

SOUTH AFRICAN NATIONAL SURVEY OF RESEARCH AND EXPERIMENTAL DEVELOPMENT



MAIN REPORT 2016/17



Produced by the Centre for Science, Technology and Innovation Indicators on behalf of the Department of Science and Technology.

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► DISSEMINATION

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► REVISIONS

The Department of Science and Technology (DST), Statistics South Africa (Stats SA) and the Human Sciences Research Council's Centre for Science, Technology and Innovation Indicators (HSRC-CeSTII) reserve jointly 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, or amendments in response to internal and external data quality requirements and consistency monitoring such as that carried out by the Organisation for Economic Co-operation and Development (OECD), which conducts quality checks through global comparative analyses, time series analyses and other methods. Explanations of any revisions will be made available and accessible on the DST and HSRC websites.





► FOREWORD



The National Survey of Research and Experimental Development (R&D Survey) is published annually to update South Africa's R&D statistics. These statistics measure the size, growth and composition of R&D expenditure and the human resources devoted to R&D.

The survey is overseen by the Department of Science and Technology (DST) as a partner within the National Statistics System (NSS). R&D statistics are key to informing policy implementation by government and are also of use to the private sector, the international community, media, and researchers.

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). Accordingly, each R&D survey is subjected to a quality assessment process which is undertaken by a Clearance Committee, prior to its publication. This is done in accordance with the South African Statistical Quality Assessment Framework (SASQAF), to ensure the survey remains credible and true to its purpose.

There have been changes in the R&D landscape over the previous years. It is vital for the survey to adapt accordingly. As such, the 2016/17 R&D Survey introduced minor refinements, to mark the initial phase of incorporating the 2015 revisions to the Frascati Manual, an international guide for R&D statistics. The changes have added new sub-categories of R&D personnel data, but these have had minimal effect on the time series. Scoping for the next phase of this process has commenced, and clearly indicates a need for consultations locally and exchanges of practices with other countries, both to address domestic R&D measurement requirements and to maintain international comparability.

Through the quality assessment process, the Clearance Committee noted that the 2016/17 R&D Survey was conducted following good practices, and met most of the set quality requirements. The questionnaire response rate was 68.9%, which is below the set standard of 75%. The collection rate was 81.8%, which is above the standard of 75%. These two key quality indicators capture the dynamics of R&D performing units across the five sectors covered by this survey, which include units



that perform R&D more consistently and those that do not. To reduce imputations, specific public higher education institutions should be assisted to address common R&D data collection constraints. Efforts to expand the universe of R&D performers in the business sector must continue, and the survey design should gradually adapt to the changes in the way R&D is funded and organised within firms.

Given my assessment of the recommendations of the Clearance Committee, I endorse the 2016/17 R&D Survey results, and encourage its use by stakeholders.



Risenga Maluleke
STATISTICIAN-GENERAL, REPUBLIC OF SOUTH AFRICA





► PREFACE



Increasing research and development (R&D) investment in order to drive innovation and in turn inclusive growth is an important pillar of the proposed White Paper on Science, Technology and Innovation. The National Survey of Research and Experimental Development (R&D Survey) is crucial for monitoring South Africa's progress in this regard.

Conducted annually on behalf of the Department of Science and Technology, the R&D Survey provides statistics on our country's performance in terms of key indicators of R&D expenditure and human resources devoted to R&D.

The survey estimates that South Africa's nominal gross domestic expenditure on research and development (GERD) in 2016/17 amounted to R35,693 billion, while in real terms the estimates amounted to R25,305 billion for the same period. The headcount of R&D personnel for the period under consideration was 80 029, the majority (56 761 or 71%) of which were researchers.

Viewed on a year-to-year basis since the recovery from the recent global financial crisis, the respective R&D statistical series on financial and human resources point to a steady growth. This is important for South Africa's growth and development. The upward trend in investment in R&D in real terms needs to be aggressively stimulated towards the achievement of the targets in the National Development Plan in a manner that stimulates inclusive economic growth.

The past two decades of implementing programmes under the 1996 White Paper on Science, Technology and Innovation have provided proof on how innovations can uplift our nation. Over the period, we saw, for the first time in the field of health research, major strides being made that resulted in the discovery and development of a malaria drug on African soil. Others successes in this area include the development of software used in the treatment of multiple-drug resistant tuberculosis and the development of a device to monitor foetal development. Industry saw domestic innovations in hydrogen and fuel cell technologies beginning to position South Africa in key global value chains, and promising a significant contribution to competitiveness and economic development. In all these examples, government funding served a catalytic role, with subsequent co-investment from the private sector and international sources taking these initiatives to the next level. These technologies not only lead to new discoveries but also enhance the capabilities for absorbing new technologies and addressing critical development gaps.



Notwithstanding the successes, considering the broader socio-economic situation in South Africa, as noted before, much higher levels of investment in real terms are needed. For instance, the ratio of full-time equivalent researchers per 1 000 employed remain unchanged compared to the 1,7 ratio of 2015/16. The National Development Plan requires a much larger pool of scientists, engineers and technologically skilled workers than is currently available. GERD as a percentage of GDP, for the fourth consecutive year, increased under conditions of sluggish economic growth. Internationally, South Africa's R&D intensity exceeds that of many developing countries but still lags behind that of developed countries.

