure and human resources data, reflect a GERD/GDP ratio of 0.83%. Trend data reflect that while GERD/GDP increased steadily from 0.58% in 1997/98, it is yet to surpass the highest level recorded – 0.90% in 2006/07. As government's recent review of progress towards achieving national democratic developmental goals acknowledged:

> While there have been significant shifts in R&D expenditure over the 25 years of democracy, South Africa continues to lag behind the target of 1.5% of GDP in R&D spend (The Presidency, 2019: 131).

The 25-year review also notes that growth in R&D expenditure and capacity in South Africa has been slower than in comparable middle-income countries. A positive trend highlighted in the 25-year review is that despite lower GDP growth than projected, there has been increasing R&D expenditure across all institutional sectors since 2011.

As shown above, there is growing policy concern to assess why South Africa has not been able to reach its research intensity targets. The Department of Science and Innovation is undertaking modelling work to determine what the gap is between current R&D investment levels, and the levels required to reach national targets. For instance, an R8 billion shortfall is estimated for the year 2017/18, if the target of 1% GERD/GDP was to have been achieved. A number of scenarios are being interrogated, to determine what additional investment each of the R&D performing sectors will need over time (Parliamentary Monitoring Group, 2019).

As stakeholders, policymakers and researchers read and consider the 2017/18 trend data in this report, it is therefore appropriate to interrogate how it can contribute to inform these current policy concerns. Understanding disaggregated trends in R&D expenditure and human resources can point to areas of growth or stagnation over time, which in turn, can raise policy questions for further investigation. For example, spatial analysis demonstrates that over the past few years there has been a decline in R&D expenditure in the Gauteng province, long viewed as the economic 'powerhouse' of South Africa. This trend points to the need for further interrogation of R&D expenditure in the province. When did the decline begin, and can it be linked to any significant economic events? In which institutional and industrial sectors is the decline most evident? How does the trend in Gauteng compare to other provinces? Of course, the identification of such trends is not sufficient, and further in-depth research will be required to understand why there is a decline.

Nevertheless, such interrogation of trends over time may provide insight into how and where DSI can focus its attempts to increase and grow R&D investment, to reach the R&D intensity targets.

We therefore encourage the reader of this report to consider the R&D 2017/18 data in terms of a key policy question: Where are the trends of growth, decline and stagnation in R&D spending and human resources over time, in South Africa?

1.1 Key indicators

Table 1 summarises key indicators over the three years from 2015/16 to 2017/18, to provide a high-level overview of domestic R&D activity, which will be elaborated on in the sections that follow.

Table 1: Key R&D indicators for the years 2015/16, 2016/17 and 2017/18

KEY INDICATOR	VALUE		
	2015/16	2016/17	2017/18
Gross domestic expenditure on R&D (GERD) (R million)	32 337	35 693	38 725
Gross domestic expenditure on R&D in constant 2010 prices (R million)	24 467	25 191	25 963
GERD as a percentage of GDP (%)	0.80	0.82	0.83
Civil GERD as a percentage of GDP (%)	0.75	0.78	0.79
Basic research (R million)	8 210	9 543	10 224
Government-funded* R&D (R million)	14 426	16 428	18 082
Business-funded R&D (R million)	12 578	14 046	16 067
Foreign funding of R&D (R million)	4 210	4 172	3 937
Total R&D personnel (FTE**)	41 054.5	42 533.0	44 259.3
Total researchers# (FTE**)	26 159.4	27 656.2	29 515.2
Total researchers# (headcount)	51 877	56 761	61 840
Female researchers# (headcount)	23 334	25 591	27 774
Total R&D personnel (FTE**) per 1 000 in total employment	2.6	2.6	2.7
Total researchers# (FTE**) per 1 000 in total employment	1.7	1.7	1.8
Female researcher# headcount as a percentage of total researcher headcount (%)	44.4	45.1	44.9
Gross domestic product (GDP) level at current prices (R million)	4 049 884	4 359 060	4 653 579
SA employment ('000)	15 663	16 212	16 378

Data notes	* Government-funded R&D includes science council and university own funds. ** FTE = Full-time equivalent. # Includes doctoral students and post-doctoral fellows. Also includes emeritus professors, research fellows and honorary research fellows in 2017/18. These categories of personnel do not incur salary costs, but there are time and other costs associated with their institutional position. Headcount data includes non-SA R&D personnel in 2017/18.
Data sources	South African National Survey of Research and Experimental Development, 2015/16 to 2017/18. GDP values: Stats SA, GDP, Fourth Quarter 2019, P0441 Series (Stats SA, 2019b). Total employment values: Stats SA, Quarterly Labour Force Survey, First Quarter 2019, P0211 Series (Stats SA, 2019a).

2. R&D EXPENDITURE

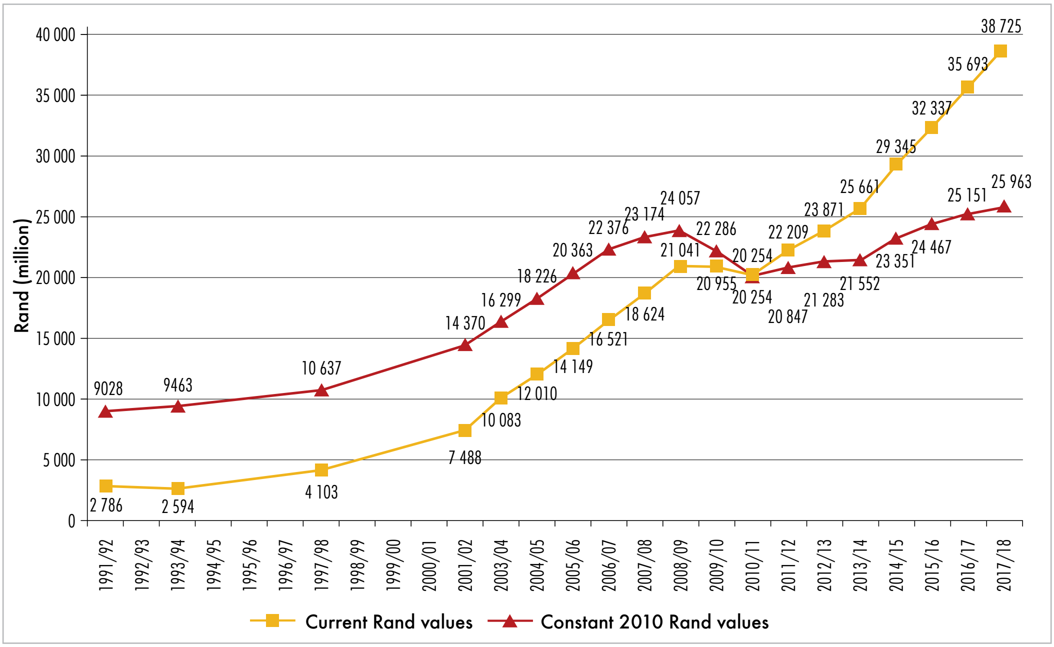
In brief

- Gross domestic expenditure on R&D increased year-on-year in nominal and real terms, and as a proportion of the country's GDP.
- Excepting science councils, whose R&D expenditure declined in real terms, year-on-year spending increased in all other institutional sectors.

2.1 Gross domestic expenditure on R&D

Gross domestic expenditure on research and experimental development (GERD) amounted to R38.725 billion 2017/18 (Figure 1).

Figure 1: GERD in current and constant 2010 Rand value (R million), South Africa, 1991/92 to 2017/18



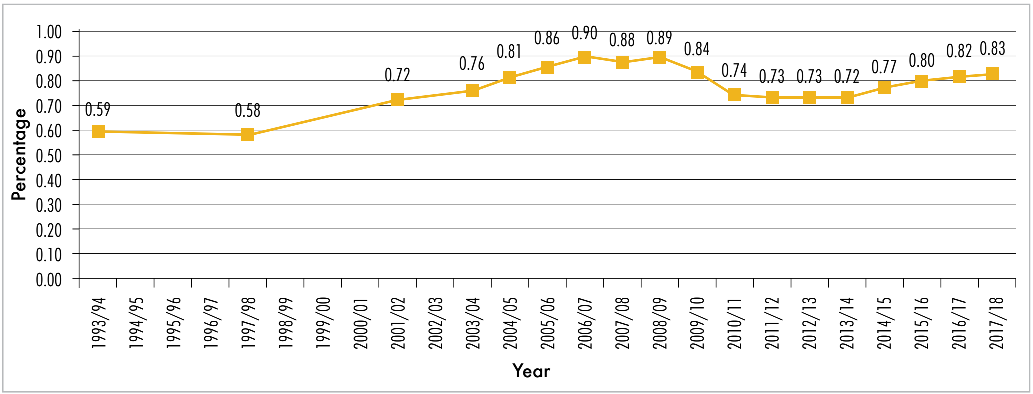
Data note	GDP deflator values derived from the fourth quarter release of the Stats SA GDP series P0441 (Stats SA, 2019b) were used to calculate constant 2010 Rand values for R&D expenditure.
Data sources	Revised GDP (current values): Stats SA, GDP, Fourth Quarter 2019, P0441 Series, (Stats SA, 2019b). R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2017/18. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE, 1993; DACST, 1996b; DACST, 2000).

In nominal terms, this represents an increase of R3.032 billion from the R35.693 billion recorded in 2016/17. At constant 2010 Rand value, GERD amounted to R25.963 billion in 2017/18, which was a small increase of R772 million from R25.151 billion in 2016/17.

2.2 GERD as a percentage of GDP

GERD as a percentage of GDP, a measure of R&D intensity in South Africa, was 0.83% in 2017/18 (Figure 2). This indicator increased by one basis point from 0.82% in 2016/17, after declining to 0.73% between 2011/12 and 2013/14. The trend data show that GERD as a percentage of GDP in South Africa increased steadily from 0.58% in 1997/98 and peaked at 0.90% in 2006/07.

Figure 2: GERD as a percentage of GDP, South Africa, 1993/94 to 2017/18



Definition	GERD expressed as a percentage of GDP indicates the intensity of R&D in an economy.
Data sources	Revised GDP (current values): Stats SA, GDP, Fourth Quarter 2019, P0441 Series, (Stats SA, 2019b). R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2017/18. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE, 1993; DACST, 1996b; DACST, 2000).

2.3 GERD by institutional sector

The business sector remained the largest performer of R&D in South Africa in 2017/18 (Figure 3). Business expenditure on R&D at current expenditure amounted to R15.859 billion, and at constant prices amounted to R10.633 billion, which is equivalent to 41.0% of GERD. The year-on-year increase in BERD from 2016/17 to 2017/18 was a relatively low 1.9%, compared to the overall growth in GERD year-on-year of 3.1%.

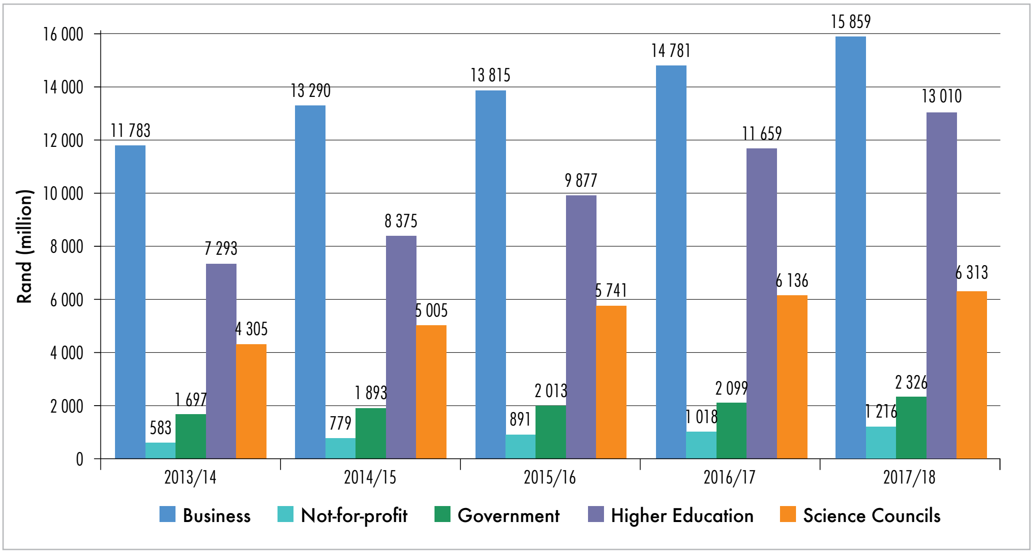
The second largest performer of R&D was the higher education sector. At constant 2010 Rand values, the higher education sector R&D expenditure (HERD) increased by 6.0% from R8.229 billion in 2016/17, to R8.722 billion in 2017/18. In current values, HERD in 2017/18 amounted to R13.010 billion.

The expenditure on R&D by science councils accounted for 16.3% of GERD, and amounted to R6.313 billion. In constant 2010 Rand values, their aggregate expenditure decreased by 2.4%, from R4.330 billion in 2016/17 to R4.233 billion in 2017/18.

Government expenditure on R&D (GOVERD) constituted 6.0% of GERD. It amounted to R2.326 billion in current values, and at constant 2010 Rand values, this represented an increase of 5.3%, from R1.481 billion in 2016/17 to R1.559 billion in 2017/18.

Not-for-profit organisations recorded, at constant 2010 Rand values, a 13.5% increase in R&D expenditure from R718 million in 2016/17 to R815 million in 2017/18. While this increase is significant for the NPO sector, it had little impact on the overall growth rate of GERD in 2017/18.

Figure 3: R&D expenditure by sector (R million), South Africa, 2013/14 to 2017/18



Definition	The Frascati Manual (OECD, 2002, 2015) defines the R&D-performing sectors as the government, higher education, business and not-for-profit sectors. In South Africa, science councils are surveyed separately from government departments. For these statistics, GERD has been broken down by sector of performance as recorded in the R&D Survey.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

3. FUNDING FOR R&D

In brief

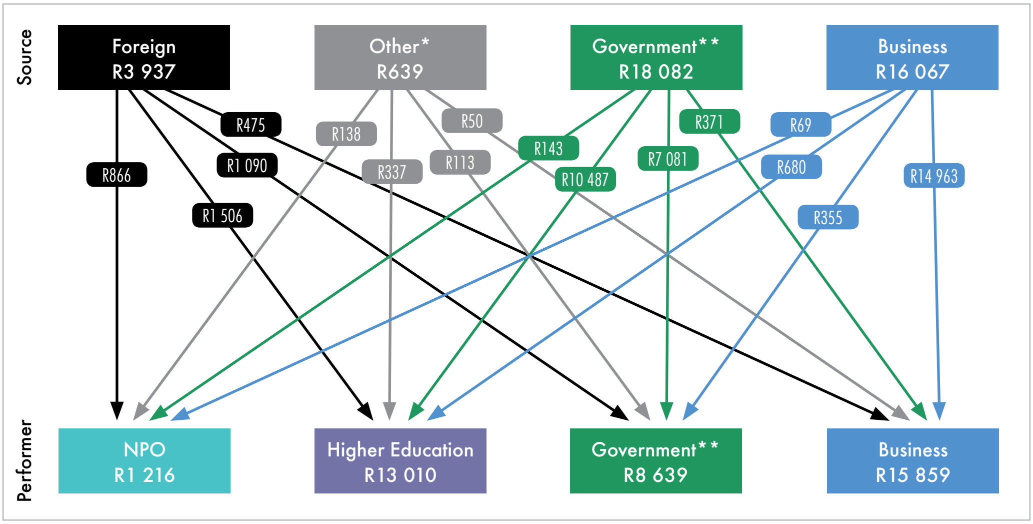
- The South African government funded 46.7% of R&D in South Africa in 2017/18 – a 10.1% year-on-year increase.
- Business funding for R&D in 2017/18 amounted to R16.067 billion, making it the second largest R&D funder after government.
- Funding for R&D by foreign sources decreased by 1.5% in 2017/18. Business was hardest hit, recording a 65.8% year-on-year decline of foreign R&D funding.
- By contrast, the not-for-profit sector recorded an increase in foreign funding for R&D.
- Higher education institutions and science councils were the largest recipients of government R&D funding, both of which reported year-on-year increases.

3.1 Major flows of R&D funding

Government continued to fund the largest proportion of R&D in South Africa in 2017/18 (Figure 4). Government funding increased by 10.1% from R16.428 billion in 2016/17 to R18.082 billion in 2017/18, representing 46.7% of total R&D funding. The largest share of total government funding went to higher education institutions, which received 58.0% (R10.487 billion). Government institutions and science councils received 39.2% (R7.081 billion) of total government R&D funding. The business and not-for-profit sectors were the smallest recipients of direct R&D funding from government, receiving 2.1% (R0.371 billion) and 0.8% (R0.143 billion) respectively.

The business sector was the second-largest funder of R&D, contributing 41.5% (R16.067 billion) towards total national R&D funding. The business sector continued to fund its R&D using its own sources of funds, which amounted to 93.1% (R14.963 billion) of total business funding. The remainder was allocated mainly to the higher education and science councils – R680 (4.2%) and R355 (2.2 %) million respectively. The third-largest source of funding for R&D in 2017/18 was from abroad. This amounted to 10.2% (R3.937 billion) in 2017/18, decreasing by 5.6% nominally from R4.171 billion in 2016/17.

Figure 4: Major flows of funding, (R million), South Africa, 2017/18



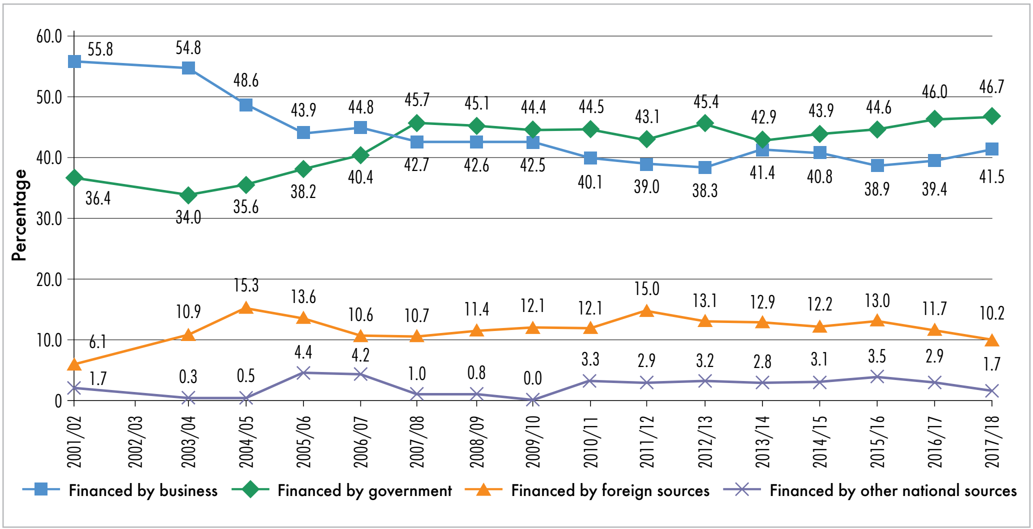
Data note	*Other national sources include contributions from higher education, not-for-profit organisations and individual donations. **Government includes science councils.
Data source	National Survey of Research and Experimental Development, 2017/18.

3.2 GERD by sources of funds

Government and business has consistently funded the largest proportion of GERD in South Africa (Figure 5), a trend that continued in 2017/18. The proportion of R&D funding by government and business increased in 2017/18, while foreign sources and other national sources decreased during the same period.

Specifically, funding of R&D from government increased by seventy basis points from 46.0% of total funding in 2016/17 to 46.7% in 2017/18. Funding of R&D from business increased by 2.1 percentage points from 2016/17 (39.4%) to 2017/18 (41.5%), its highest contribution since 2009/10. Foreign funding and funding from other national sources continued showing decreases from 2015/16. Foreign funding decreased slightly by 1.5 percentage points from 11.7% in 2016/17 to 10.2% in 2017/18, while contributions from higher education, not-for-profit organisations and individual donations decreased by 1.2 percentage points from 2.9% in 2016/17 to 1.7% in 2017/18.

Figure 5: GERD by source of funds (percentage), South Africa, 2001/02 to 2017/18



Data notes	*Other national sources include contributions from higher education, not-for-profit organisations and individual donations. **Government includes science councils.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

3.3 Business-funded R&D

The business sector continued to fund its own research almost exclusively, funding 93.1% of its own R&D expenses in 2017/18 (Table 2, Figure 6). Business funding for R&D in the higher education sector decreased by 25.0%, from R0.907 billion in 2016/17 to R0.680 billion in 2017/18. Similarly, funding of R&D from business sources to the science councils decreased by 26.6% from R0.483 billion in 2016/17 to R0.355 billion in 2017/18, while the not-for-profit sector received the same investment (R0.69 million) in 2017/18 as it did in 2016/17.

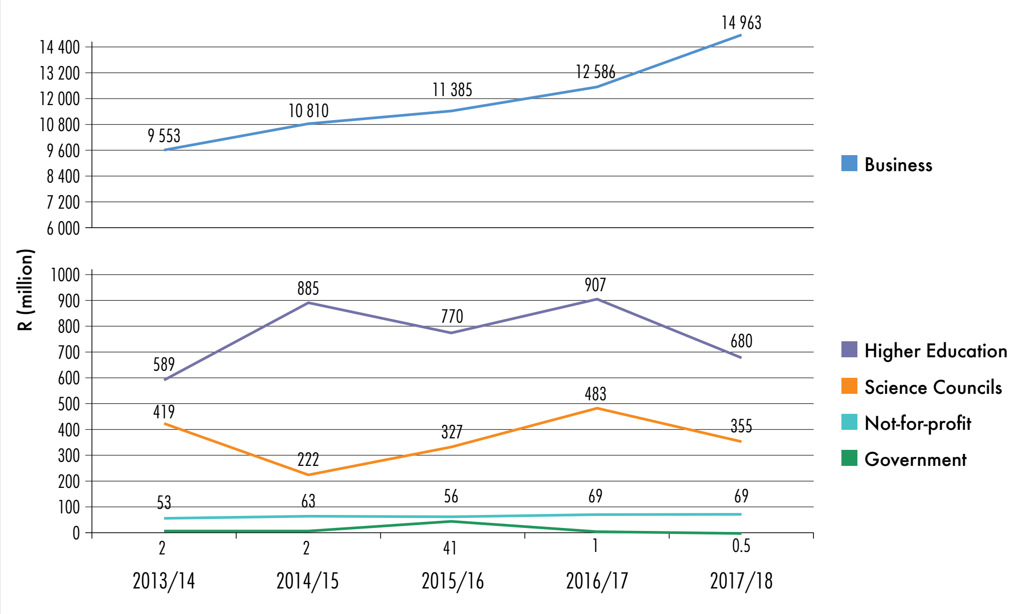
The government sector showed a substantial decrease in R&D investment from the business sector, decreasing from R1.261 million in 2016/17 to R519 thousand in 2017/18.

Table 2: Business-funded R&D by sector of performance (R million), South Africa, 2013/14 to 2017/18

SECTOR	2013/14	2014/15	2015/16	2016/17	2017/18
Business	9 552 717	10 810 428	11 384 709	12 586 109	14 963 198
Not-for-profit	53 359	63 084	55 584	68 705	68 747
Government	1 759	290	41 109	1 261	519
Science councils	419 469	222 892	326 647	483 166	354 820
Higher education	588 598	885 280	770 448	906 651	679 563
Total (current Rand value)	10 615 902	11 981 974	12 578 497	14 045 892	16 066 846
Total (constant 2010 Rand value)	8 916 961	9 515 357	9 513 948	9 957 895	10 771 991

Data note	GDP deflator values derived from Stats SA (2019b) were used to calculate constant 2010 Rand values for R&D expenditure.
Data source	Revised GDP (current values): Stats SA, GDP, Fourth Quarter 2019, P0441 Series, (Stats SA, 2019b). National Survey of Research and Experimental Development, 2013/14 to 2017/18.

Figure 6: Business-funded R&D by sector of performance (R million), South Africa, 2013/14 to 2017/18



Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

3.4 Government funding of local R&D

Government funding of R&D has grown steadily since 2008/09, with the sector having become the largest funder of R&D nationally (Table 3). Higher education institutions and science councils are by far the largest recipients of government funding. Nationally, the higher education sector has sustained the largest share of government funding, which increased by 13.7% from R9.222 billion in 2016/17 to R10.487 billion in 2017/18. Government funding of R&D to the science councils sector increased marginally by 4.6% from R5.077 billion in 2016/17 to R5.311 billion in 2017/18. Government-funded R&D to other government departments, such as research institutions and museums (excluding science councils), increased by 15.6% from R1.531 billion in 2016/17 to R1.770 billion in 2017/18. The business and not-for-profit sectors both showed decreases in government-funded R&D. Funding from government to the business sector decreased by 18.3% from R0.454 billion in 2016/17 to R0.371 billion in 2017/18, while government funding to the not-for-profit sector decreased by 0.5% during the same period.

Table 3: Government-funded R&D (R million), South Africa, 2013/14 to 2017/18

SECTOR	2013/14	2014/15	2015/16	2016/17	2017/18
Business	685 670	690 396	522 631	453 958	371 165
Not-for-profit	103 148	131 288	161 682	143623	142908
Government	1 436 141	1 711 809	1 425 598	1 530 964	1 769 929
Science councils	3 412 790	4 319 393	4 922 222	5 076 805	5 311 190
Higher education	5 369 334	6 020 572	7 393 857	9 222 246	10 486 989
Total (current Rand value)	11 007 083	12 873 458	14 425 990	16 427 596	18 082 182
Total (constant 2010 Rand value)	9 245 538	10 223 319	10 911 329	11 593 995	12 123 170

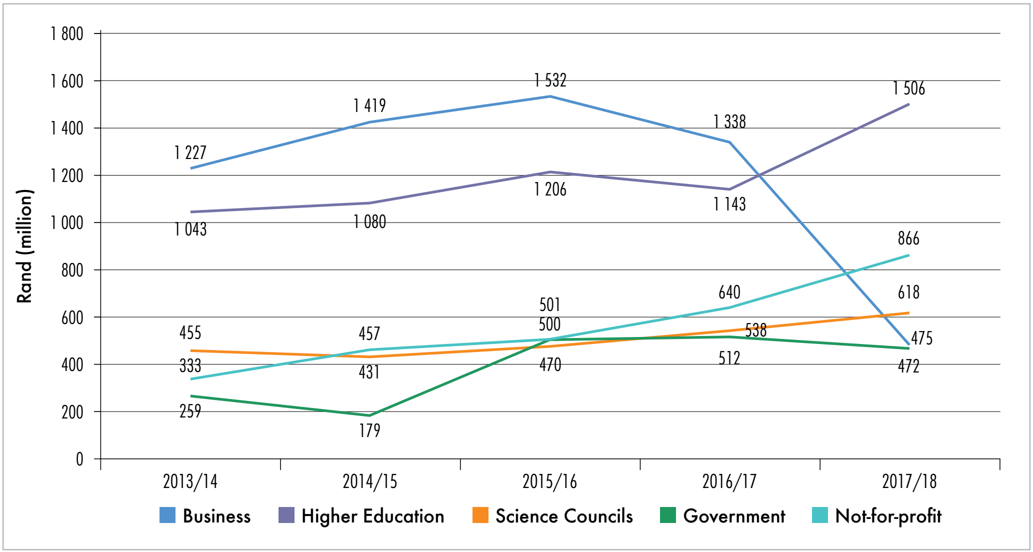
Data note	GDP deflator values derived from Stats SA (2019b) and were used to calculate constant 2010 Rand values for R&D expenditure.
Data source	Revised GDP (current values): Stats SA, GDP, Fourth Quarter 2019, P0441 Series, (Stats SA, 2019b). National Survey of Research and Experimental Development, 2013/14 to 2017/18.

3.5 Foreign funding of local R&D

Fluctuations in R&D funding from abroad continued into the 2017/18 period, with increases and decreases across the sectors (Figure 7). The largest share of foreign funding was received by the higher education sector at R1.506 billion (38.3%), and the not-for-profit sector at R0.866 billion (22.0%). Foreign funding of R&D to the higher education sector increased by R0.363 billion (31.8%) from R1.143 billion in 2016/17 to R1.506 billion in 2017/18. Similarly, the NPO sector's share of funding increased by 35.3% from R0.640 billion in 2016/17 to R0.866 billion in 2017/18, while funding to science councils increased by 14.9%, from R0.538 billion to R0.618 billion during the same period.

The largest decrease of foreign-funded R&D was in the business sector, which decreased by 65.8% from R1.338 billion in 2016/17 to R0.475 billion in 2017/18. Foreign funding of R&D to the government sector decreased by 7.8%, from R0.512 billion in 2016/17 to R0.472 billion in 2017/18.

Figure 7: Foreign-funded R&D by sector of performance (R million), South Africa, 2013/14 to 2017/18



Data note	Foreign sources include all funding from foreign sources from all sectors.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4. FUNCTIONAL DISTRIBUTION OF R&D EXPENDITURE

In brief

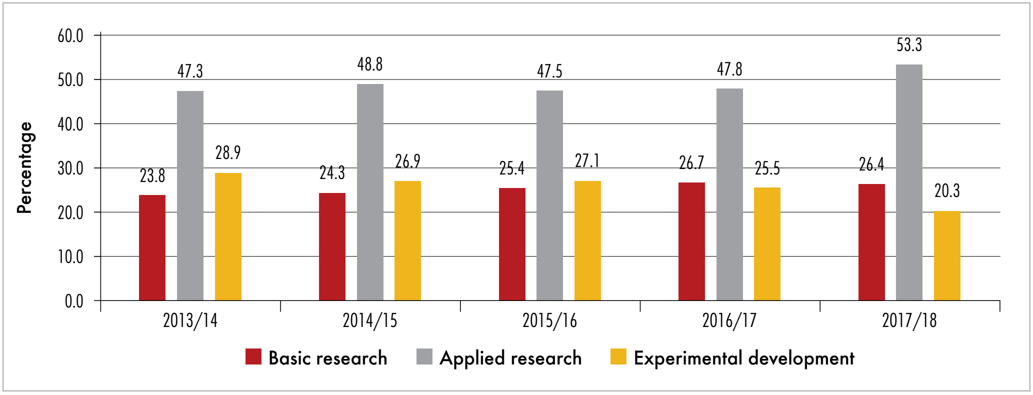
- The share of R&D expenditure for applied research increased year-on-year, while the proportion of expenditure for basic research and experimental development declined. Year-on-year increases in R&D expenditure for applied research were reported in all sectors, excepting the NPO sector, which remained static.
- R&D expenditure across all sectors remained largely concentrated in the natural sciences, technology and engineering.
- Over the past five years, the biggest drivers of increased R&D expenditure were capital expenditure and labour costs, respectively.
- In 2017/18, nearly half of all business R&D expenditure was concentrated in the finance and real estate services sector, and just below 30% in manufacturing. Expenditure on R&D focussed on HIV/AIDS, malaria and TB increased year-on-year, while expenditure on green R&D and R&D within biotechnology fell.
- R&D expenditure in four provinces (Gauteng, Western Cape, KwaZulu-Natal and Free State) exceeded R1 billion in 2017/18.

4.1 GERD by type of research

There was a notable increase in applied research and a decline in both basic research and experimental development in the 2017/18 reference year (Figure 8). The largest proportion of R&D expenditure was allocated to applied research (53.3%). As a result, the proportional share of expenditure allocated to the experimental development category reflects a decrease, from 25.5% in 2016/17 to 20.3% in 2017/18. The proportion of GERD spent on experimental development over time has been declining, except between the period 2014/15 and 2015/16, when there was a slight increase from 26.9% to 27.1%.

The current reference period also saw a decrease in the proportion of R&D expenditure devoted to basic research, a slight drop from 26.7% in 2016/17 to 26.4% in 2017/18.

Figure 8: GERD by type of research (percentage), South Africa, 2013/14 to 2017/18



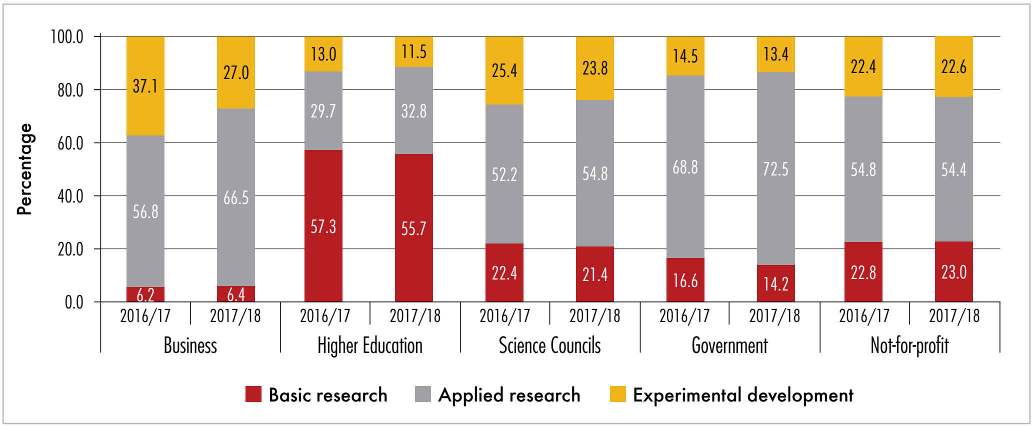
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4.2 GERD by type of research and institutional sector of performance

In general, the type of research conducted by each sector did not change significantly in the current reference period. In 2017/18, all the sectors except the higher education sector devoted the largest proportion of expenditure to the applied sciences, the highest proportion being 72.5% in the government sector (Figure 9). All the sectors recorded an increased proportion of applied research from the 2016/17 survey period, except for the not-for-profit sector, which remained static. Continued measurements should be developed to assess ongoing trends in this regard.

The higher education sector reported a larger share of GERD on basic research, compared to the business, science councils, government and not-for-profit sectors. However, the higher education sector recorded a decline in the 2017/18 period (55.7%) compared to that reported in the 2016/17 period (57.3%). The business sector recorded the lowest percentage, that is, less than 10.0% investment in basic research. Conversely, the business sector reported a larger proportion of investment in experimental development than basic research, in both 2016/17 (37.1%) and 2017/18 (27.0%).

Figure 9: GERD by type of research and sector of performance (percentage), South Africa, 2016/17 to 2017/18

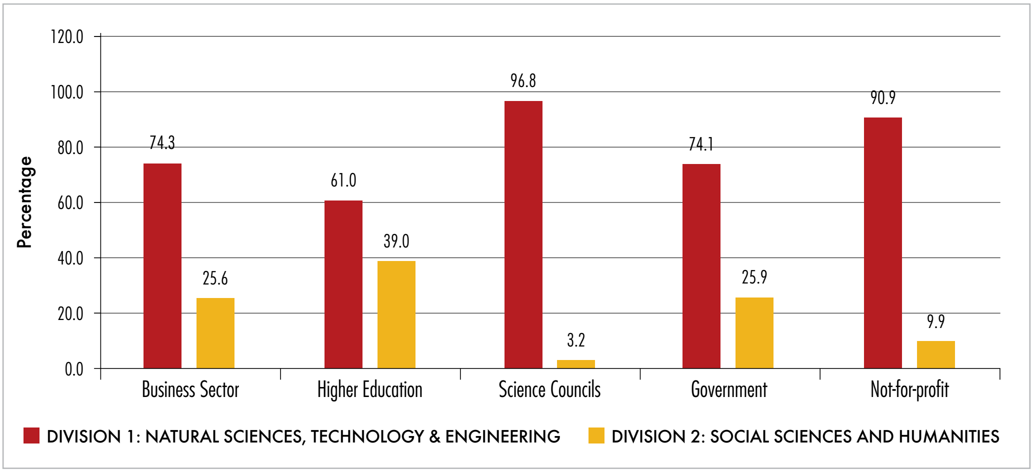


Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4.3 GERD by division of research field and institutional sector of performance

The South African R&D Survey classifies research fields into two major categories, namely Division 1, which includes natural sciences, technology and engineering and Division 2, which represents social sciences and humanities. Traditionally, the largest share of GERD has been reported in the natural sciences research fields. This general trend remains evident in the 2017/18 data. The same trend has been observed since around 2010. The proportion of GERD devoted to natural sciences research fields compared to the proportion devoted to social sciences and humanities fields, was higher across all five institutional sectors, but with some significant differences (Figure 10). The largest proportion of R&D expenditure in the natural sciences fields was in the science councils sector, at 96.8% of their total expenditure on R&D, while the NPO sector spent 90.9% of their total R&D expenditure in Division 1. The business sector spent 74.3% of their R&D expenditure within natural sciences fields, and government spent 74.1%. The higher education sector spent the largest proportion, 39.0% of total sectoral expenditure, on fields in Division 2.

Figure 10: R&D expenditure by research field and sector (percentage), South Africa, 2017/18



Data note	The 2015 Frascati Manual classifies the Fields of Research (FORD) as follows: natural sciences, engineering and technology, medical and health sciences, agricultural and veterinary sciences, social sciences and humanities and art sciences. Data in South Africa is collected according to most of the research fields in FORD and can be aggregated or disaggregated in the FORD format.
Data source	National Survey of Research and Experimental Development, 2017/18.

4.4 R&D expenditure by accounting category

The Frascati Manual 2015 differentiates between two types of R&D expenditure: capital expenditure and current expenditure. The latter distinguishes between two types of costs, which are labour costs and other current costs. Capital expenditure comprises all annual gross expenditure on fixed assets used for R&D performance, and it includes acquisition of software and licensing fees, databases lasting for more than one year, major repairs and modifications on land and buildings.

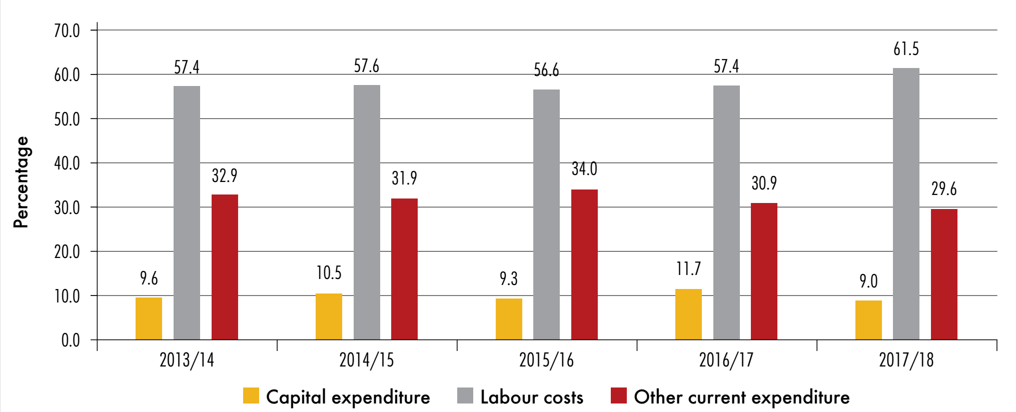
In the five-year period shown in Figure 11, capital costs for R&D fluctuated between 9.0% and 11.7%. According to the DSI 2017/18 annual report, the number of research infrastructure grants had to be reduced because of the substantial cuts in the budget from National Treasury, and only 28 could be awarded (DST, 2017/18). This may have affected the capital costs of entities receiving grants or transfers for the purchase of capital assets meant for R&D. However, there may be other reasons, as capital expenditure had consistently been low prior to 2017.

Other current expenditure includes non-capital purchases of materials, supplies and equipment to support R&D. Other current expenditure equalled 29.6% of GERD, and decreased by 1.3% between 2016/17 and 2017/18.

Labour costs of R&D personnel consist of annual wages, salaries and all associated costs or fringe benefits. The share of R&D labour costs for the five years shown in Figure 11 indicates that labour costs were generally well above 50.0% of GERD. This indicator increased to 61.5 % of GERD in 2017/18. There are three scenarios that might explain this: labour costs may have grown as a result of salaries and wages, or as a result of increases in the number of R&D personnel (volume) in FTEs, or both. The average increase in R&D personnel FTEs between 2013/14 to 2017/18 was 4.8% while labour costs increased by 9.6% in the same period.