The public, private and international sectors' efforts complement each other in terms of R&D funding and performance. The government remains the main funder of R&D in the country, followed by the business sector and funding from other countries. Our country needs a sharp real increase in business investment expenditure in R&D. Incentives such as the R&D tax incentive by government are in place precisely for this purpose. Connections between business, science councils and higher education institutions need to be strengthened in order to capitalise on the country's researcher base and to overcome sector-specific constraints on R&D performance. Engagements with stakeholders in industry and higher education has revealed the important work underway in South Africa that links to the unfolding new era, the fourth industrial revolution. It is important that our country increasingly devote financial and human resources in order to respond to and drive the fourth industrial revolution.

On behalf of the Department of Science and Technology, I extend my appreciation to the Centre for Science, Technology and Innovation Indicators for their efforts in conducting this survey each year, and to Statistics South Africa for facilitating the process of assessing the quality of the R&D statistics. A special word of thanks goes to all survey respondents, in both the private and the public sectors, who gave their time to make this survey a success.



Mmamoloko T. Kubayi-Ngubane
MINISTER OF SCIENCE AND TECHNOLOGY





► ACKNOWLEDGEMENTS

The South African National Survey of Research and Experimental Development (R&D Survey) is conducted annually by the Human Sciences Research Council's Centre for Science, Technology and Innovation Indicators (HSRC-CeSTII) on behalf of the Department of Science and Technology (DST).

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

The support and contributions of Imraan Patel, Godfrey Mashamba, Tshidi Mamogobo, Kgomotso Matlapeng and Nangamso Mnwana of the DST are very much appreciated.

Technical inputs and advice by the DST 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.

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

The HSRC-CeSTII project team for the 2016/17 South African National Survey of Research and Experimental Development comprised: Lindiwe Binda, Mario Clayford, Nozibele Gcora, Zinziswa Hlakula, Lwando Kondlo, Glenda Kruss, Xolisa Magawana, Nhlanhla Malaza, Hlamulo Makelane, Maria Maluleke, Jerry Mathekgwa, Neo Molotja, Vuyiseka Mpikwa, Precious Mudavanhu, Nazeem Mustapha, Saahier Parker, Gerard Ralphs, Theodore Sass, Natasha Saunders, Janine Senekal, Moses Sithole, Natalie Vlotman, Sibusiso Ziqubu, and Thembinkosi Zulu.



► 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
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, Computer 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
SA	South Africa
SASQAF	South African Statistical Quality Assessment Framework
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
VAT	Value Added Tax





► DEFINITION OF TERMS

Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, 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.

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 expenditures are the annual gross expenditures on fixed assets used in the R&D programmes of statistical units. These are reported in full for the period when they took place and are not registered as an element of depreciation. Capital expenditures on R&D consist of buildings, vehicles, plant machinery and equipment.

Current expenditure is expenditure on items that generally reoccur after a short period. Current expenditure on R&D activities consists of labour costs and other 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 and services, or to improving substantially those already produced or installed.

Full-time equivalent (FTE) is an estimate of the time spent on R&D activities. It is the proportion of time spent on R&D activities out of all time spent at work.

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. This statistic is obtained from the Statistics South Africa GDP survey P0441, 1st Quarter 2018 (Stats SA, 2018a).

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



Headcounts refers to the number of people directly involved in or supporting R&D (i.e. the total number of R&D personnel within a category).

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, payroll taxes, etc. The labour costs of persons providing indirect services which 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 and included in other current costs.

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

Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometres, where unique phenomena enable novel applications.

New materials pertain 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.

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 into 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.

Open-source software is computer software that is available in source code form under an open-source licence. The source code and certain other rights normally reserved for copyright holders are provided under a software licence that permits anyone to study, change, improve and, at times, also to distribute the software.

Other current expenditure comprises non-capital purchases of materials, supplies and equipment to support R&D performed by the statistical unit in a given year. These include, but are not limited to running costs, overhead expenses, repairs and maintenance, payments to outside organisations for use of specialised testing facilities, payments to outside organisations for specialised services and on-site consultant expenses in support of R&D projects carried out by the R&D performer.





Other support staff includes skilled and unskilled craftsmen, 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) comprise 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 R&D personnel engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.

R&D intensity estimated by GERD as a proportion of GDP is the total intramural expenditures on R&D performed in the country in a given year relative to GDP.

R&D personnel refers to all persons (irrespective of nationality) employed directly on R&D, as well as those providing direct services such as R&D managers, administrators, and clerical staff. These include emeritus professors, honorary fellows and research fellows¹.

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

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

Socio-economic objective (SEO) classification provides an indication of the R&D activities by main purpose. The SEO classification used in this survey is consistent with the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS) that was published by Eurostat in 2007.

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 employed labour force in the South African economy. This statistic is obtained from Stats SA Labour Force Survey series P0211 (Stats SA, 2018b) where employed persons were defined as 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%.

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 and discusses key results of the South African National Survey of Research and Experimental Development (R&D Survey) for the 2016/17 financial year. The Survey is conducted annually by the Centre for Science, Technology and Innovation indicators (CeSTII) on behalf of the Department of Science and Technology (DST).

R&D expenditure increased to R35.693 billion in 2016/17.

R&D expenditure has shown steady but slow growth over the past few years, peaking at R35 693 billion in 2016/17. This represents a nominal increase of 10.4% from the R32.337 billion recorded in 2015/16. At constant 2010 Rand values, gross domestic expenditure on R&D (GERD) amounted to R25.305 billion in 2016/17, an increase of R847 million from R24.458 billion in 2015/16. The year-on-year change in real GERD was 3.5% in 2016/17, which was a drop from the 5.0% recorded in 2015/16.