In summary, an increase in GERD of 10.2% between 2013/14 and 2017/18 was driven by an increase of 10.6% in other capital expenditure, and 9.6% in labour costs, including an increase of R&D FTEs of 4.8%.

Figure 11: R&D expenditure by accounting category (percentage), South Africa, 2013/14 to 2017/18



Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

Figure 12 shows disaggregated R&D expenditure by accounting category for each institutional sector of performance. The proportion allocated to capital expenditure was the highest for the business sector and the higher education sector at R1.421 billion and R1.386 billion respectively. Capital expenditure for the science councils sector was R0.824 billion. Government and the NPO sector spent the least proportionally in this regard, that is, R0.392 billion and R0.076 billion respectively.

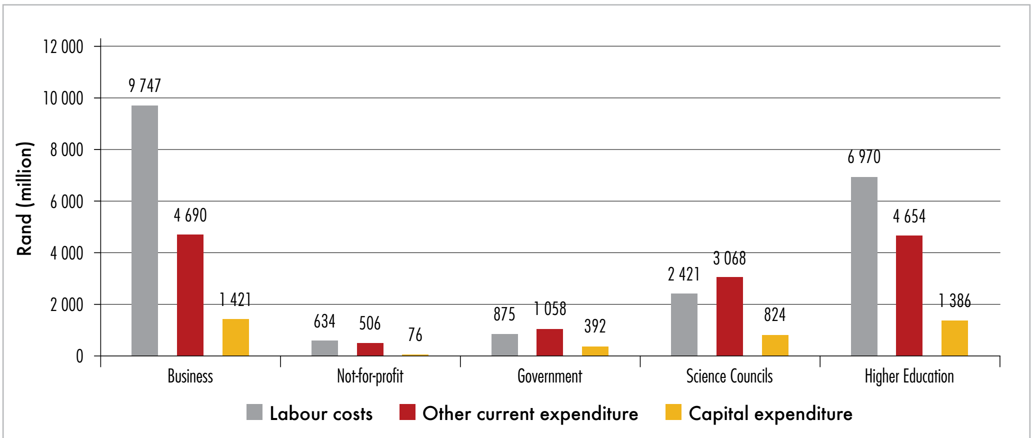
Other current expenditure was highest in the business sector (R4.690), followed by the higher education (R4.654) and science councils (R3.068) sectors. The government sector recorded other current expenditure of R1.058 billion.

Labour costs were larger than capital and other current expenditure in the business, higher education and NPO sectors. Labour costs of the business sector were highest at R9.747 billion, equivalent to 61.5% of total business sector expenditure on R&D in 2017/18.

In the science councils sector however, labour costs were proportionately closer to current expenditure, at R2.421 billion and R3.068 billion respectively.

Notably, labour costs in the science councils and NPO sectors were lower than other current expenditure.

Figure 12: R&D expenditure by accounting category (R million), South Africa, 2017/18



Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4.5 Business sector R&D expenditure by Standard Industrial Classification

Disaggregation by Standard Industrial Classification (SIC) codes allows researchers and policymakers to understand better the industrial clusters within which BERD is being conducted, as well as the source and destination of R&D investment. This data disaggregation by industrial classification is only recorded and reported on for the business sector.

The industrial sector investing the largest proportion of BERD in 2017/18 was financial, intermediation, real estate and business services (Figure 13 and Table 4). Within the reference period, firms in this SIC sector accounted for 48.8% of BERD. The manufacturing sector (Figure 14 and Table 5), accounted for 28.2% of BERD, compared to 27.8% in the previous reference period.

The fluctuating but generally declining expenditure in the manufacturing sector (Table 6) points to a reduced investment in manufacturing sector R&D, and a maturing of R&D investments within the services sector of the economy. The decrease in R&D expenditure in the manufacturing sector is significant for policymakers committed to promoting the digital possibilities of the fourth industrial revolution in the manufacturing sector in future.

Figure 13: Business R&D expenditure by Standard Industrial Classification (as a percentage of GERD), South Africa, 2016/17 to 2017/18

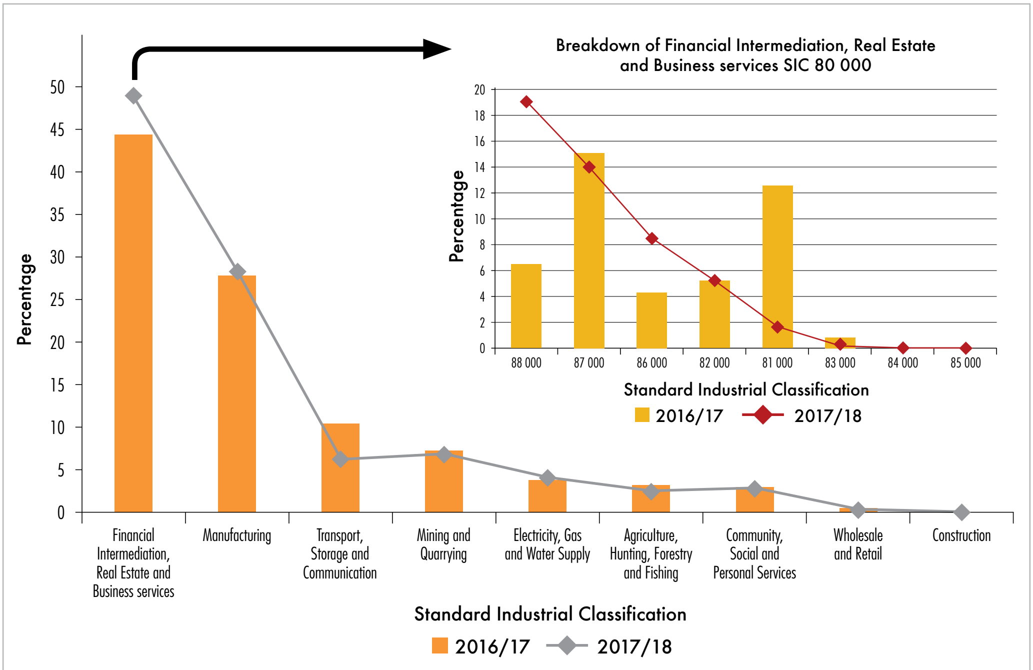


Table 4: Standard Industrial Classification codes in the financial intermediation, real estate and business services sector

81000	Financial Intermediation, except Insurance and Pension Funding
82000	Insurance and Pension Funding, except Compulsory Social Security
83000	Activities Auxiliary to Financial Intermediation
84000	Real Estate Activities
85000	Renting of Machinery and Equipment, and of Personal and Household Goods
86000	Computer and Related Activities
87000	Research and Development
88000	Other Business Activities; N.E.C

Definition	Industry classification is based on Stats SA's five-digit SIC codes, which are used to classify businesses according to economic activities.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

Figure 14: Business R&D expenditure by manufacturing Standard Industrial Classification category (R million), South Africa, 2016/17 to 2017/18

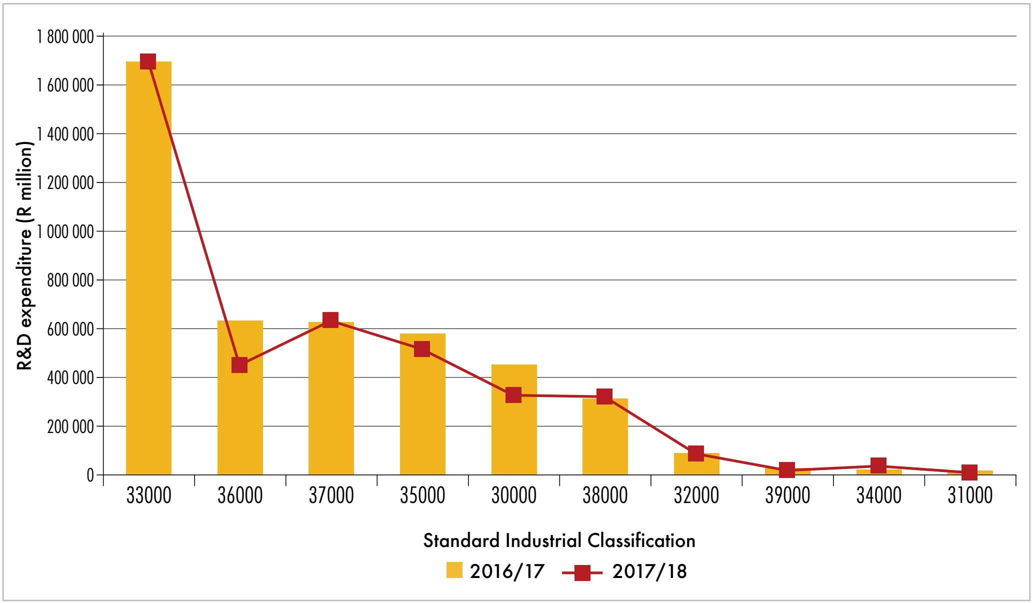


Table 5: Standard Industrial Classification (SIC) codes in the manufacturing sector

30000	Manufacture of Food Products, Beverages and Tobacco Products
31000	Manufacture of Textiles, Clothing and Leather Goods
32000	Manufacture of Wood and Products, except furniture; Paper Products; Publishing and Printing Material
33000	Manufacture of Refined Petroleum, Coke and Nuclear Fuel; Chemical Products (incl. Pharmaceuticals); Rubber and Plastic Products
34000	Manufacture of Non-Metallic Mineral Products
35000	Manufacture of Basic and Fabricated Metal Products, Machinery & Equipment; Office, Accounting and Computing Machinery
36000	Manufacture of Electrical Machinery and Apparatus
37000	Manufacture of Radio, Television and Communication Equipment & Apparatus; Medical, Precision and Optical Instruments, Watches and Clocks
38000	Manufacture of Transport Equipment
39000	Manufacture of Furniture; Recycling; Manufacturing not elsewhere classified

Definition	Industry classification is based on Stats SA's five-digit SIC codes, which are used to classify businesses according to economic activities.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

Table 6: Manufacturing and services sector R&D expenditure as a percentage of BERD (2013/14 to 2017/18)

SECTOR	2013/14	2014/15	2015/16	2016/17	2017/18
Services	50.5	52.2	55.5	61.7	62.3
Manufacturing	32.2	33.9	32.2	27.8	28.2

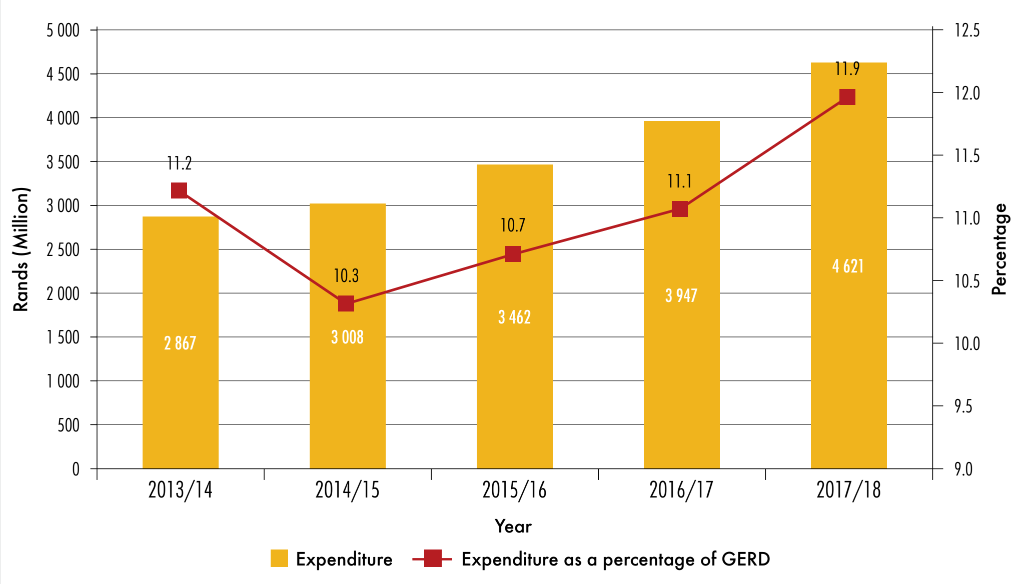
4.6 R&D related to tuberculosis, HIV/AIDS, malaria and biotechnology

HIV, malaria, and other diseases directly and indirectly affect food and nutrition security, rural development, and agricultural productivity. The production of indicators related to these diseases allows for monitoring and assessment of achievements, such as global access to treatments of these diseases, as well as assessing whether progress has been made in reversal of the incidences of the diseases. Biotechnology is a science-based technology that encompasses a wide range of procedures for modifying living organisms according to human purposes. The multidisciplinary area of biotechnology has been of interest to multiple sectoral stakeholders including government, business, higher education and firms, mostly pharmaceutical firms because of its application in multiple areas. According to the White Paper 2019, increased investment in this type of STI is important because it enables knowledge breakthroughs. The investments are monitored through several instruments including the R&D Survey and other specialised surveys. The statistics collected are used to measure the contribution of modern biotechnology to the bio-economy and the economy as a whole.

4.6.1 R&D on tuberculosis, HIV/AIDS and malaria

R&D investment in priority areas of health research, including TB, HIV/AIDS and malaria, has increased from 2.867 billion in 2013/14 to 4.621 billion in 2017/18 (Figure 15). Growing investment in health-related areas of R&D has been a key driver for government policy over the last five years and this is reflected in the upward trend.

Figure 15: R&D expenditure on TB, HIV/AIDS and malaria (R million and as a percentage of GERD), South Africa, 2013/14 to 2017/18

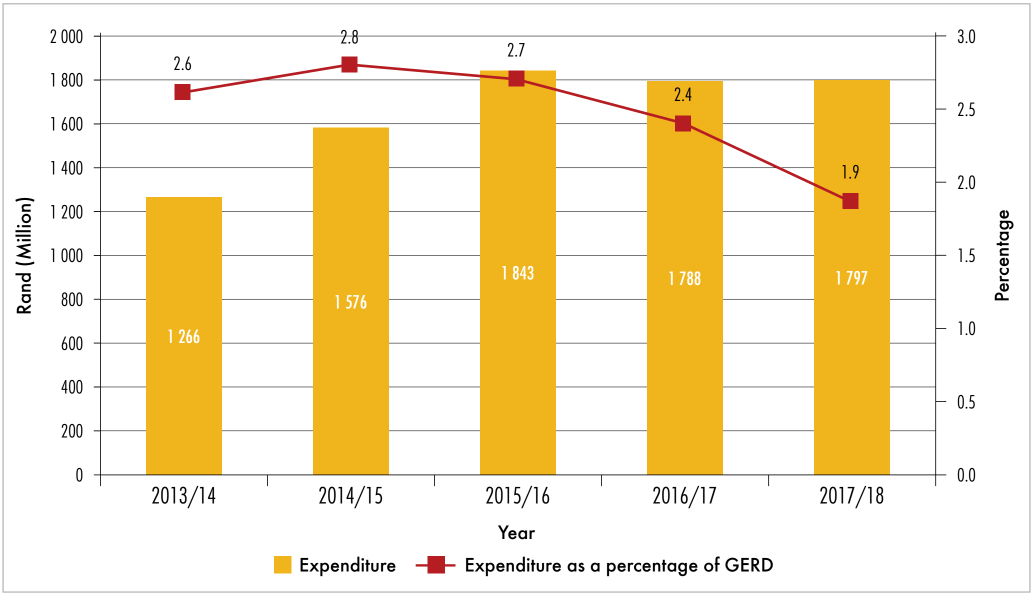


Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4.6.2 Biotechnology-related R&D

R&D expenditure on biotechnology research increased from R1.266 billion in 2013/14 to R1.843 billion in 2015/16. There was a decline in 2016/17 to R1.788 billion compared to that recorded in 2015/16. However, there was a marginal increase to R1.797 billion in 2017/18 survey cycle. When the expenditure is analysed as a percentage of GERD (Figure 16) a question arises: do the data reflect a trend towards an overall decline in biotechnology R&D spending?

Figure 16: R&D expenditure on biotechnology (R million and as a percentage of GERD), South Africa, 2013/14 to 2017/18



Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

4.7 Green R&D

Green R&D includes research and experimental development that focuses on the sustainability of natural resources, environmental impact, animal and plant science, energy research, economic impact, sustainable development, mobility and engineering sciences. Communities and other stakeholders who demand environmental responsibility drive the focus on green R&D. The ultimate results of greening the economy are the reduction of pollution, green technologies for waste disposal, mitigation and adaptation of climate change and improved management of water scarcity. The R&D Survey's results should contribute to the responses on greening the economy by providing relevant green R&D indicators.

4.7.1 R&D investments in green R&D by research field and sector of performance

In 2017/18, total green R&D expenditure by research field in Division 1: Natural sciences, technology and engineering and Division 2: Social sciences and humanities amounted to R6.607 billion.

Expenditure on green R&D amounted to 17.1% (R6.607 billion) of GERD, which reflects a decrease from R9.572 billion reported in 2016/17. Division 1 expenditure was R6.383 billion and Division 2 expenditure was R0.225 billion in 2017/18 (Table 7).

The higher education sector had the largest green R&D expenditure overall, spending R2.484 billion, followed by science councils at R1.630 billion; and the business sector at R1.505 billion. Both government and the not-for-profit sectors spent less than a billion, R878 million and R110 million, respectively on green R&D in 2017/18.

For Division 1, the higher education sector was the largest performer of green R&D in 2017/18 (R2.279 billion), followed by science councils (R1.630 billion), and the business sector (R1.505 billion) (Table 7). For Division 2, higher education spent R0.205 billion, and the government sector allocated R0.019 billion to green R&D in the social sciences and humanities.

Within Division 1 research fields, higher education recorded the highest green R&D expenditure within environmental sciences (R0.760 billion), biological sciences (R0.448 billion) and earth sciences (R0.350 billion). Business sector expenditure was higher in agricultural science (R0.779 billion) than engineering sciences (R0.338 billion).

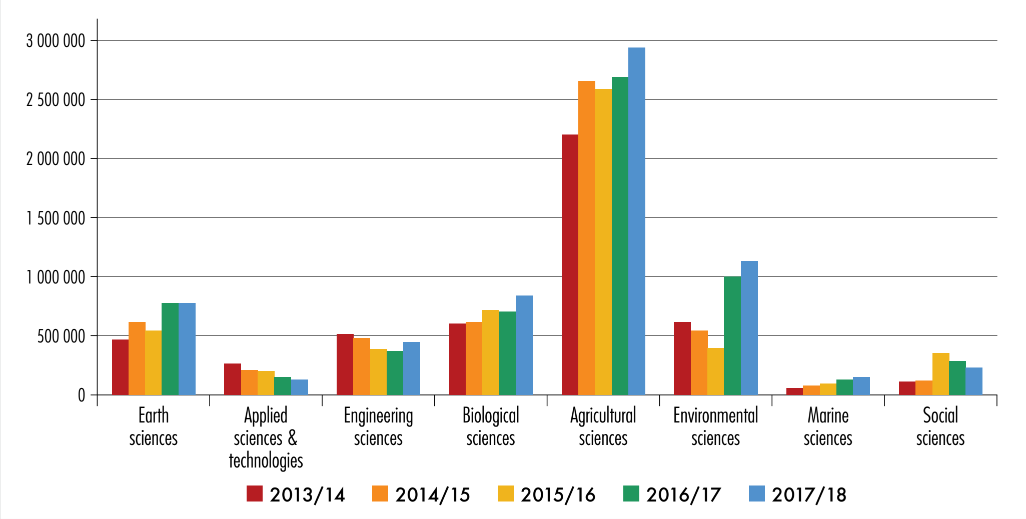
The science councils' highest expenditure in green R&D research fields was in agricultural sciences (R0.990 billion) and environmental sciences (R0.267 billion). Government expenditure on green R&D by research field was highest in the agricultural sciences and biological sciences, at R0.523 billion and R0.173 billion respectively.

Table 7: Green R&D expenditure by research field, South Africa, 2017/18

MAIN RESEARCH FIELD	GOVERNMENT R'000	SCIENCE COUNCILS R'000	HIGHER EDUCATION R'000	BUSINESS R'000	NOT-FOR-PROFIT R'000	TOTAL R'000
Division 1: Natural sciences, technology and engineering	85 524	1 630 261	2 279 195	1 504 760	109 760	6 382 500
Earth sciences	50 110	198 140	349 553	160 745	8 008	766 556
Applied sciences and technologies	9 683	0	18 178	97 011	0	124 871
Engineering sciences	5 664	0	89 871	337 997	0	433 532
Biological sciences	173 145	146 444	447 657	70 046	12 868	850 161
Agricultural sciences	523 343	989 974	583 113	778 583	63 037	2 938 049
Environmental sciences	13 085	267 495	760 600	60 379	24 150	1 125 709
Marine sciences	83 495	28 207	30 223	0	1 697	143 621
Division 2: Social sciences and humanities	19 706	0	204 835	0	24	224 566
Social sciences	19 706	0	204 835	0	24	224 566
Total	878 230	1 630 261	2 484 030	1 504 760	109 784	6 607 065

Data source National Survey of Research and Experimental Development, 2017/18.

Figure 17: Green R&D expenditure by research field, South Africa, 2013/14 to 2017/18



Data source National Survey of Research and Experimental Development, 2017/18.

Figure 17 shows the disaggregation of green R&D by research field. The largest share was expended in the agricultural sciences, and increased over the period, from R2.200 billion in 2013/14 to R2 938 billion in 2017/18, despite a slight dip of 3.2% between 2014/15 and 2015/16. The environmental sciences is the second largest field, but expenditure is far lower, passing the R1 billion mark in 2017/18. The marine sciences displays the lowest expenditure of all research fields over the five-year period, a concern for those promoting the blue economy.

4.7.2 R&D investments in green R&D by socio-economic objective and sector of performance

Table 8 shows expenditure on green R&D by Socio-economic Objective (SEO) and sector of performance. Proportionally, green R&D expenditure by SEO was largest in the higher education sector at 35.3% (R2.585 billion) of the total. Science councils' share of total green R&D expenditure was 28.3% (R2.067 billion), the business sector's was 22.9% (R1.677 billion) and government's 11.7% (R0.855 billion). The NPO sector had the lowest expenditure, at 1.8% (R0.130 billion) of green R&D. The SEOs where there is pronounced activity, as indicated by expenditure in two or more sectors, include plant production and plant primary production, energy supply, economic framework and natural resources.

The largest expenditure on green R&D by SEO was economic development at R4.516 billion, followed by environment at R2.000 billion, and advancement of knowledge at R0.797 billion. Within the economic development cluster, the bulk of expenditure was oriented to plant production and plant primary products (R1.585 billion), of which the higher education and business sectors spent almost equal amounts, R0.435 and R0.628 billion respectively, and science councils R0.369 billion. The second largest expenditure on green R&D within the economic development cluster was natural resources (R0.902 billion). Expenditure in this cluster was mainly concentrated in the public sector (government, higher education and science councils), at 68.0% of total green R&D expenditure.

Table 8: Green R&D expenditure by socio-economic objectives and sector of performance, South Africa, 2017/18

SOCIO-ECONOMIC OBJECTIVE	GOVERNMENT R'000	SCIENCE COUNCILS R'000	HIGHER EDUCATION R'000	BUSINESS R'000	NOT-FOR-PROFIT R'000	TOTAL R'000
Economic development	596 122	1 107 375	1 368 994	1 374 580	69 296	4 516 366
Plant production and plant primary products	117 664	368 829	435 054	628 123	5 197	1 584 868
Animal production and animal primary products	129 024	230 518	293 129	41 588	2 635	696 895
Energy resources	0	6 682	0	0	0	6 682
Energy supply	25 102	0	104 680	307 247	4 400	441 429
Commercial services	2 287	2 937	8 955	46 141	0	60 321
Economic framework	108 830	204 884	139 680	350 969	19 811	824 174
Natural resources	213 214	293 524	387 495	511	7 253	901 997
Environment	208 704	782 034	687 433	283 454	38 078	1 999 703
Environmental knowledge	100 339	434 251	309 293	116 313	2 780	983 976
Environmental aspects of development	50 936	13 215	185 488	52 852	6 559	309 051
Environmental and other aspects	57 429	334 567	192 652	114 289	7 739	706 676
Advancement of knowledge	49 774	177 809	52 091	18 858	22 939	797 471
Natural sciences, technologies and engineering	49 774	177 809	528 091	18 858	22 939	797 471
Total	854 600	2 067 217	2 584 518	1 676 892	130 313	7 313 540

Data source National Survey of Research and Experimental Development, 2017/18.

Table 9: Green R&D expenditure by socio-economic objectives, South Africa, 2013/14 to 2017/18

SOCIO-ECONOMIC OBJECTIVES	2013/14 R'000	2014/15 R'000	2015/16 R'000	2016/17 R'000	2017/18 R'000
Economic development	3 311 306	3 593 176	3 834 899	4 288 313	4 516 366
Plant production and plant primary products	1 398 343	1 353 036	1 414 277	1 539 767	1 584 868
Animal production and animal primary products	803 403	694 423	655 059	729 713	696 895
Energy resources	27 914	29 910	35 179	38 710	6 682
Energy supply	302 165	440 338	332 137	398 643	441 429
Commercial services	46 978	53 433	68 565	62 324	60 321
Economic framework	208 019	266 128	565 782	660 209	824 174
Natural resources	524 485	755 909	763 900	858 947	901 997
Environment	854 719	1 403 621	1 458 273	2 015 344	1 999 703
Environmental knowledge	383 529	820 590	840 485	969 476	983 976
Environmental aspects of development	224 579	286 097	299 812	361 391	309 051
Environmental and other aspects	246 612	296 934	317 975	684 478	706 676
Advancement of knowledge	816 661	590 618	640 544	791 520	797 471
Natural sciences, technologies and engineering	816 661	590 618	640 544	791 520	797 471
Total	4 982 687	5 587 415	5 933 715	7 095 177	7 313 540

Table 9 illustrates the expenditure on green R&D by SEO from 2013/14 to 2017/18, showing a marked increase over the five-year period, from R4.983 billion in 2013/14 to R7.314 billion in 2017/18. Notably, R&D expenditure was concentrated within plant production and plant primary products, also for five consecutive years, contributing 23.6% to total expenditure on green R&D.

4.8 Spatial dimensions of R&D

This section describes where R&D activities are taking place, and whether the spatial trends are changing over time.

4.8.1 R&D expenditure by province

The provincial level of analysis is important, as it is within the provinces where the country's R&D capabilities are geographically located. R&D takes place in all provinces in South Africa, although it is skewed because of size and composition of the research institutions and firms, as well as their level of funding. It is also a fact that R&D tends to be concentrated and volatile, in that it is not performed with absolute regularity by all actors all the time.

Table 10 presents an overview of R&D expenditure by province from 2013/14 to 2017/18. R&D expenditure is concentrated in three provinces namely: Gauteng (44.7%), Western Cape (24.1%) and Kwa-Zulu Natal (10.8%). The Gauteng province recorded the largest R&D expenditure of these three provinces. However, there has been a small but steady decline in the relative proportion of R&D expenditure located in Gauteng province, which stood at 46.7% in 2013/14, but declined to 44.7% in 2017/18.

The Western Cape had the second largest expenditure on R&D activities in 2017/18. A shift in the proportion of the expenditure between Gauteng and the Western Cape provinces, identified in previous reports, continued to be visible in 2017/18. The Western Cape expenditure on R&D increased proportionally, from 19.3% in 2013/14 to 24.1% in 2017/18. R&D expenditure in Kwa-Zulu Natal remains unchanged at around 10% of expenditure for the years shown in Table 10. R&D in the North West province has been declining steadily, from 4.0% in 2013/14 to 3.4% in 2017/18. Limpopo, Free State and Eastern Cape provinces show signs of volatility, as indicated by fluctuating R&D expenditures over the years. The lowest R&D expenditure was recorded in the Northern Cape and Mpumalanga provinces, with 1.5% and 1.8% of GERD in the 2017/18 period respectively.

Table 10: R&D expenditure by province, South Africa, 2013/14 to 2017/18

YEAR	GERD R'000	EASTERN CAPE %	FREE STATE %	GAUTENG %	KWA-ZULU-NATAL %	LIMPOPO %	MPUMALANGA %	NORTHERN CAPE %	NORTH-WEST %	WESTERN CAPE %
2013/14	**25 660 573**	5.8	7.6	46.7	10.7	1.7	2.4	1.8	4.0	19.3
2014/15	**29 344 977**	5.9	5.0	46.6	10.9	2.1	2.9	2.0	4.8	19.8
2015/16	**32 336 679**	6.6	5.5	45.4	10.3	1.9	2.4	2.0	3.7	22.0
2016/17	**35 692 973**	6.2	5.1	46.0	10.2	2.0	2.0	1.5	3.6	23.3
2017/18	**38 724 590**	5.9	5.6	44.7	10.8	2.2	1.8	1.5	3.4	24.1

Data source National Survey of Research and Experimental Development, 2013/14 to 2017/18.

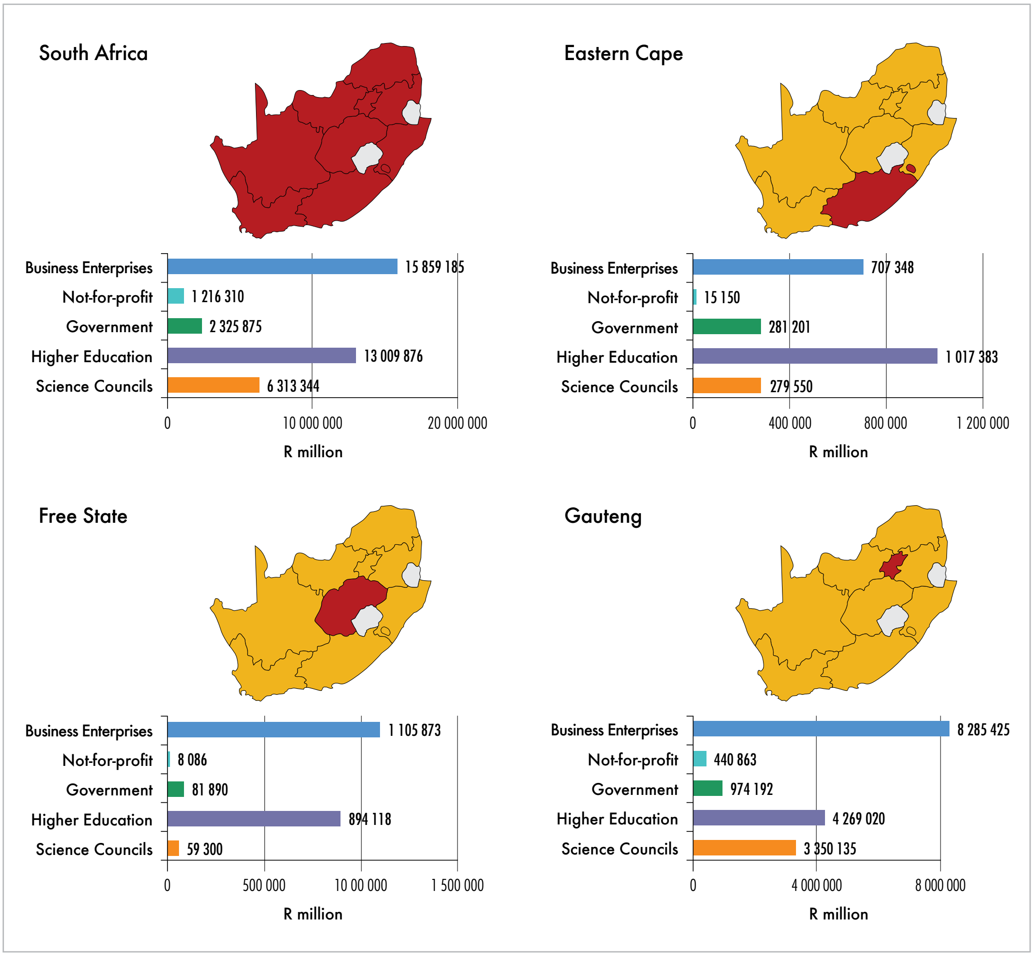
4.8.2 R&D expenditure by province and sector of performance

The assessment of provincial R&D by sector of performance (Figure 18) shows that in eight of the nine provinces, the business and higher education sectors were the largest performers of R&D. Business R&D expenditure increased for all provinces between 2016/17 and 2017/18. However, provinces that surpassed the one billion mark included Gauteng (R8.285 billion), Western Cape (R2.927 billion), Kwa-Zulu Natal (R1.679 billion) and Free State (R1.106 billion).

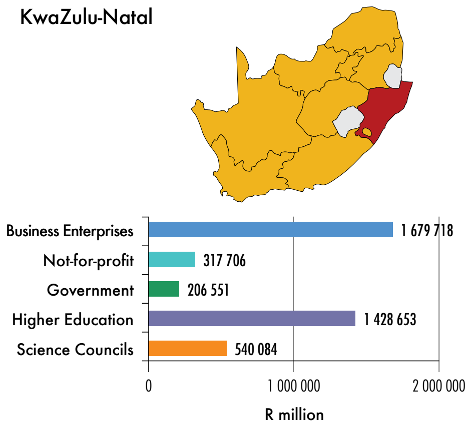
R&D expenditure in the higher education sector was recorded in all provinces, although at varying levels. Expenditure on R&D in the higher education sector exceeded R&D expenditure in the business sector in the Eastern Cape, Limpopo, Northern Cape and Western Cape.

R&D expenditure in the science councils across South Africa was concentrated in provinces with overall high expenditure namely: Gauteng (R3.35 billion), Western Cape (R1.52 billion) and Kwa-Zulu Natal (R0.540 million). The high R&D expenditure in the science councils' sector in the Northern Cape can be accounted for by projects such as the Square Kilometre Array (SKA), for which there is much long-term R&D activity towards building and delivering the telescopes. Science councils spent less than R100 million on R&D in the Free State (R0.59 billion) and the North West province (R0.98 billion).

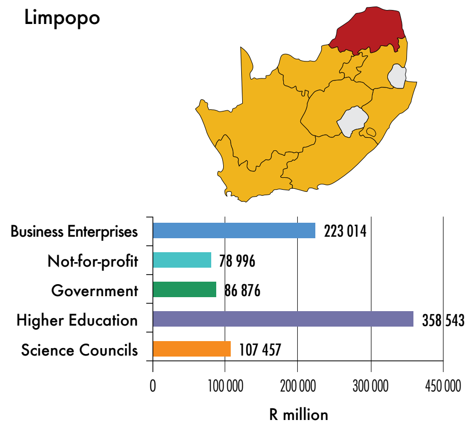
Figure 18: R&D expenditure by province and sector of performance (R million), South Africa, 2017/18



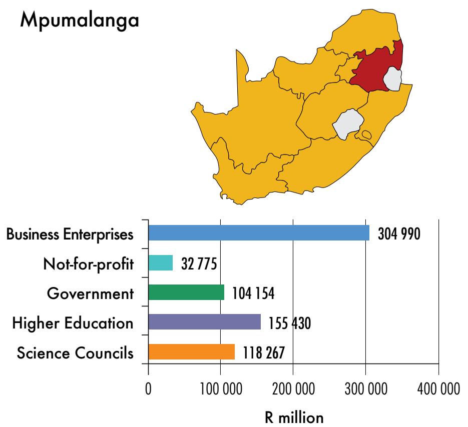
KwaZulu-Natal



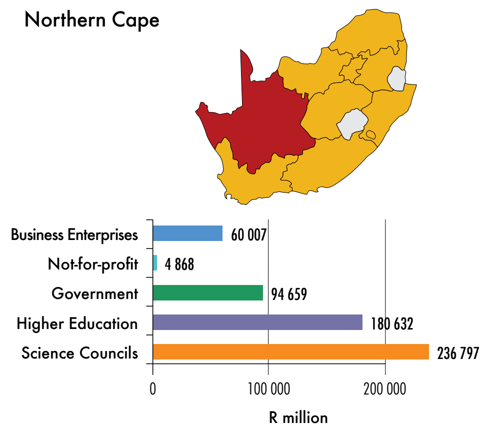
Limpopo



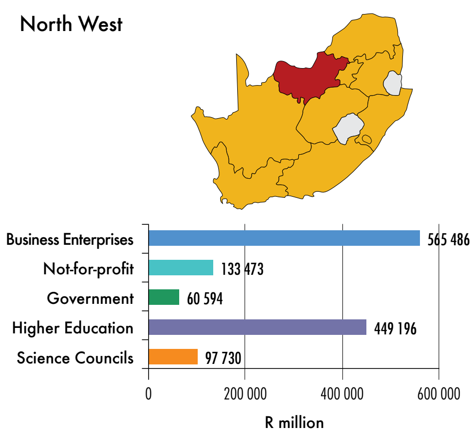
Mpumalanga



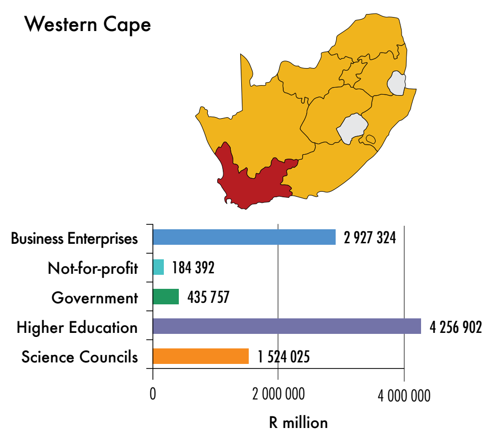
Northern Cape



North West



Western Cape



Data source National Survey of Research and Experimental Development, 2017/18.

5. PEOPLE IN R&D

In brief

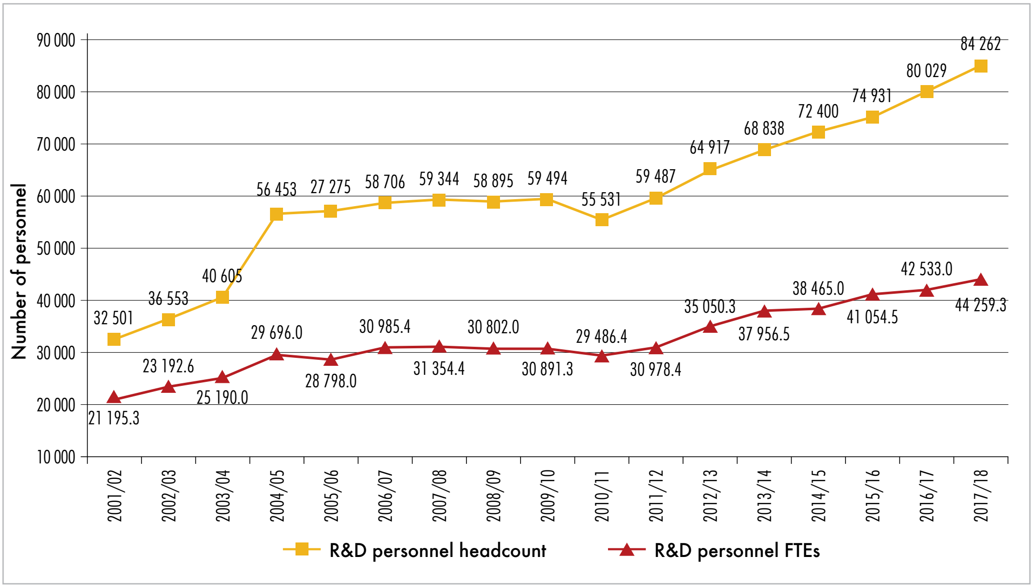
- Year-on-year growth in R&D personnel, measured by headcount and number of full-time equivalents, were recorded in 2017/18. An increase in the number of postgraduate students contributed to the growth.
- Time spent on research decreased year-on-year from 53.1% in 2016/17 to 52.5% in 2017/18.
- The proportion of researchers in 2017/18 increased relative to the share of technicians and other support staff, respectively.
- Of the country's researcher cohort, 44.9% were women in 2017/18, while 21.6% were citizens of foreign countries.