GERD as percentage of GDP grew from 0.80% to 0.82%.

GERD expressed as a percentage of GDP provides an indication of the concentration or intensity of R&D in the economy. GERD as percentage of GDP was 0.82% in 2016/17. This indicator improved slightly, by 0.02% from 0.80% in 2015/16, after remaining constant at 0.73% for three consecutive years, from 2011/12 to 2013/14. The improvement may largely be due to the slow growth in GDP. Trend data shows 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.

R&D expenditure in all sectors increased in nominal terms.

The business sector was the largest performer of R&D in 2016/17, with business expenditure on R&D (BERD) amounting to R14.781 billion. Higher education expenditure on R&D increased by 18.0% from R9.877 billion in 2015/16 to R11.659 billion in 2016/17. Expenditure on R&D by science councils rose from R5.741 billion in 2015/16 to R6.136 billion in 2016/17, and accounted for 17.2% of total GERD. Government expenditure on R&D constituted 5.9% of GERD, increasing marginally from R2.013 billion in 2015/16 to R2.099 billion in 2016/17. Not-for-profit organisations showed a consistent increase in R&D expenditure, from R891 million in 2015/16 to R1.018 billion in 2016/17. In constant 2010 Rand values, the only sector to reflect a year-on-year decline in R&D expenditure was the government sector.





R&D expenditure in manufacturing continued its decline, while R&D in business services increased.

Within the business sector, the largest proportion of BERD in 2016/17 continued to be committed in financial, intermediation, real estate and business services, accounting for R6.555 billion or 44.3% of BERD, and reflecting a year-on-year increase of 10.9%. This was followed by manufacturing, which accounted for 27.8% of BERD compared to 32.2% in the previous reference period. The decline points to reduced investment in manufacturing sector R&D, in contrast to a maturing of R&D investment in the services sector.

Foreign funding for R&D declined by R38.354 million in 2016/17.

Government funded the largest proportion of R&D (R16.428 billion) in South Africa in 2016/17, followed by the business sector, which contributed R14.046 billion towards total R&D funding. The bulk of business sector funding was committed to business sector R&D (89.6%), while the remainder of R&D funding from the business sector was allocated to higher education (6.5%), science councils (3.4%), and non-profits (0.5%). The third largest source of funding for R&D in 2016/17 was from abroad, although for the first time in years, this funding decreased from R4.210 billion in 2015/16 to R4.172 billion in 2016/17. Foreign funding decreased in the business and higher education sectors but increased slightly in the government, science council, and NPO sectors.

South Africa's R&D headcount grew by 6.8% in 2016/17.

South Africa's R&D personnel headcount and full-time equivalents (FTEs) continue to grow. The R&D personnel headcount increased from 74 931 in 2015/16 to 80 029 in 2016/17, reflecting a 6.8% increase and an improvement on growth of 3.4% reported between 2014/15 and 2015/16. The growth in personnel is mostly attributed to increased numbers of researchers, and specifically to growth in postgraduate student numbers in the higher education sector. The 2016/17 R&D Survey introduced new aspects to the collection of R&D personnel data², which contributed partially to the increase in headcounts and FTEs observed. R&D FTEs grew from 41 054.5 in 2015/16 to 42 533.0, reflecting growth of 3.6%.

² The growth was based on a methodological adjustment and actual increases; notably from the postgraduate students. The category introduced to the personnel in the higher education sector includes the reclassification of staff to reflect emeritus professors, honorary fellows and research fellows.



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► INTRODUCTION

This report provides descriptive analysis and commentary on the results of the 2016/17 R&D Survey. It is accompanied by the *Statistical Report*, which presents data tables for 2016/17 against the previous ten years of trend data. Based on the data trends, the reports can assist to catalyse policy and research questions, though the answers and solutions may require further in-depth investigation.

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 in order 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 discussion in this report is presented in terms of global standard categories of indicators, namely:

- Gross domestic expenditure on R&D (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 (SEO);
- R&D personnel by occupation (researchers, technicians and support staff) and full-time equivalents (FTEs);
- R&D expenditure in multidisciplinary and selected areas of policy interest, namely biotechnology, nanotechnology, environment-related R&D, open-source software, new materials, space, tuberculosis (TB), HIV/AIDS and malaria research; and,
- R&D expenditure by province.

This report is divided into seven themed sections. Section 1 provides a contextual overview of the survey, indicators and measurements in South Africa, as well as a brief summary of key indicators. Sections 2, 3 and 4 analyse patterns of 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. A conclusion is provided in Section 7, highlighting issues that require further research or policy attention. While survey methodology is documented in detail in the accompanying statistical report, a short methodological note is included at the end of this report.



► 1. IS SOUTH AFRICA KEEPING PACE WITH RAPID CHANGES IN SCIENCE, TECHNOLOGY AND INNOVATION?

Science, technology and innovation (STI) are dynamic. The impact of this dynamism has far-reaching policy implications, and informs both how STI is measured and how the resulting STI indicators are used. The recent changes to the internationally accepted manuals that are adopted by countries all over the world to collect R&D and innovation statistics (the Oslo and Frascati manuals) serve to reinforce the dynamic nature of STI indicators.

Within this context, measuring STI, and creating robust and reliable indicators to understand the development of a national system of innovation, is not an easy task. Most developing countries either do not collect STI data, or are playing catch-up with the practice. This has negative and positive implications: The negative implications include data becoming less relevant due to it being old, and thus not suitable to inform interventions on the latest policy issues. Budget planning particularly needs to be informed by credible data; the older the data, the less impact it can have. The positive aspects of catch-up include learning from the best practitioners, and preparing data collection properly from the outset. The OECD and other developed countries have made great strides in STI measurement, from which South Africa has learned much (OECD, 2017).