5.1. R&D personnel

There has been a notable upward trend in South Africa's R&D human resources since 2001/02, whether measured in terms of personnel headcount or full-time equivalents (FTEs). Gradual growth trends were noted between 2005/06 and 2010/11; and more robust year-on-year growth was recorded between 2010/11 and 2017/18 (Figure 19). The R&D personnel headcount increased from 80 029 in 2016/17 to 84 262 in 2017/18, reflecting a growth of 5.3%, which is a continuation of the pattern of 6.8% growth recorded between 2015/16 and 2016/17.

The growth in the headcount is mostly attributed to increased numbers of researchers, as well as the growth in postgraduate student numbers in the higher education sector. The 2016/17 R&D Survey cycle introduced new aspects to the collection of R&D personnel data, which contributed to the increase in the headcount and number of FTEs observed. The changes in methodology should be considered when making inferences about the human resources devoted to R&D within the country.

Figure 19: R&D personnel (headcount and FTEs), South Africa, 2001/02 to 2017/18



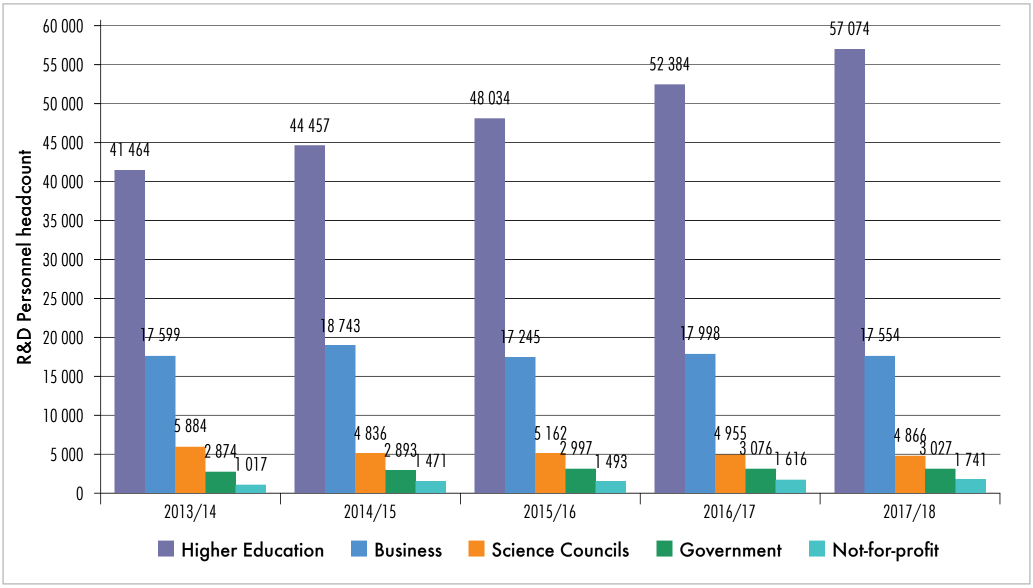
Data note	Following OECD (2015) guidance, doctoral students and post-doctoral fellows are counted as researchers in the South African R&D Survey. Non-South African personnel are classified as those that are not citizens of South Africa but undertaking research in the country for a period exceeding six months. In addition, emeritus professors, honorary fellows and research fellows were explicitly included in the estimates of R&D personnel.
Data source	National Survey of Research and Experimental Development, 2001/02 to 2017/18.

5.1.1 R&D personnel headcount by institutional sector of performance

Researchers, particularly at the level of postgraduate students within the higher education sector, contributed the most towards the growth of the R&D personnel headcounts (Figure 20). The largest proportion of R&D personnel remain located in the higher education and business sectors, with 57 074 and 17 554 headcounts recorded in 2017/18 respectively. The higher education sector reflected the greatest growth, where the total R&D personnel increased from 52 384 in 2016/17 to 57 074 in 2017/18.

Minor decreases in headcounts were noted in science councils, showing a relatively small year-on-year decline in R&D personnel of 4 955 in 2016/17 and 4 866 in 2017/18. Government and the business sector also reported a decreased number of R&D personnel in 2017/18. In the 2017/18 R&D Survey, the decline of the personnel headcounts in these institutional sectors was observed in the categories of 'other personnel directly supporting R&D', 'technicians directly supporting R&D' and to a lesser extent, also in the 'researcher' category. The decrease may be linked to sustained weak growth in the South African economy.

Figure 20: R&D personnel by sector (headcount), South Africa, 2013/14 to 2017/18



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

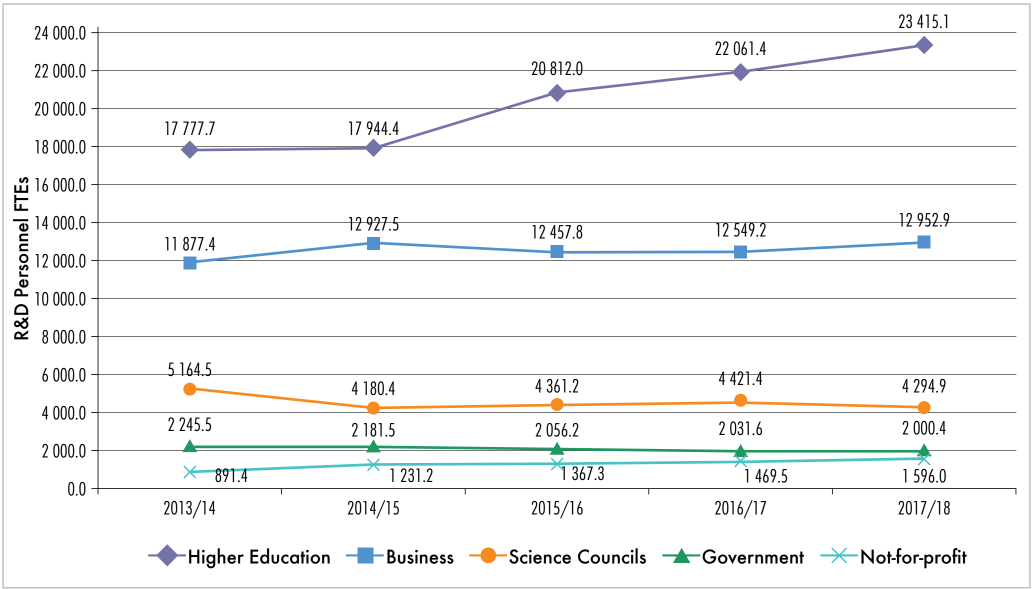
5.1.2 R&D personnel FTEs by institutional sector of performance

The total R&D personnel FTE increased by 4.1% between 2016/17 and 2017/18. This represents an improvement on the 3.6% increase reported between 2015/16 and 2016/17. The indicator measuring R&D personnel FTEs per thousand in total employment remained static over the five-year period, however, reaching 2.5 in 2013/14 and 2014/15, increasing by 0.1 to 2.6 in 2015/16 and remaining at this level in 2016/17. The 2017/18 R&D Survey data reflected another slight increase of 0.1 in reported R&D personnel FTEs per thousand in total employment, to 2.7.

Minimal changes in the patterns of R&D personnel FTE per sector were noted between 2016/17 and 2017/18 (Figure 21). The government sector and science councils displayed a slight decrease, while the business, not-for-profit and higher education sectors all indicated slight increases in their FTEs in 2017/18. The highest FTEs and greatest year-on-year change was noted in the higher education sector, where a 6.1% growth from 22 061.4 FTEs in 2016/17 to 23 415.1 FTEs in 2017/18, was recorded.

While the continued improvements of the headcount and FTEs in R&D personnel may reassure policy makers, survey data reveals that just over half of work time was actually spent on research. This is evident in the figures obtained in the last three survey periods of 2015/16, 2016/17 and 2017/18, where 54.8%, 53.1% and 52.5% of time was spent on research respectively (calculated as FTEs as a percentage of headcount).

Figure 21: R&D personnel by sector (FTEs), South Africa, 2013/14 to 2017/18



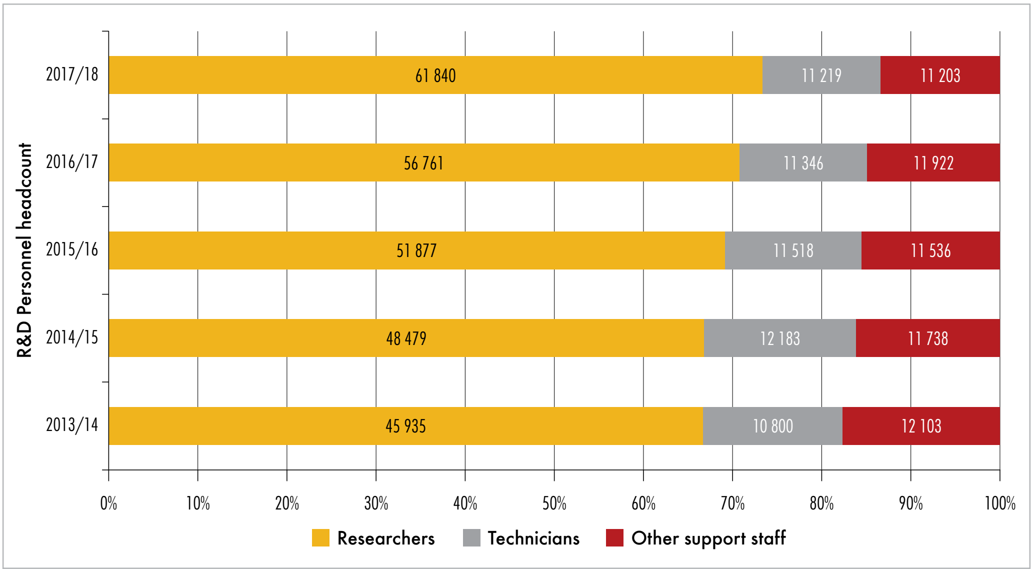
Data note	Following OECD (2015) guidance, doctoral students and post-doctoral fellows are counted as researchers.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.1.3 R&D personnel by occupation

The 2017/18 R&D Survey revealed that the personnel contingent was made up of 73.4% researchers, 13.3% technicians and 13.3% other R&D support staff (Figure 22). This profile ratio has remained consistent over time, showing an increased proportion of researchers and a related decline in technician and other support staff percentages.

The proportional increase in researchers was accounted for by an 8.9% increase in the researcher headcount from 56 761 to 61 840 between 2016/17 and 2017/18. Technician headcount continued to decline from 11 346 in 2016/17 to 11 219 in 2017/18. The headcount of other support staff showed a decline from 11 922 in 2016/17 to 11 203 in 2017/18.

Figure 22: R&D personnel by occupation (headcount), South Africa, 2013/14 to 2017/18

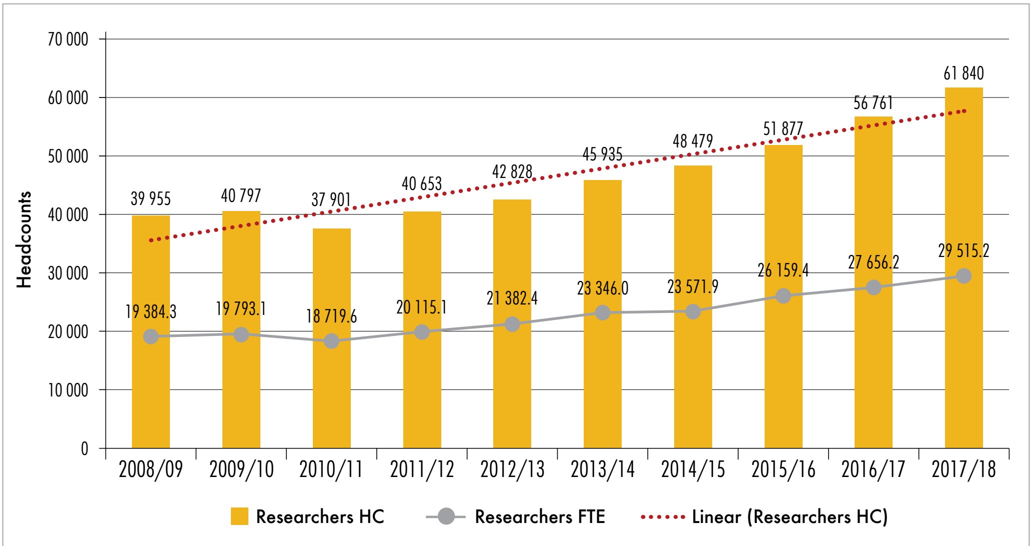


Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.2 Researchers

Researchers are the driving force in the conception and creation of new knowledge, and the robustness of the National System of Innovation relies on the capacitation of the R&D workforce. The period 2011/12 to 2017/18 reflects steady growth in researcher headcount and FTEs (Figure 23). Total researcher headcounts reached 61 840 in 2017/18, with 29 515.2 FTEs for the same period.

Figure 23: Researchers (headcount & FTEs), South Africa, 2008/09 to 2017/18



Data note	Following OECD (OECD, 2015) practice, doctoral students and post-doctoral fellows are counted as researchers.
Data source	National Survey of Research and Experimental Development, 2008/09 to 2017/18.

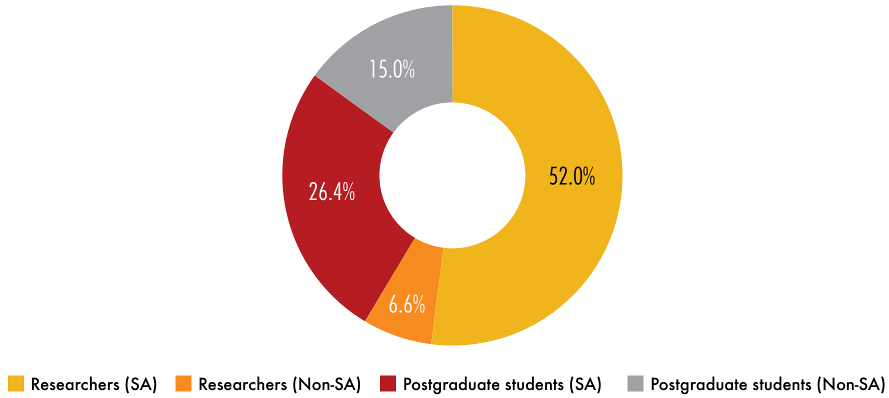
5.2.1 Distribution of researchers by headcount

The 2016/17 R&D Survey for the first time disaggregated R&D personnel in terms of South African and foreign nationals. In terms of the disaggregation, the 'researcher' category includes South African and foreign national researchers, and South African and foreign national postgraduate students (post-doctoral fellows and doctoral students).

The 2017/18 R&D Survey reported that South African researchers comprised 52.0% of total researchers, with a smaller representation of non-South African researchers at 6.6% (Figure 24).

Of the the total researchers, South African postgraduates were 25% in 2016/17 and 26.4% in 2017/18.

Figure 24: Distribution of researchers (headcount, %), South Africa, 2017/18



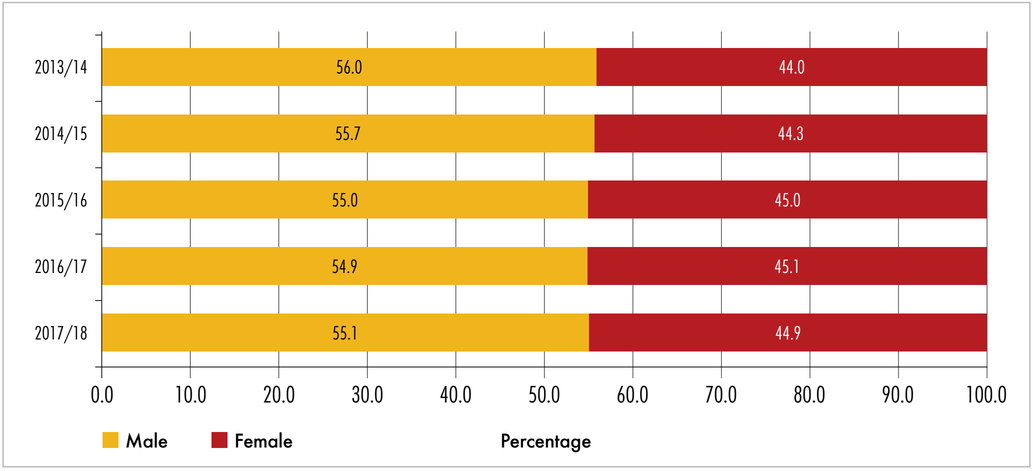
Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2017/18.

5.2.2 Researcher headcount by gender

From 2013/14 to 2017/18, there was very slow but steady growth of female researchers, from 44.0% in 2013/14 to 45.1% in 2016/17. In 2017/18, women researchers accounted for 44.9% of all researchers (Figure 25).

Of the total researchers, approximately 27.6% are females holding a PhD, including students currently enrolled for a PhD.

Figure 25: Researchers by gender (percentage), South Africa, 2013/14 to 2017/18



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

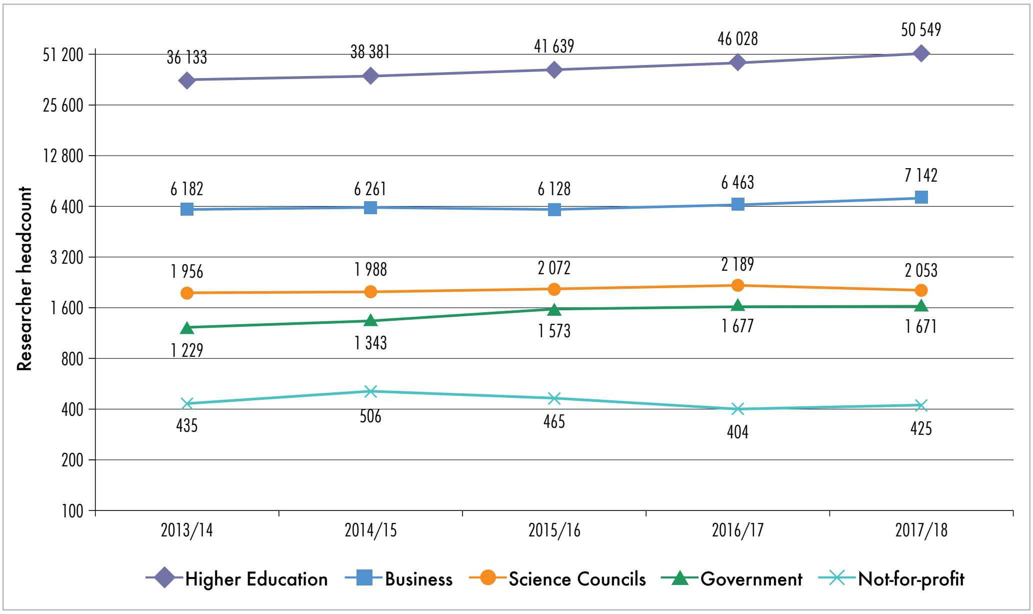
5.2.3 Researcher headcount by institutional sector of performance

Higher education remained the sector with the greatest concentration of researchers, with the number of researchers increasing to 50 549 in 2017/18, a 9.8% increase from the 46 028 recorded in 2016/17 (Figure 26).

The overall headcount of not-for-profit sector R&D personnel has increased over the last five years. However, the downward trend of the researcher total in the sector continued until 2016/17, with an increase in researchers noted in 2017/18, accompanied by increases in the number of technicians and other supporting personnel.

The number of researchers in the business sector improved by 10.5% in 2017/18. A minimal change in the headcounts of researchers was observed in the government sector between 2016/17 (1 677) and 2017/18 (1 671). Science councils reported a reduction in the number of researchers of 6.2% between 2016/17 and 2017/18.

Figure 26: Researchers by sector (headcount), South Africa, 2013/14 to 2017/18



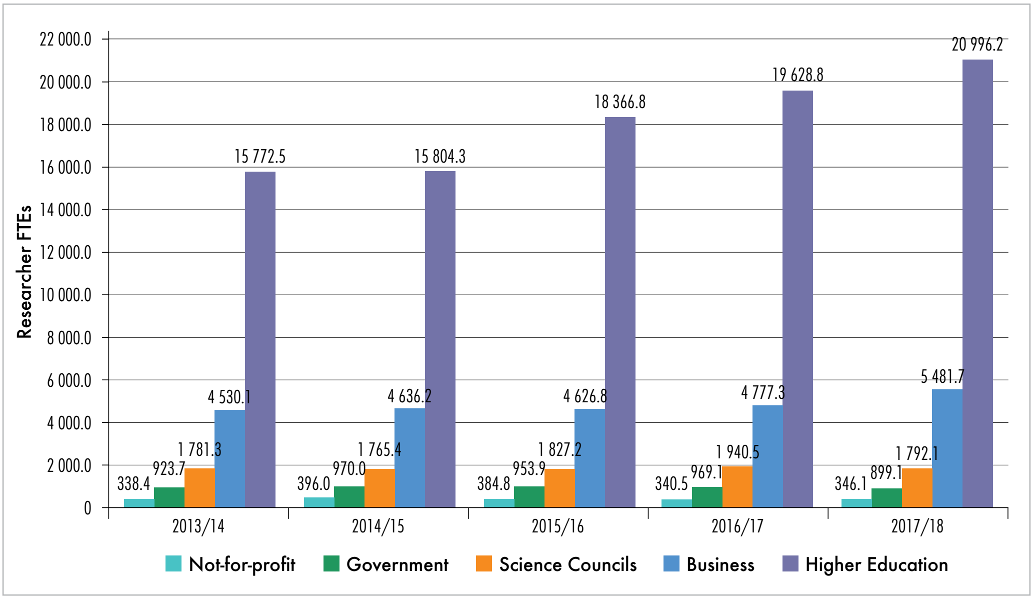
Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.2.4 Researcher FTEs by sector of performance

The upward trend of researcher FTEs in the higher education sector continued in 2017/18, increasing by 7.0% from 19 628.8 in 2016/17 to 20 996.2 in 2017/18 (Figure 27). These increases were associated with increased postgraduate student numbers as well as the additional personnel categories included from 2016/17 onwards. The FTEs of researchers in the government and not-for-profit sectors remained fairly constant, with minimal changes between 2013/14 and 2017/18. Science council researcher FTEs decreased from 1 940.5 in 2016/17 to 1 792.1 in 2017/18.

In the business sector, the researcher headcounts and FTEs did not change considerably between 2013/14 and 2016/17. However, in 2017/18 there were increases in both headcounts and FTEs, with a year-on-year increase in FTEs of 14.7%. The improvement in the number of FTEs can be attributed to improved reporting of headcounts and FTEs by respondents.

Figure 27: Researchers by sector (FTEs), South Africa, 2013/14 to 2017/18



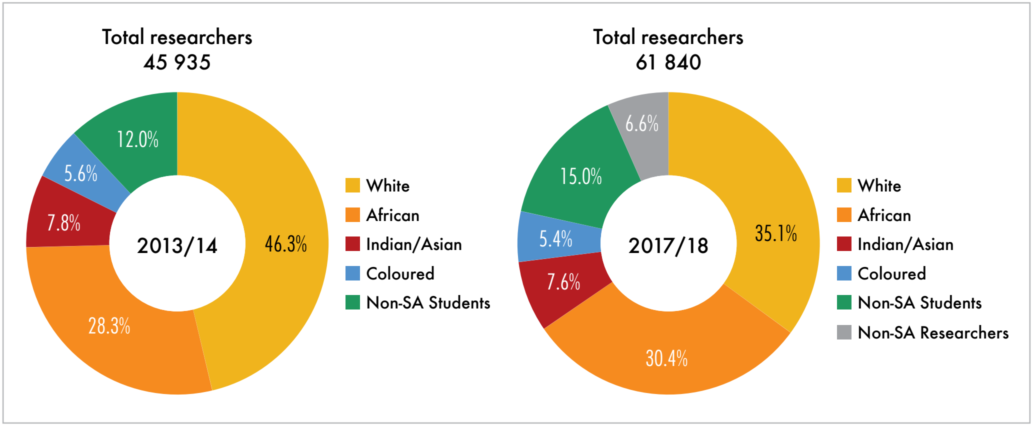
Data note	Higher education researchers include post-doctoral fellows and doctoral students under the 'researcher' category. FTEs refer to the number of hours (in terms of person years of effort) spent on R&D activities.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.2.5 Researchers by population group

The proportions of the various population groups differ somewhat from previous survey data. Nominal changes in these population group representations may be accounted for by the inclusion of a non-South African classification in the 2016/17 survey cycle. This was a methodological adjustment, based on the recommendations of the revised Frascati Manual. This new category of non-South African researchers constituted 6.6% of the R&D researchers, which was an increase from the 5.4% reported in 2016/17. A total of 21.6% of the researchers active in South African R&D are non-South Africans (including foreign students).

Over one third of researchers were from the White population group, 35.1% in 2017/18, compared to the 46.3% recorded in 2013/14. The collective representation of other population groups (African, Coloured and Indian/Asian) constituted 43.3% of the total R&D workforce in 2017/18, a nominal increase from 41.6% in 2013/14.

Figure 28: Researchers by population group (percentage), South Africa, 2013/14 and 2017/18



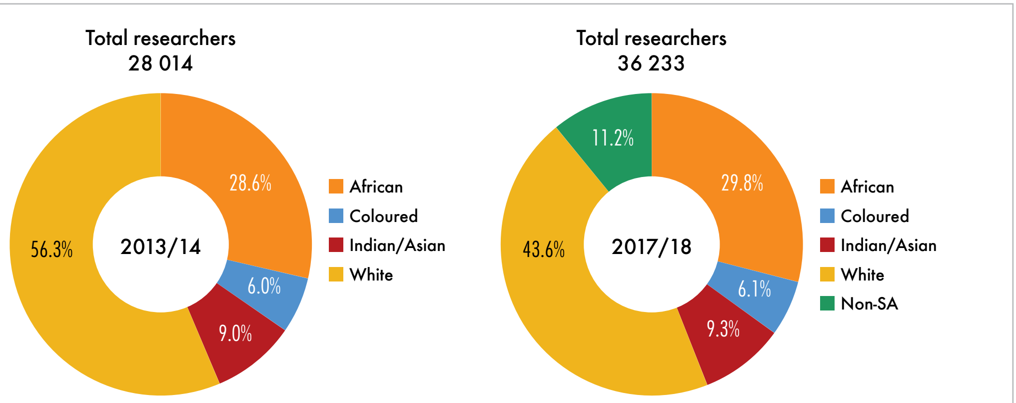
Definition	Higher education researchers include post-doctoral fellows and doctoral students under the 'researcher' category. Student data differentiates between South African and non-South African nationals. The population is classified according to the following race groups: African, Coloured, Indian/Asian and White.
Data source	National Survey of Research and Experimental Development, 2013/14 and 2017/18.

5.2.6 Researchers (excluding doctoral students and post-doctoral fellows) by population group

Disaggregating researchers by excluding doctoral students and post-doctoral fellows more accurately reflects the country's R&D-active workforce. Using this approach, the five-year trend reflects a marked increase in total researchers, as well as a year-on-year growth of 9.7%, from 33 035 in 2016/17 to 36 233 in 2017/18. This constitutes a slightly higher rate of growth, compared to the 8.9% growth of researchers including postgraduate students for the same period.

The decrease in the proportion of White researchers from 56.3% in 2013/14 to 43.6% in 2017/18 is an indication of demographic transformation in the country's pool of researchers. However, the rate at which the demographic profile of researchers in South African R&D is changing remains extremely slow. The proportion of African researchers increased by 1.2 percentage points, from 28.6% in 2013/14 to 29.8% in 2017/18. In the same period, the proportion of Coloured and Indian/Asian researchers remained almost unchanged, from 6.0% to 6.1%, and 9.0% to 9.3% respectively. The inclusion of the category of non-South African researchers accounts for the decrease in White researchers, representing 11.2% of the researchers for 2017/18, an increase from the 9.2% reported in 2016/17. To note, this methodological change may account for the relative change in some of the other population groupings, when comparing demographics between 2013/14 and 2017/18.

Figure 29: Researchers (excluding doctoral students and post-doctoral fellows) by population group (percentage), South Africa, 2013/14 and 2017/18



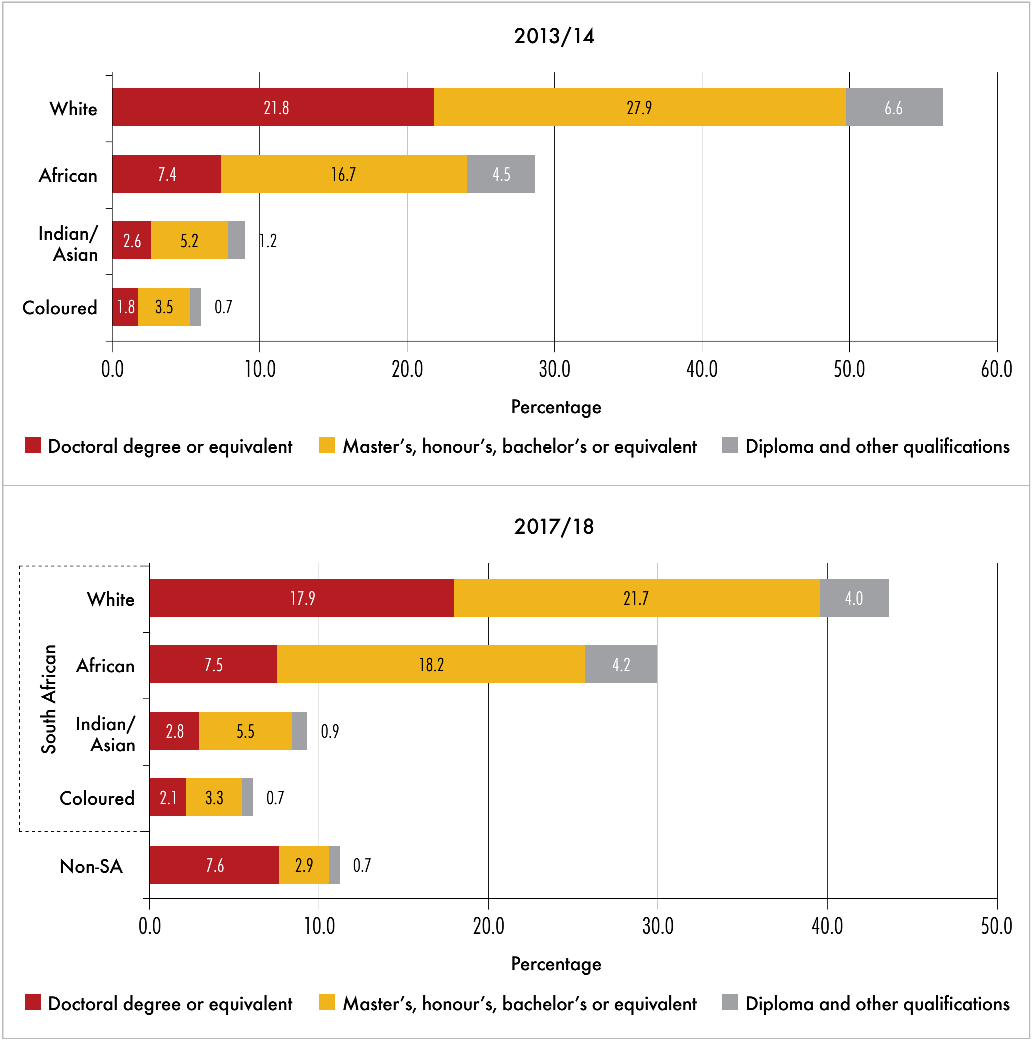
Data note	For this section only the higher education researchers do not include post-doctoral fellows and doctoral students under the 'researcher' category.
Definition	The population is classified according to the following race groups: African, Coloured, Indian/Asian and White.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.2.7 Researchers (excluding doctoral students and post-doctoral fellows) by qualification and population group

The proportion of African researchers with doctoral degrees remained largely static at 7.4% in 2013/14 compared to 7.5% in 2017/18 (Figure 30). The largest proportion of researchers with doctoral degree qualifications, 17.9%, remained clustered in the White population group in 2017/18. In 2017/18, the general trend remains that the greatest proportion of research personnel, 51.6%, hold a master's, honour's, bachelor's or equivalent degree qualification, which was similar to the 53.4% data point recorded in 2013/14. A total of 37.9% of researchers held doctoral degrees or equivalent in 2017/18, which was an increase from 33.5% in 2013/14. The smallest proportion of researcher personnel held diplomas or other qualifications, at 10.5% in 2017/18, down from 13.0% in 2013/14.

It is evident that non-South African doctoral holders contributed to the total number of researchers with PhDs, showing an increase on the 5.8% reported in 2016/17 to 7.6% in 2017/18.

Figure 30: Researchers (excluding doctoral students and post-doctoral fellows) by qualification and population group (percentage), South Africa, 2013/14 and 2017/18



Data note	For this section only the higher education researchers do not include post-doctoral fellows and doctoral students under the 'researcher' category.
Definition	The population is classified according to the following race groups: African, Coloured, Indian/Asian and White.
Data source	National Survey of Research and Experimental Development, 2013/14 and 2017/18.

5.3 Higher education R&D personnel

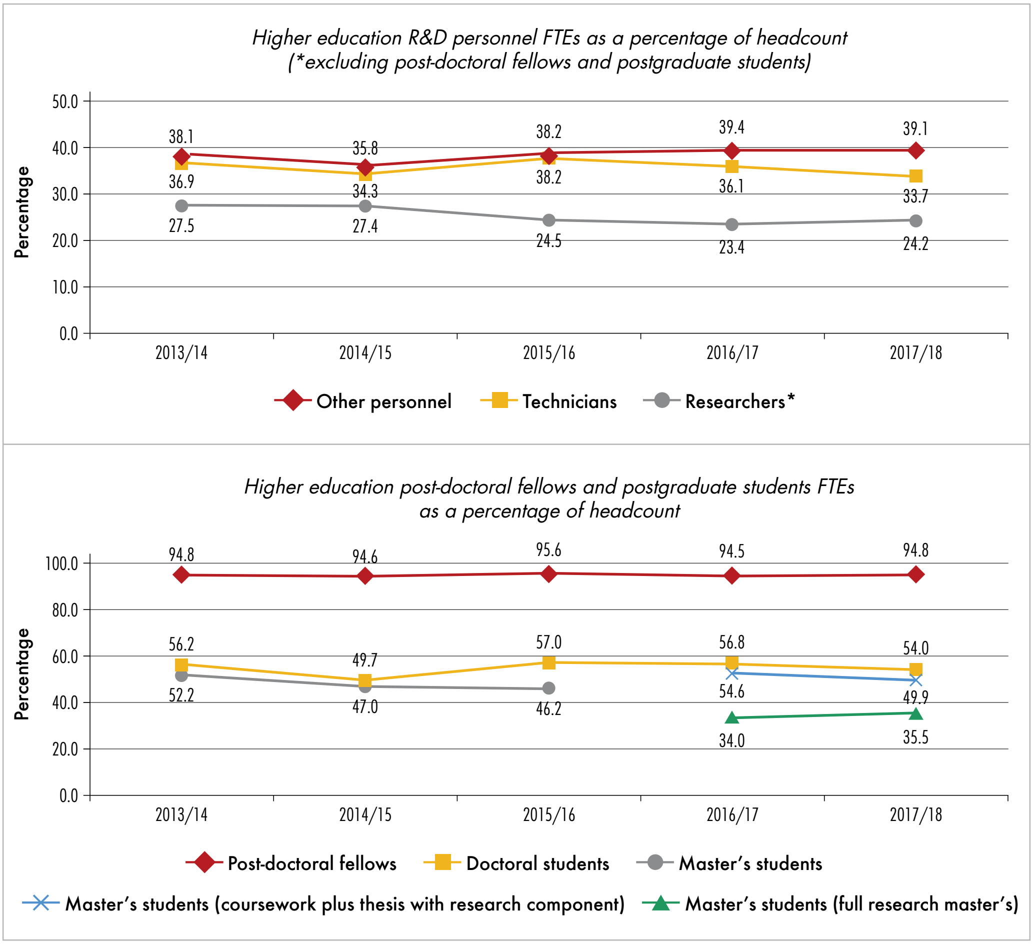
5.3.1 Higher education R&D personnel: FTEs as a percentage of headcount

The 2017/18 R&D Survey data reflected increases in headcounts and FTEs in both the R&D personnel and researcher categories (Figure 31). Higher education researchers (excluding post-doctoral fellows and postgraduate students) increased from 22 302 in 2016/17 to 24 942 in 2017/18. An increase in the number of researchers in the higher education sector was evident in the 2016/17 and 2017/18 surveys.

The observed decline in the time spent on R&D activities by researchers (excluding post-doctoral fellows and postgraduate students) from 27.4% in 2014/15 to 24.5% in 2015/16, to 23.4% in 2016/17, may have stabilised at 24.2% in 2017/18.

Post-doctoral fellows continued to spend the majority of their time on R&D activities, at 94.8% in 2017/18, a data point that has remained relatively stable in the previous five survey cycles. Doctoral students continued to spend just over half of their time on R&D activities, with 54.0% FTE recorded in 2017/18. For the first time in 2016/17, the survey differentiated between full research master's students and master's with coursework and a thesis component. The master's-by-thesis-only students spent 35.5% of their time on R&D activities, while master's-by-coursework-and-thesis students spent 49.9% of their time on R&D activities in 2017/18.

Figure 31: Higher education R&D personnel and students (FTEs as a percentage of headcount), South Africa, 2013/14 to 2017/18



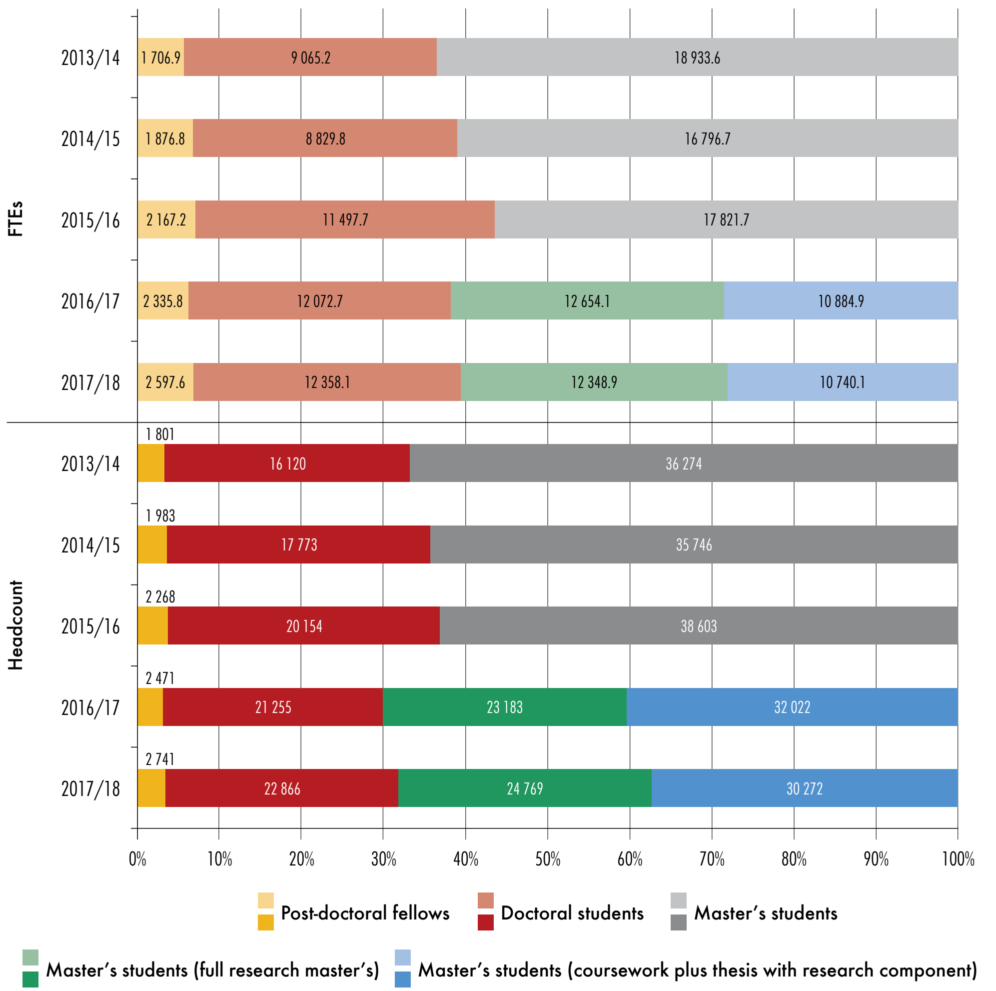
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.3.2 Post-doctoral fellow and postgraduate student headcount and full-time equivalents (FTEs)

The overall growth of post-doctoral fellows and postgraduate students (doctoral and master's students) engaged in R&D grew from 78 931 in 2016/17 to 80 648 in 2017/18 (Figure 32).