In the reference period of the 2016/17 R&D Survey, the World Economic Forum identified significant STI advancements, which have a complex range of economic, political and social consequences, and which can be summed up in the notion of the 'fourth industrial revolution' (Schwab, 2016). A study undertaken by PricewaterhouseCoopers (PwC) in 2016, entitled *Industry 4.0: Building the digital enterprise*, indicates the extent of investments in the digital revolution across the globe. 'Industry 4.0' represents change that is occurring in the manufacturing sector, building on previous technological revolutions in micro-processors and developing on the 'internetisation' of economic activity. What is distinctive is the combination of cyber and physical systems, where computers are interconnected, and data is used to make decisions without direct human involvement. In this context, statisticians in developed economies are considering how to collect information on the digital revolution, artificial intelligence, robotisation of manufacturing, and the skills required for these activities (PwC, 2016).





Many companies in South Africa already have, or plan to introduce new digital products and data-based services over the next few years. Data is the foundation for the digital economy, identified by some as the 'new oil' of the present era. The Draft White Paper on Science, Technology and Innovation (DWP) 2018 considers how South Africa should respond to the opportunities and challenges posed by the 'fourth industrial revolution', and highlights the potential impact on industry going forward. At the same time, the DWP attempts to orient the national system of innovation to address the socio-economic development challenges of South Africa. Going forward, it argues, the country needs to develop innovation systems to support economic growth, but also environmental sustainability, inclusive development and improved government performance.

Undoubtedly, there will be implications from these global and local contextual and policy developments for the ways in which STI data is collected, analysed, used and archived in the future. New skills, competencies and even technologies are likely to be required for such tasks. Those countries that have already started a process of adapting to these exigencies indicate that there are both risks and challenges, but also opportunities. The creation and adaptation of new measurement processes in South Africa will of course need to be guided by good coordination between data gatherers and users, and take into account the speed at which implementation takes place.

In a context of changing STI but also changing STI measurement urgencies, it is important to interrogate the evidence generated by R&D Survey 2016/17 to inform policy thinking and action. With this round of the survey, and indeed over the next few years, the main policy questions our data will need to address include: Are sufficient resources allocated to domestic R&D, so that South Africa can keep pace with rapid changes in STI? Does the national system of innovation generate sufficient R&D personnel for these tasks?



1.1 Key indicators

South Africa's key R&D indicators for 2014/15 to 2016/17 are presented in Table 1. These results reflect that, despite the challenging domestic economic environment, South Africa's research intensity ratio (GERD/GDP) increased to 0.82%, and the complement of R&D personnel grew. The remaining sections of this report will provide an elaboration of the data, to contribute to STI policy debate in South Africa.

Table 1: Key R&D indicators for the years 2014/15, 2015/16 and 2016/17

KEY INDICATOR	VALUE		
	2014/15	2015/16	2016/17
Gross domestic expenditure on R&D (GERD) (R million)	29 345	32 337	35 693
Gross domestic expenditure on R&D in constant 2010 prices (R million)	23 304	24 458	25 305
GERD as a percentage of GDP (%)	0.77	0.80	0.82
Civil GERD as a percentage of GDP (%)	0.72	0.75	0.78
Basic research (R million)	7 133	8 210	9 543
Government-funded* R&D (R million)	12 873	14 426	16 428
Business-funded R&D (R million)	11 982	12 578	14 046
Foreign funding of R&D (R million)	3 566	4 210	4 172
Total R&D personnel (FTE**)	38 465.0	41 054.5	42 533.0
Total researchers# (FTE**)	23571.9	26159.4	27656.2
Total researchers# (headcount)	48 479	51 877	56 761
Female researchers# (headcount)	21 471	23 334	25 591
Total R&D personnel (FTE**) per 1 000 in total employment	2.5	2.6	2.6
Total researchers# (FTE**) per 1 000 in total employment	1.5	1.7	1.7
Female researchers# headcounts as a percentage of total researcher headcounts (%)	44.3	44.4	45.1
Gross domestic product (GDP) level at current prices (R million)	3 805 350	4 051 421	4 350 314
SA employment ('000)	15 459	15 663	16 212

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 (2016/17 only). These categories of personnel do not incur salary costs, but there are time and cost associated with their institutional position. Headcount data includes non-SA R&D personnel in 2016/17.

Data sources

South African National Survey of Research and Experimental Development, 2014/15 to 2016/17.

GDP values: Stats SA, GDP, First Quarter 2018, P0441 Series (Stats SA, 2018a).

Total employment values: Stats SA, Quarterly Labour Force Survey, First Quarter 2018, P0211 Series (Stats SA, 2018b).