Post-doctoral fellows and doctoral student numbers combined grew by 7.9% from 2016/17 to 2017/18. The headcount of doctoral students increased by 41.8% from 16 120 in 2013/14 and reached 22 866 in 2017/18. An increase of 10.9% in post-doctoral fellows was recorded reflecting an improvement increase from 2 471 in 2016/17 to 2 741 in 2017/18.

Figure 32: Higher education post-doctoral fellows and postgraduate students (headcount and FTEs), South Africa, 2013/14 to 2017/18

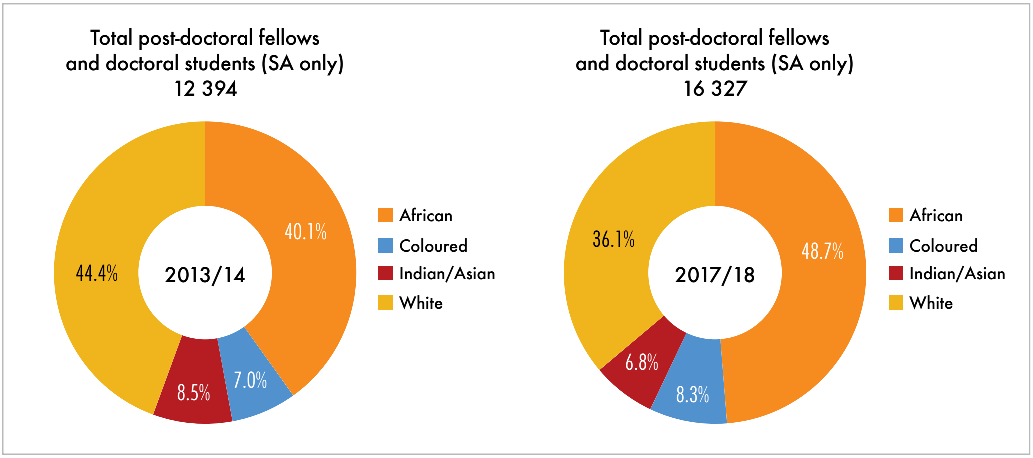


Data note	The revised Frascati Manual (OECD, 2015) advises that master's students are to be counted as R&D personnel. This change in methodology was first implemented in the South African R&D Survey in 2016/17.
Data source	National Survey of Research and Experimental Development, 2013/14 to 2017/18.

5.3.3 Post-doctoral fellows and doctoral students by population group

Changes to the demographic profile of South African post-doctoral fellows and doctoral students can be observed using trend data (Figure 33): the proportion of White post-doctoral fellows and doctoral students decreased from 44.4% in 2013/14 to 36.1% in 2017/18 and African population representation increased from 40.1% to 48.7% over the same period. The Indian/ Asian population group showed a decrease from 8.5% in 2013/14 to 6.8% in 2017/18, and the Coloured population group showed an increase from 7.0% to 8.3% for the same period. The trend data shows growing racial transformation; however, these numbers are still far from being representative of the national population demographics.

Figure 33: Higher education post-doctoral fellows and doctoral students by population group (percentage), South Africa, 2013/14 and 2017/18



Data note	The 2013/14 and 2017/18 surveys distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master's students.
Definition	The population is classified according to the following race groups: African, Coloured, Indian and White.
Data source	National Survey of Research and Experimental Development, 2013/14 and 2017/18.

5.3.4 Profile of South African and foreign postgraduate students

Analyses of postgraduate students by nationality revealed a total of 25 607 post-doctoral fellows and doctoral students at the higher education institutions reporting to the 2017/18 R&D Survey, of which 63.8% were South African nationals and the remaining 36.2% were foreign nationals

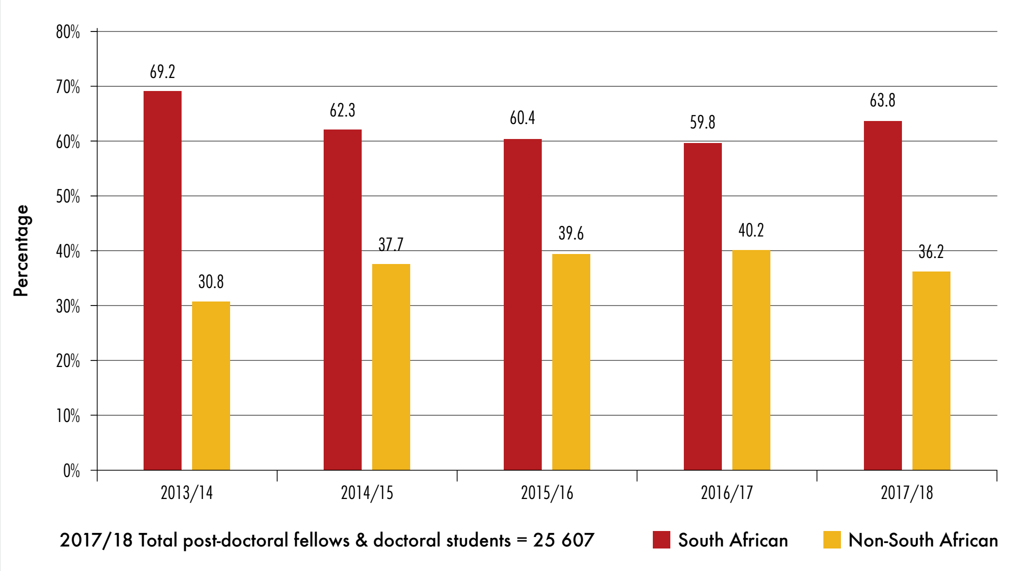
(Figure 34, Table 11). This shows an increase from 59.8% South African nationals for this group in 2016/17.

The proportion of South African to foreign nationals observed among doctoral students for 2017/18 reflected 66.7% and 33.3% respectively. An inverted trend was observed for post-doctoral fellows, with a split of 39.3% South African nationals to 60.7% foreign nationals in 2017/18 (Figure 35).

The majority of master's students were South African nationals in 2017/18, broken down as 81.0% of the master's by thesis students and 88.0% of the master's by coursework and thesis.

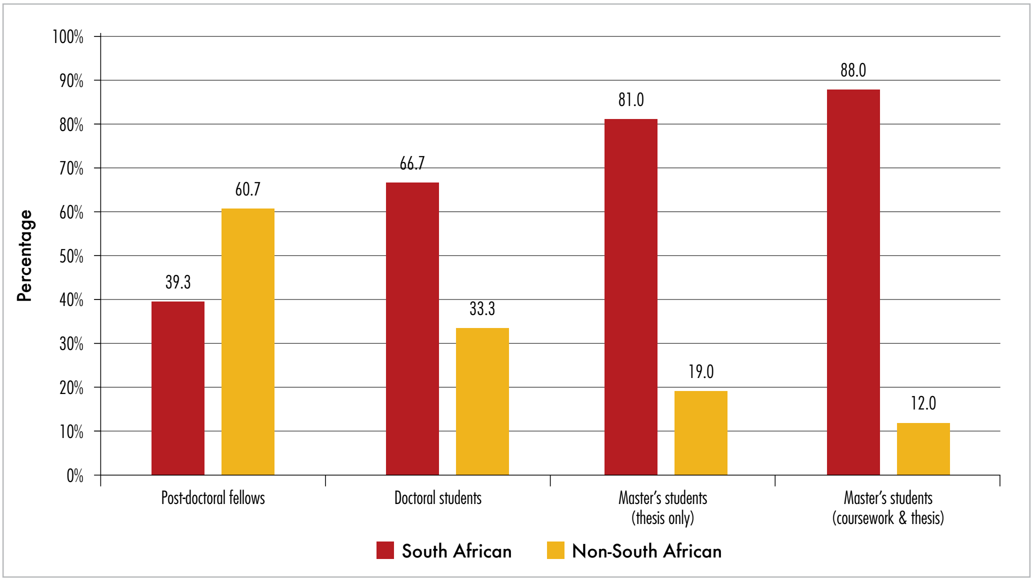
The number of non-South African researchers at each of these levels continued to increase between 2013/14 and 2017/18, with the exception of the doctoral students.

Figure 34: Higher education post-doctoral fellows and doctoral students by nationality (headcount), South Africa, 2013/14 to 2017/18



Data note	The 2013/14 to 2017/18 surveys distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master's students. Non-South African personnel are classified as those that are not from South Africa but are undertaking research in South Africa for a period exceeding six months. They can be temporary or permanent residents as described by SNA.
Data source	National Survey of Research and Experimental Development, 2017/18.

Figure 35: Higher education postgraduates by qualification (headcount), South Africa, 2017/18



Data note	The 2017/18 survey distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master's students. Non-South African personnel are classified as those that are not from South Africa but are undertaking research in South Africa for a period exceeding six months. They can be temporary or permanent residents as described by SNA.
Data source	National Survey of Research and Experimental Development, 2017/18.

Table 11: Higher education postgraduates by qualification and nationality (headcount), South Africa, 2013/14 to 2017/18

QUALIFICATION	HEADCOUNT		
2013/14	**SOUTH AFRICAN**	**NON-SOUTH AFRICAN**	**TOTAL**
Post-doctoral fellows	616	1 185	1 801
Doctoral students	11 778	4 342	16 120
Master's students	31 424	4 850	36 274
Total	**43 818**	**10 377**	**54 195**
2014/15			
Post-doctoral fellows	657	1 326	1 983
Doctoral students	11 644	6 129	17 773
Master's students	29 598	6 148	35 746
Total	**41 899**	**13 603**	**55 502**
2015/16			
Post-doctoral fellows	843	1 425	2 268
Doctoral students	12 711	7 443	20 154
Master's students	31 951	6 652	38 603
Total	**45 505**	**15 520**	**61 025**
2016/17			
Post-doctoral fellows	957	1 514	2 471
Doctoral students	13 229	8 026	21 255
Master's students (full thesis)	19 236	3 947	23 183
Master's students (coursework & thesis)	25 906	6 116	32 022
Total	**59 328**	**19 603**	**78 931**
2017/18			
Post-doctoral fellows	1 078	1 663	2 741
Doctoral students	15 249	7 617	22 866
Master's students (full thesis)	21 332	4 990	26 322
Master's students (coursework & thesis)	25 282	3 437	28 719
Total	**62 941**	**17 707**	**80 648**

Data note	The 2013/14 to 2017/18 surveys captured postgraduate students according to race and gender, and distinguished between South African and non-South African nationals for master's and doctoral students, and post-doctoral fellows.
Data source	National Survey of Research and Experimental Development 2013/14 to 2017/18.

6. INTERNATIONAL COMPARISONS

In brief

- South Africa's R&D data is comparable internationally and therefore represents a vital source of evidence for decision makers all around the world.
- South Africa's research intensity in 2017/18 was about half that of China's and about two-thirds that of Russia. By contrast, Egypt recorded a year-on-year decrease in research intensity between 2016 and 2017.
- Business is typically the biggest funder of R&D in research-intensive countries, such as Japan (78.3%), China (76.5%), Germany (66.2 %) and the USA (63.6%). As is the case in South Africa, in countries such as Argentina, Burkina Faso, Chile, Mali, Russia and Tunisia, government funds more than 40% of R&D.
- In South Africa, a higher proportion of researchers are female compared to most of the countries with high R&D expenditure, such as Germany and France.

Public authorities expect that increasing investment in R&D will intensify technological progress and in turn, accelerate sustainable socio-economic growth. The objective of this chapter is to evaluate South Africa's R&D performance in relation to its international counterparts. The comparison takes cognisance of the differences in economic and structural status of the selected countries, along with the availability of the latest data. With regard to country selection[2], the chapter encompasses analysis of a combination of African countries that have data for the current survey period 2017/18 (or closest year), some of the BRICS countries, other developing countries and selected leaders in the R&D-performing sphere. Such comparisons will allow policymakers to assess South Africa's R&D performance when compared with a mix of other countries.

[2] The analysis of data in terms of "largest or smallest" expenditure on R&D is based on the countries selected for this report, not according to values in the OECD Main Science and Technology indicators or UNESCO_UIS.

6.1. Gross domestic expenditure on R&D

6.1.1 GERD for selected countries

When it comes to international GERD comparisons (Table 12), the world's leaders, Japan, USA, China and Germany, continue to surpass the $100 000-million-dollar mark in purchasing power parities (PPPs) (OECD, 2020). France, Italy, Russia, Spain and Turkey reported GERD of between $15 000 million and $60 000 million respectively.

Within the BRICS countries China showed the highest GERD increase of 9.9%, followed by Russia. Although not on par with the other states in this grouping when comparing GERD, South Africa managed to show an increase of 4.6% over the three-year period. There is a lack of reliable data for Brazil and India in order to conduct a full group comparison.

In Latin America, countries such as Argentina, Chile and Peru reported lower GERD growth than that of South Africa. The World Bank (2019) classifies Chile as a high-income country and, like South Africa, Argentina and Peru are classified as upper middle-income countries.

On the African continent, Egypt reported a decrease of 9.3% in GERD from 2016 to 2017, whereas the GERD of Mali remained static. Countries such as Burkina Faso and Mauritius are still fairly new to R&D measurement, and more data points are required to begin to compare each countries' R&D capacity with that of South Africa over a meaningful period of time.

It is worth noting that the aim of this section is not to rank countries but to comparatively illustrate level of investment per country selected. Recommendations to increase R&D spending based on simple comparisons of investment can be counterproductive if the investment conditions of the countries compared are not known.

Table 12: GERD for selected countries (billion current PPP$), 2015 to 2017 or the latest available year

COUNTRY		2015		2016		2017
United States of America	b	495 098	dp	516 254	de	543 249
China		407 466		451 412		495 981
Japan		168 546		164 758		170 901
Germany		114 128		119 921		132 004
Korea		76 932		80 466		90 973
France		61 646	p	62 330	e	64 672
Russian Federation		38 776		38 743		41 868
Italy		30 003	b	32 460	p	33 543
Spain		19 821		20 229		21 932
Turkey		17 739		19 718		21 729
Israel	d	12 671	de	14 083	de	15 392
Poland		10 235		10 153	p	11 758
Finland		6 690		6 591		7 038
Egypt		7 244		7 548		6 846
South Africa		5 817		6 090		6 369
Argentina		5 467		4 682		5 024
Chile		1 552	b	1 539	p	1 591
Tunisia		814		794		
Peru		462		496		521
Burkina Faso						240
Mali		94		..		120
Mauritius						102

Data note	b) Time series break p) Provisional value e) Estimated value d) Do not correspond exactly to Frascati Manual recommendation (definition differs)
Data source	South Africa: National Survey of Research and Experimental Development, 2017/18. Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Poland, Russian Federation, Spain, Turkey, USA: OECD (OECD, 2020). Burkina Faso, Egypt, Mali, Mauritius, Peru, Tunisia: UNESCO (UNESCO, 2019).

6.1.2 GERD as a percentage of GDP

South Africa spent 0.83% of its GDP on R&D during 2017/18, which surpassed other African R&D performing nations such as Burkina Faso (0.67%), Egypt (0.61%) and Tunisia (0.60%). In the African countries assessed in Figure 36, Mali spent the least on R&D, with GERD over GDP of 0.29%.

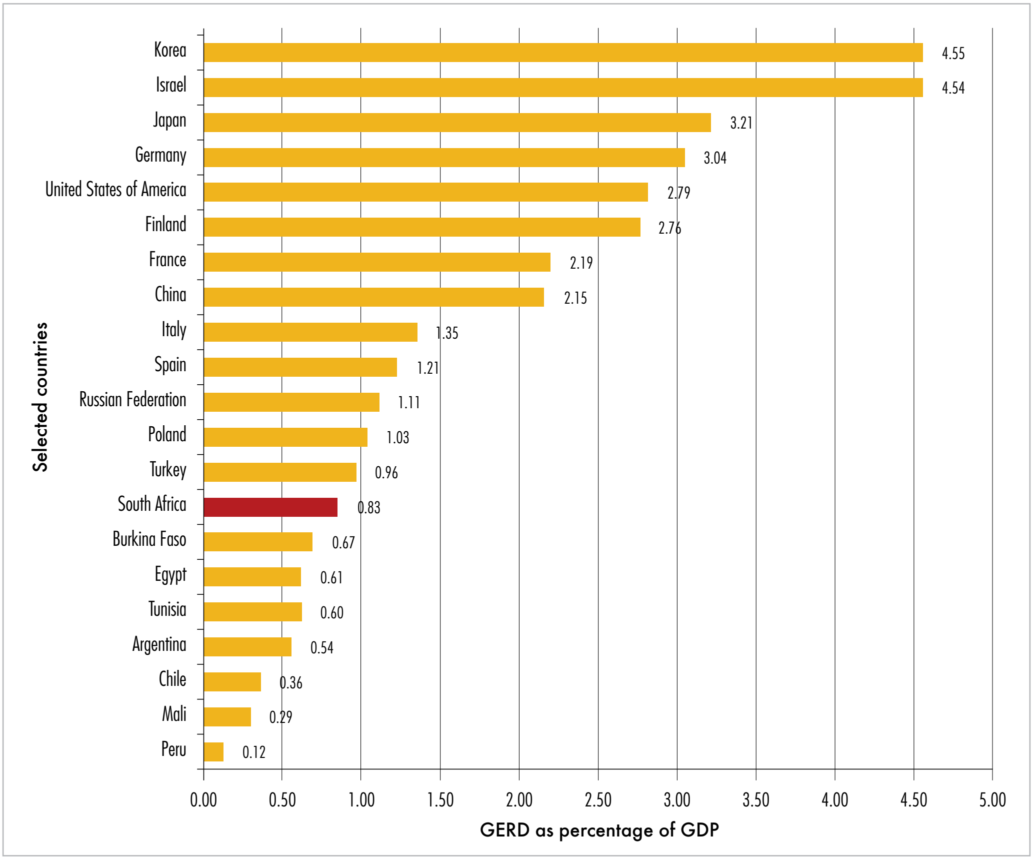
South Korea has seen the fastest growth in R&D expenditure among OECD countries over the last decade (OECD, 2020). At 4.55%, it now ranks first in R&D intensity in the OECD rankings. South Korea's spending on R&D as a share of GDP has grown rapidly from 2004, when it intersected with the US (2.50%), to 2009, when it intersected with Japan (3.23%). In 2017, Korea overtook Israel to become the country with the highest R&D intensity, at 4.55%. In 2015, almost three quarters of Korea's R&D expenditure was within the manufacturing sector. Approximately 20% of R&D in Korea was undertaken by the public sector, namely government and higher education (OECD, 2020).

Investment in R&D is driven by the country's private business sector, which includes global technology giants, Samsung and LG, the *Financial Times* reported in 2017 (Jung-a, 2017).

China leads the BRICS grouping with a 2.15% GERD intensity. This is more than many developed states, such as Italy, Spain and Poland. The R&D intensity of Argentina, Chile and Peru is less than most other countries presented in this report.

Within the OECD group of countries, Japan recorded the highest GERD as a percentage of GDP, at 3.20%. In 2010, the objective of spending 3.0% of GDP on R&D activities was outlined in the Europe 2020 strategy adopted by European Union's member states (EC, 2010). Although Japan outperformed many European counterparts, other developed states, like the USA (2.80%), Germany (3.04%), Sweden (3.31%), Austria (3.16%), Denmark (3.10%) and Finland (2.76%) recorded R&D intensity ratios greater than 2.5%.

Figure 36: GERD as a percentage of GDP for selected countries, 2017/18 or latest available year



Data source	South Africa: National Survey of Research and Experimental Development, 2017/18. Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Poland, Russian Federation, Spain, Turkey, USA: OECD (OECD, 2020). Burkina Faso, Egypt, Mali, Peru, Tunisia: (UNESCO UIS, 2019).