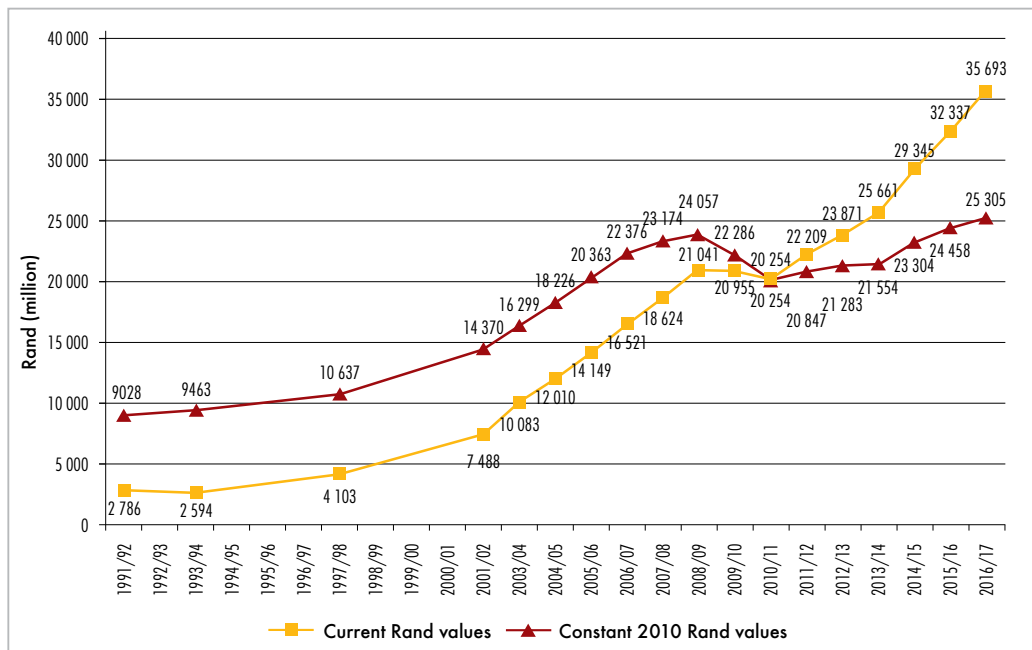


▶ 2. R&D EXPENDITURE

2.1 Gross domestic expenditure on R&D

South Africa spent R35.693 billion on research and experimental development in 2016/17 (Figure 1). This represent a nominal increase of 10.4% from the R32.337 billion recorded in 2015/16. At constant 2010 Rand values, gross domestic expenditure on R&D (GERD) amounted to R25.305 billion in 2016/17, which was a small increase of R0.847 million, from R24.458 billion in 2015/16. The increase in GERD is a positive signal.

Figure 1: GERD in current and constant 2010 Rand value (R million), South Africa, 1991/92 to 2016/17



Data note GDP deflator values derived from the fourth quarter release of the Stats SA GDP series P0441 (Stats SA, 2015) were used to calculate constant 2010 Rand values for R&D expenditure.

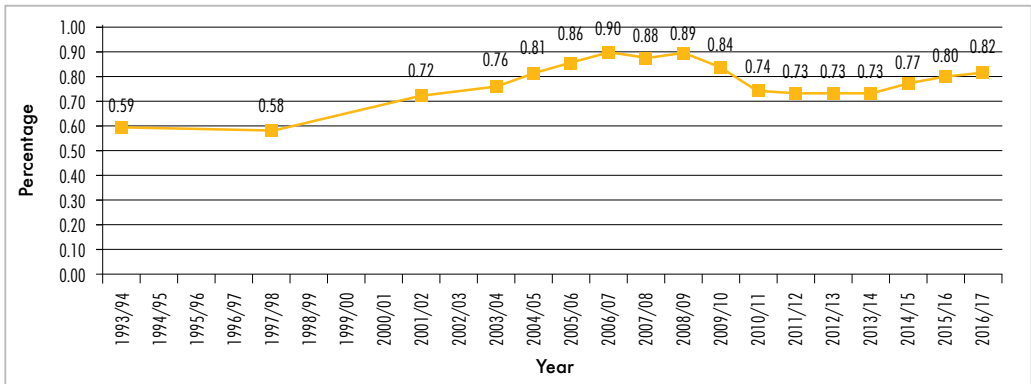
Data sources Revised GDP (current values): Stats SA, GDP, Fourth Quarter 2015, P0441 Series (Stats SA, 2015b).
R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2016/17. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE, 1993; DACST, 1996; DACST, 2000).



2.2 GERD as a percentage of GDP

GERD expressed as a percentage of GDP in South Africa was 0.82% in 2016/17 (Figure 2). This indicator has continued to improve slowly but steadily: It increased by 0.02% from 0.80% in 2015/16, after remaining constant at 0.73% for three consecutive years, from 2011/12 to 2013/14. 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. Since then, the rate of increase in R&D expenditure in nominal terms has continued to increase.

Figure 2: GERD as a percentage of GDP, South Africa, 1993/94 to 2016/17



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 2015, P0441 Series (Stats SA, 2015b). R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2015/16. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE, 1993; DACST, 1996; DACST, 2000). R&D intensities prior to GDP revision: National Survey of Research and Experimental Development, 2016/17.

2.3 GERD by institutional sector

The business sector remained the largest performer of R&D in 2016/17, with business expenditure on R&D (BERD) amounting to R14.781 billion. BERD at constant prices amounted to R10.479 billion in 2016/17, which is equivalent to 41.4% of GERD.

The higher education sector remained the second largest performer of R&D. Higher education expenditure on R&D (HERD) increased by 18.0% from R9.877 billion in 2015/16 to R11.659 billion in 2016/17. At constant 2010 Rand values, this represented a 10.6%





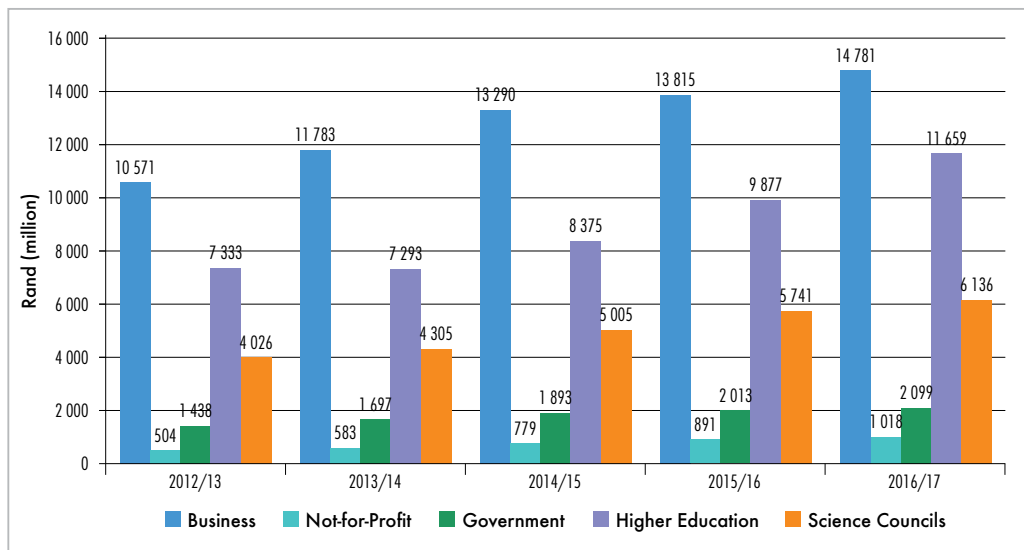
increase in R&D expenditure from R7.470 billion in 2015/16 to R8.266 billion in 2016/17. Of the increase observed in HERD, the top five R&D performing institutions contributed 77.2% to the total increase in 2016/17.

Expenditure on R&D by South Africa’s science councils increased from R5.741 billion in 2015/16 to R6.136 billion in 2016/17, and accounted for 17.2% of GERD. Science councils represent the third largest performer of R&D in South Africa. Their expenditure in constant 2010 Rand values stood at R4.350 billion in 2016/17.

Government expenditure on R&D constituted only 4.3% of GERD, increasing only slightly from R2.013 billion in 2015/16 to R2.099 billion in 2016/17. At constant 2010 Rand values, this represented a slight decrease of 2.4% from R1.523 billion in 2015/16 to R1.488 billion in 2016/17.

Not-for-profit organisations showed a small increase in R&D expenditure from R891 million in 2015/16 to R1.018 billion in 2016/17. At constant 2010 Rand values, this represented a 6.9% increase from R674 million in 2015/16 to R721 million in 2016/17.

Figure 3: R&D expenditure by sector (R million), South Africa, 2012/13 to 2016/17



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, 2012/13 to 2016/17.



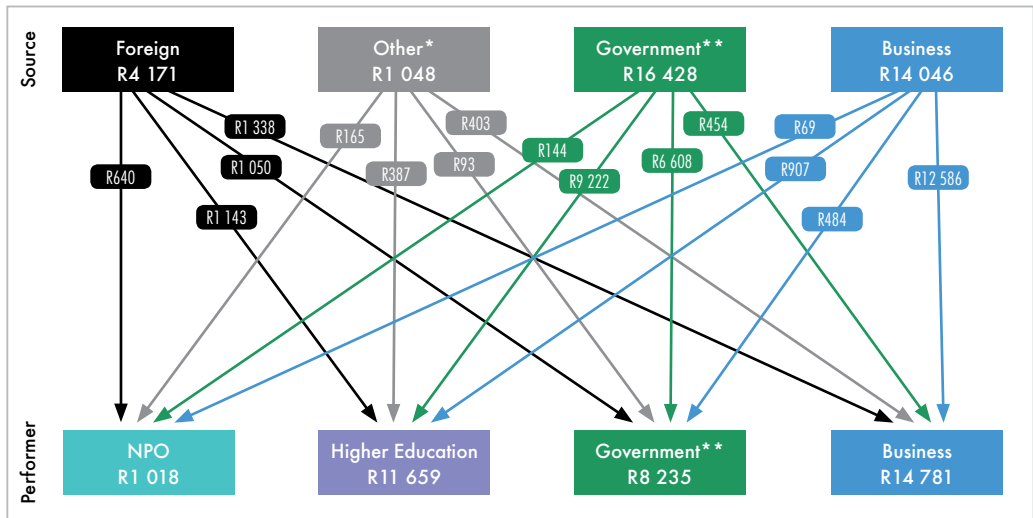
▶ 3. FUNDING FOR R&D

3.1 Major flows of R&D funding

Government funded the largest proportion of R&D in South Africa in 2016/17 (Figure 4). Government funding increased by 13.9% from R14.426 billion in 2015/16 to R16.428 billion in 2016/17, representing 46.0% of total R&D funding. Higher education institutions received 56.1% (R9.222 billion) and government institutions received 40.2% (R6.608 billion) of total government funding of R&D. The business and not-for-profit sectors were the smallest recipients of R&D funding from government, receiving 2.8% (R454 million) and 0.9% (R144 million) respectively.

The business sector was the second largest funder of R&D, contributing 39.4% (R14.046 billion) towards total R&D funding. The bulk of the funding went to the business sector, while the remainder was allocated mainly to the higher education and government sectors, at R907 million and R484 million respectively. The third-largest source of funding for R&D in 2016/17 was from abroad. This amounted to 11.7% (R4.171 billion) in 2016/17.

Figure 4: Major flows of funding, (R million), South Africa, 2016/17



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, 2016/17.