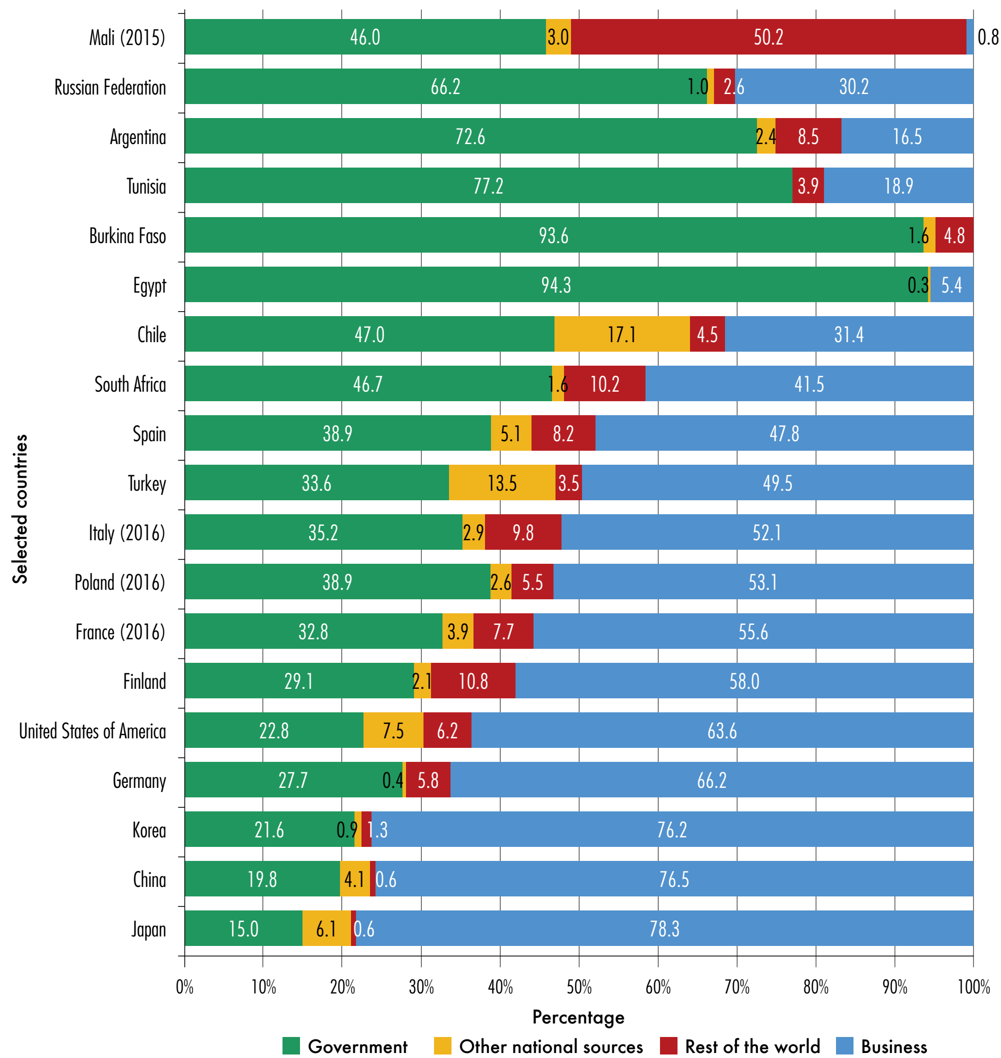
6.1.3 GERD by source of funds

The sources of funding for the R&D-performing sectors differs between countries (Figure 37). Government funding is usually predominant in low-and -middle-income countries, where the NPO sector also plays a role, but minimally so, in funding R&D. Business is typically the biggest funder of R&D in research-intensive countries.

Argentina, Burkina Faso, Chile, Mali, Russia, Tunisia and Egypt reported that more than 40.0% of their R&D funding was from the government sector. Countries that received more than 60% of R&D funding from the business sector were Japan (78.3%), China (76.5%), Germany (66.2 %) and the USA (63.6%).

Comparatively, South Africa falls between these two 'extremes'. Even though the government is the main funder of R&D (46.7% in 2017/18), there is also a considerable amount of funding for R&D from the business sector (41.5% in 2017/18).

Figure 37: GERD by source of funds in selected countries (percentages), 2017/18 or the latest available year



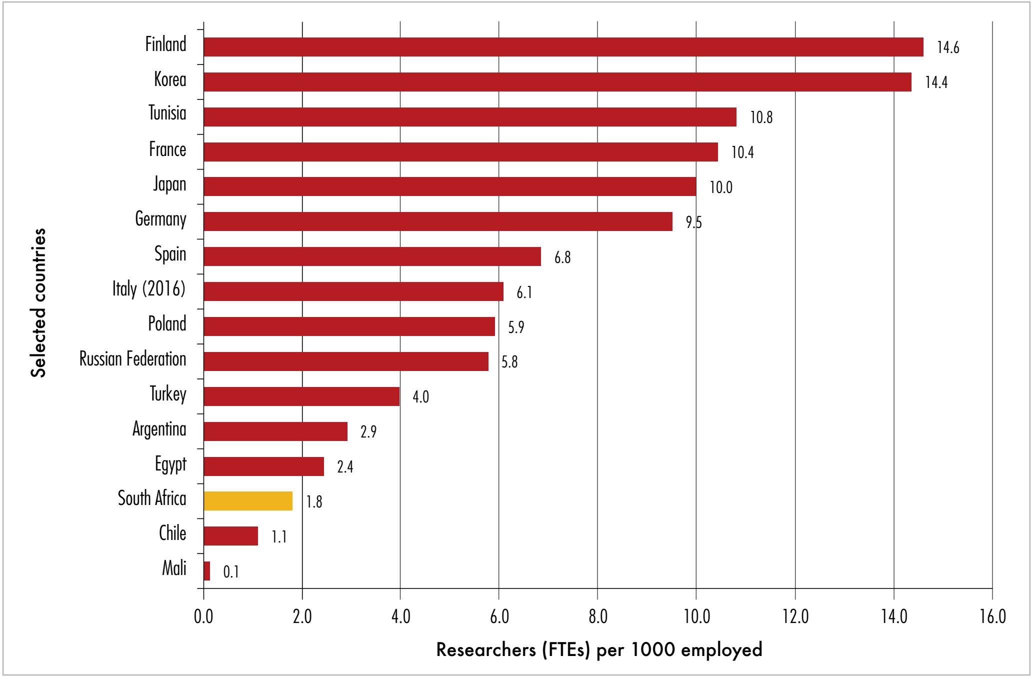
Data source	South Africa: National Survey of Research and Experimental Development, 2017/18. Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Poland, Russian Federation, Spain, Turkey, USA: OECD (OECD, 2020). Burkina Faso, Egypt, Mali, Peru, Tunisia: (UNESCO UIS, 2019).

6.2 R&D personnel

6.2.1 Researcher FTEs per thousand in total employment

South Africa's figure of 1.8 researcher FTEs per thousand employed places it between Egypt (2.4) and Chile (1.1) (Figure 38). The surge in R&D personnel in 2017/18 within the higher education sector reported in Chapter 5 does not seem to impact positively on this figure in any significant manner. In Russia, the number of researchers per thousand employed (5.8) was much higher in comparison to South Africa[3]. By contrast, in high-income countries, Finland reported 14.6 in 2017 and Japan reported 10.0 researchers per thousand employed in 2017, which was at the same level in 2016.

Figure 38: Researchers per 1 000 in total employment in selected countries, 2017/18



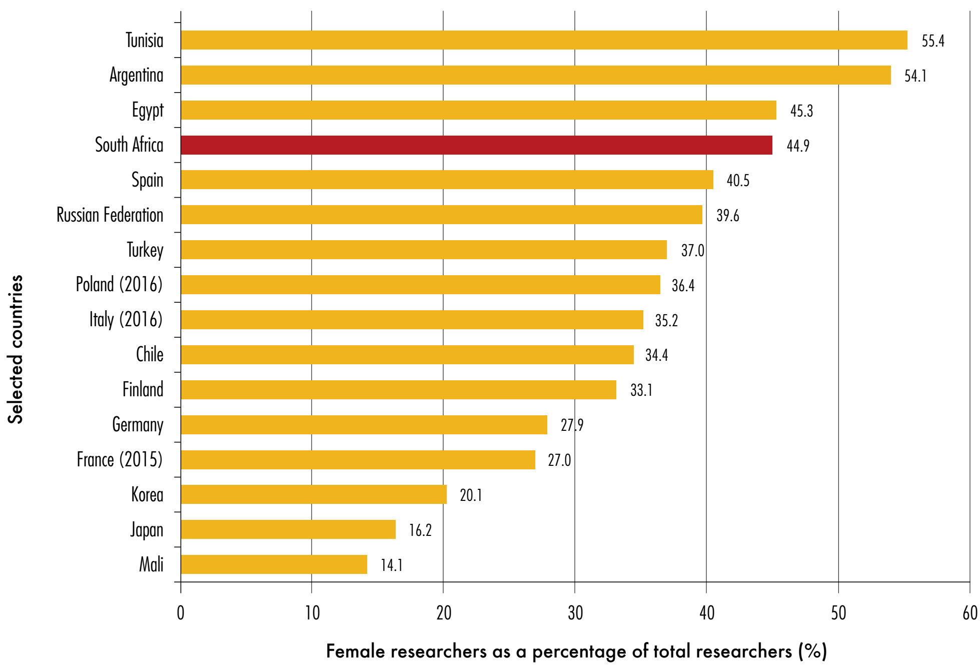
Data sources	South Africa: National Survey of Research and Experimental Development, 2017/18. Argentina, Chile, Finland, France, Germany, Italy, Korea, Japan, Poland, Russian Federation, Spain, Turkey: OECD, (OECD, 2020). Egypt, Mali, Tunisia: UIS (UNESCO, 2019).

[3] The other BRICS countries do not have data available to compare.

6.2.2 Female researchers as a percentage of total researchers

In South Africa, a higher proportion of researchers are female compared to most of the countries with comparatively large R&D expenditure, such as Germany and France (Figure 39). The proportion of female researchers in South Africa was 44.9% of total researchers in 2017/18, which is about the same as the level of 44.1% achieved in 2016/17. South Africa has improved on this indicator gradually over the last eight years. From the comparative data presented below (Figure 39), female researchers appear to form a higher proportion of total researchers in most developing countries than in most of the developed countries.

Figure 39: Female researchers as a percentage of total researchers (headcount) in selected countries, 2017/18 or latest available year



Data source	South Africa: National Survey of Research and Experimental Development, 2017/18. Argentina, Chile, Finland, France, Germany, Italy, Korea, Japan, Poland, Russian Federation, Spain, Turkey: OECD, 2020. Egypt, Mali, Tunisia: UNESCO UIS, 2019.

7. CONCLUDING REMARKS

In brief

- In the context of relatively small increases to R&D expenditure across sectors, including and especially in the business sector, policy makers face a strategic challenge to improve the country's capacity to meet its R&D spending goals.
- Provincially, spatial analyses of which institutional and economic sectors are growing or declining in each of the provinces over time, and how these are related to growing or declining R&D expenditure, are essential to inform region-specific strategies for intervention.
- There is a need for deeper understanding of postgraduate throughput, in particular how the pool of future researchers is created and utilised in South Africa.

The report began by encouraging the reader to consider the R&D Survey's 2017/18 data trends in terms of how they reflect growth, decline and stagnation in the investment in R&D over time. These concluding remarks highlight some key trends, and raise questions for further investigation, research and policy action, if South Africa is to improve the capacity to attain the 1.5% target of GERD/GDP.

Gross domestic expenditure on research and experimental development (GERD) has been increasing nominally over the years. The annual growth rate between 2008/09 and 2017/18 is about 0.8% in real terms. The question is whether this growth rate is fast enough to reach the 1.5% target by 2030.

Government funding of R&D has almost doubled over the past ten years, with higher education receiving most of the funds. The question is whether these levels of government funding are sufficient, and whether they can be sustained. Moreover, in the 2017/18 reference period, funding from foreign sources declined. Is this likely to be a new trend over the longer term, and what are the implications?

Sections 7.1 to 7.3 focus on the R&D investment data trends, extracting such policy questions and highlighting issues that need further investigation.

Across the system, there has been an increase in R&D personnel in general, but particularly, in the higher education sector. However, the surge in postgraduate student numbers does not seem to impact positively on researcher numbers, nor to decrease the unemployment rate in South Africa. Section 7.4 considers where there are spaces to intervene in this regard.

7.1 The need to support business sector R&D

The business sector has the potential to drive economic growth and development, environmental consciousness, and create employment. It remains the largest performer of R&D in South Africa over all the years of the survey, but despite this dominance, business expenditure on R&D as a percentage of GDP declined between 2008/09 and 2012/13. It began increasing again from 2013/14 to 2014/15, but although there have been nominal increases between 2015/16 and 2017/18, BERD/GDP stagnated at 1.4% during these years. The policy question arises: is the business sector investing in R&D at the right level, to drive economic growth?

The data also show that the business sector has been funding its own R&D activities, with little funding from the government sector. It is well known that the decision of firms to undertake R&D is based on their assessment of the private returns to R&D. Can we attribute the low proportion of government funding to the fact that firms do not rely on R&D, nor see the value of R&D to their productivity or innovation activities?

The data trends therefore suggest that if government aims to boost private R&D investments, it needs to know what types of R&D business is likely to fund itself, and what are those R&D activities that business will not fund, but that are crucial to economic growth. To achieve the optimal level of R&D investment, how can government policy strengthen the uptake of incentives aimed to increase the share of GDP invested in R&D by the business sector?

7.2 R&D expenditure by province

There is no ideal model for R&D investment spatially, with several factors influencing performance. Access to universities or research institutes with special scientific or engineering expertise, market size and R&D intensity all play a role in determining the location of investment. The preferred spatial location should have qualified and skilled R&D personnel, that is, the pool of R&D personnel active in the province indicates the potential for research activity. The policy question raised in the literature is whether it is an advantage or a disadvantage to invest in less intensive-R&D regions that may benefit from broader private and public investment in R&D through spillovers; or in more R&D intensive regions that can be more competitive and drive economic growth.

The Gauteng province generated about 34% of South Africa's GDP (R4.654 trillion) in 2017, making it the nation's biggest provincial economy, followed by Kwa-Zulu Natal and the Western Cape, contributing 16% and 14% of GDP respectively (Stats SA, 2019a). It is therefore appropriate that Gauteng remains the largest provincial spender on R&D activities. R&D expenditure in the Western Cape has been consistently above that of Kwa-Zulu Natal province, however, and there is also a trend of decreasing proportions of provincial R&D expenditure in Gauteng, and increasing proportions in the Western Cape. These point to the need for deeper scrutiny of the spatial location of R&D investment and performance.

Each province has its competitive or comparative advantage in as far as the main industries driving the economy are concerned. For instance, in some of the provinces with the least R&D expenditure, mining is the most important industry: in the Northern Cape, North West, Mpumalanga and Limpopo. Government is the largest 'industry' in the Eastern Cape and the Free State. It will therefore be important to investigate which institutional and economic sectors are growing or declining in each of the provinces over time, and how these are related to growing or declining R&D expenditure, to inform strategies for intervention. Are there differing regional R&D strategies that may be impacting positively or negatively? In such ways, the R&D data, used in conjunction with other secondary data, can facilitate the framing of polices that will enable greater investments in R&D.

7.3 Priority niche areas: the example of biotechnology R&D

Identifying priority research fields of R&D investment can highlight niche areas that can be supported and subsequently exploited to enhance R&D performance. Here we consider the case of biotechnology, which is lately associated with the development of drugs, but has historically been associated with addressing food security and famine. It is therefore one of the priority sectors that have been promoted in STI policy. The data on biotechnology R&D are used to measure the contribution of modern biotechnology to the Southern African economy; and in the formulation of policies and procedures in support of modern biotechnology business activity.

The expenditure on biotechnology R&D has been fluctuating over the years, leading to an inconclusive assessment of the levels of investment. Biotechnology research expenditure was about 4.6% of GERD in 2017/18, a slight year-on-year decrease of 0.5% in expenditure. How can investment in priority sectors be monitored, sustained and grown?

7.4 R&D personnel: the impact of postgraduate students

R&D personnel play a role in the production, development, diffusion and application of knowledge. South Africa requires high-level skills, through targeted curricular and cross-disciplinary learning for graduates, and through the openness of the system to allow for the diffusion of knowledge and inflow of foreign talent.

There has been an overall increase in R&D personnel in South Africa over the past period. However, the increases should be disaggregated at the level of institutional sector, to understand the origin and levels of this growth – to assist in understanding where growth can be promoted further.

The growth in researcher numbers has been driven by an increase in postgraduate students, notably at the level of Master's students. This is a positive achievement, indicating the growth of the potential pool of researchers, as Master's students become devoted to R&D activities.

The question arises however, whether sufficient human resources are produced for R&D nationally. Here, the data reflect that at the doctoral level, there is a higher proportion of South African nationals in the potential cohort. An inverted trend was observed at the level of post-doctoral fellows, where non-South African nationals predominate, suggesting that South African doctoral graduates are being lost to the R&D system.

This concern is reinforced by examining the distribution of researchers across institutional sectors. There is a decline in the number of researchers in science councils and government, and only modest increases in higher education (if postgraduate students are excluded), and in the business sector. The stagnating number of researchers per thousand in the population, coupled with a climbing unemployment rate (29.1%) in South Africa, raises the question: where do South African postgraduates go once they leave the higher education system? Are there incentives in place sufficient to keep some of them as researchers? The DSI has been working to increase the number of researchers by introducing a Comprehensive Bursary Programme to target honours students and improve the retention of postgraduate students (DST, 2018). Nevertheless, these trends point to the need to investigate the outputs of the post-graduate system in terms of how the pool of future researchers is created and utilised in South Africa.

7.5. Using the R&D survey data to inform strategies to attain the 1.5% target

The White Paper 2019 has outlined new policy goals: responding to the challenges of the 4IR, specialisation in key research areas, industries and technologies aligned to the SDGs and STISA, and expansion and upgrading of the STI infrastructure. To achieve these will require increased investment in and performance of R&D, reflected in the attainment of the 1.5% target.

There remains much research and policy debate to establish why the country is not reaching the targeted levels of R&D expenditure, unlike many of its peers. This section of the report has provided illustrative examples of growth, decline and stagnation trends in R&D expenditure and human resources, to contribute to the discussion. In future, the R&D data series can be analysed and disaggregated in greater depth, alongside complementary datasets, to identify issues for further policy consideration in a more systematic manner.

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METHODOLOGICAL NOTE

The South African National Survey of Research and Experimental Development (R&D Survey) forms part of the tools for monitoring and evaluating the performance of the National System of Innovation (NSI).

The R&D survey covers four main sectors described in the Frascati Manual: business enterprise, government, private not-for-profit and higher education sectors. In South Africa, the science councils are combined with the government sector and are reported separately, thus comprising science councils as a fifth sector.

The scope of the survey includes all units performing R&D, either continuously or occasionally. The survey collects data in accordance with the guidelines recommended by the OECD in the Frascati Manual (OECD, 2002, 2015). This helps to maintain coherence and international comparability. The System of National Accounts (EC, IMF, OECD, UN and World Bank, 2009) and the National System of Innovation differ on the identification of target units and definitions.

HSRC-CeSTII performs quality management in line with practices recommended by Stats SA in the South African Statistical Quality Assessment Framework (SASQAF) (Stats SA, 2010). The survey was conducted according to a project plan aligned with the phases of the Statistical Value Chain (SVC), which is modelled on practice at Stats SA.

Three questionnaires were used in the survey: for the business sector, for the higher education sector, and for government departments (national and provincial, municipalities, research institutes, and museums), science councils and not-for-profit organisations.

R&D performers in all sectors were taken to be any units that had R&D expenditure, or were likely to have had R&D expenditure, in 2017/18. The R&D data were collected by means of questionnaires that were sent to the units in each sector by surface and/or electronic mail. Quality indicators of survey coverage, fieldwork, data processing and analysis were assessed in the metadata report of the survey.

A detailed methodology and metadata are provided in the companion 2017/18 *Statistical Report*.

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