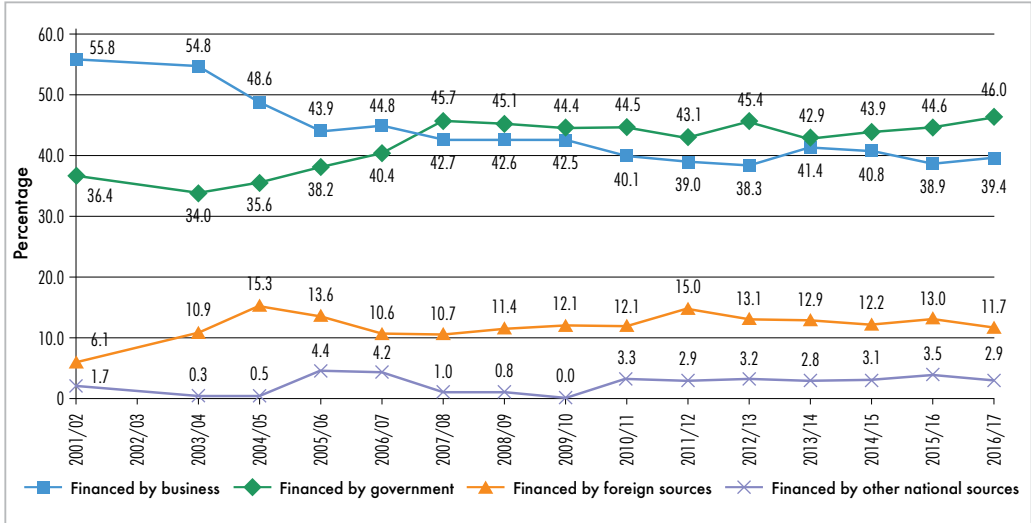




3.2 GERD by sources of funds

Government and business enterprises have consistently continued to fund the largest proportion of GERD in South Africa (Figure 5), continuing this trend in 2016/17. The proportion of R&D funding by government and business increased in 2016/17, while funding from foreign sources and other national sources decreased during the same period.

Figure 5: GERD by source of funds (percentage), South Africa, 2001/02 to 2016/17



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, 2001/02 to 2016/17.



3.3 Business-funded R&D

The business sector continued to fund its own research almost exclusively, meeting 89.6% of its own R&D expenses in 2016/17.

The higher education sector was the second largest recipient of R&D funds from the business sector, which increased by 17.7% from R770 million in 2015/16 to R907 million in 2016/17. Similarly, funding of R&D from business sources to the science councils increased by 47.9%, from R327 million in 2015/16 to R483 million in 2016/17; while the not-for-profit sector showed an increase of 23.6% from R56 million to R68 million during the same period. The government sector showed a decline in business-funded R&D, decreasing substantially from R41 million in 2015/16 to R1.261 million in 2016/17. The possible reason for this change is that a single government entity recorded R41 million as funding from the private sector in 2015/16, which was not reported as such in 2016/17.

Table 2: Business-funded R&D by sector of performance (R million), South Africa, 2012/13 to 2016/17

SECTOR	2012/13	2013/14	2014/15	2015/16	2016/17
Business	8 402 340	9 552 717	10 810 428	11 384 709	12 586 109
Not-for-profit	24 894	53 359	63 084	55 584	68 705
Government	11 552	1 759	290	41 109	1 261
Science councils	135 729	419 469	222 892	326 647	483 166
Higher education	577 527	588 598	885 280	770 448	906 651
Total (current Rand value)	9 152 042	10 615 902	11 981 974	12 578 497	14 045 892
Total (constant 2010 Rand value)	8 159 802	8 916 961	9 515 357	9 513 948	9 957 895

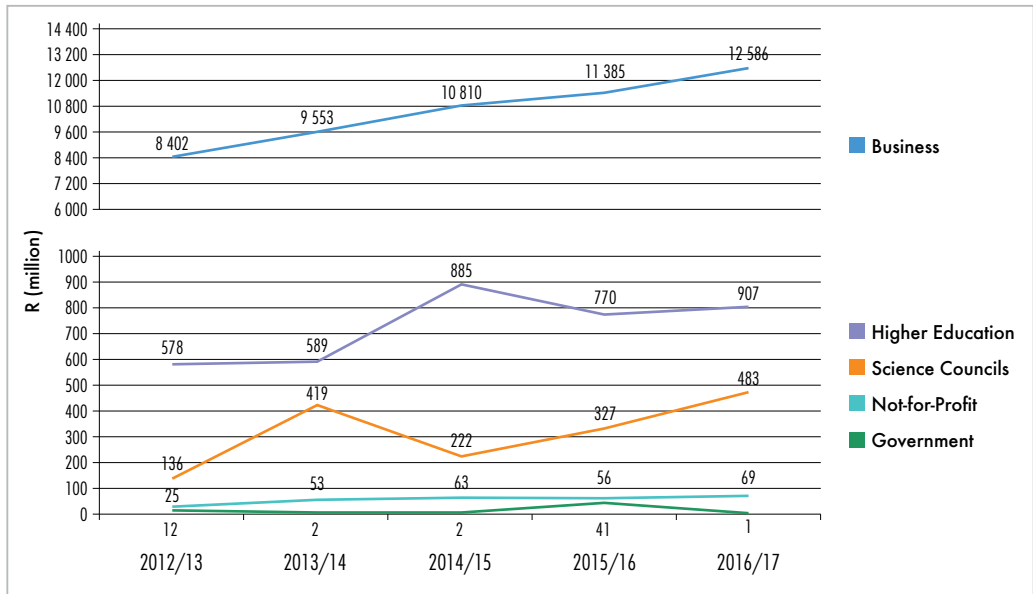
Data note GDP deflator values derived from Stats SA (2015) were used to calculate constant 2010 Rand values for R&D expenditure.

Data sources Revised GDP (current values): Stats SA, GDP, First Quarter 2018, P0441 Series (Stats SA, 2018a).
National Survey of Research and Experimental Development, 2012/13 to 2016/17.





Figure 6: Business-funded R&D by sector of performance (R million), South Africa, 2012/13 to 2016/17



Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



3.4 Government funding of local R&D

Since 2007/08, government has been the largest funder of R&D nationally. Higher education institutions and science councils continued to be the largest recipients of government funding for R&D: higher education R&D funding from government increased by 24.7% from R7.394 billion in 2015/16 to R9.222 billion in 2016/17, while funding of R&D for science councils increased marginally by 3.1%, from R4.922 billion in 2015/16 to R5.077 billion in 2016/17. Government funding of R&D to the government sector (excluding science councils and higher education) increased by 7.4% from R1.426 billion in 2015/16 to R1.531 billion in 2016/17. The business and not-for-profit sector both showed decreases in government-funded R&D. Funding from government to the business sector decreased by 13.0% from R522 million in 2015/16 to R454 million in 2016/17, while government funding for not-for-profit sector R&D decreased by 11.2% during the same period.

Table 3: Government-funded R&D, (R million), South Africa, 2012/13 to 2016/17

SECTOR	2012/13	2013/14	2014/15	2015/16	2016/17
Business	683 669	685 670	690 396	522 631	453 958
Not-for-profit	114 461	103 148	131 288	161 682	143 623
Government	1 269 337	1 436 141	1 711 809	1 425 598	1 530 964
Science councils	3 368 555	3 412 790	4 319 393	4 922 222	5 076 805
Higher education	5 395 871	5 369 334	6 020 572	7 393 857	9 222 246
Total (current Rand values)	10 831 893	11 007 083	12 873 458	14 425 990	16 427 596
Total (constant 2010 Rand values)	9 657 528	9 245 538	10 223 319	10 911 329	11 646 414

Data note GDP deflator values derived from the Stats SA (2015) were used to calculate constant 2010 Rand values for R&D expenditure.

Data sources Revised GDP (current values): Stats SA, GDP, First Quarter 2018, P0441 Series (Stats SA, 2018a).
National Survey of Research and Experimental Development, 2012/13 to 2016/17.

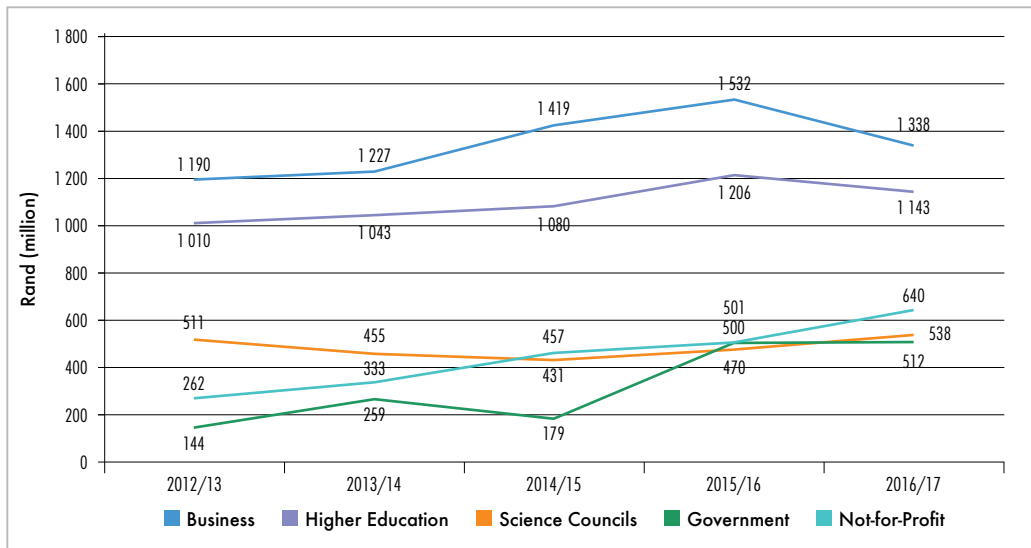




3.5 Foreign funding of local R&D

Fluctuations in R&D funding from abroad continued into the 2016/17 period, showing both increases and decreases across the sectors (Figure 7). Although the largest share of foreign funding was received by the business (32.1%) and higher education (27.4%) sectors, these were the only sectors that showed decreases in foreign funding for the 2016/17 period. Foreign-funded R&D in the business sector decreased from R1.532 billion in 2015/16 to R1.338 billion in 2016/17, while the higher education sector's receipts of foreign R&D funding decreased marginally from R1.206 billion to R1.143 billion during the same period. Not-for-profit organisations' share of funding increased by R139 million (27.7%) from R501 million in 2015/16 to R640 million in 2016/17, while foreign R&D funding to science councils increased by 14.5% from R470 million to R538 million during the same period. Foreign funding of R&D to the government sector increased slightly, from R500 million in 2015/16 to R512 million in 2016/17.

Figure 7: Foreign-funded R&D by sector of performance (R million), South Africa, 2012/13 to 2016/17



Data note Foreign sources include all funding from foreign sources from all sectors.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.

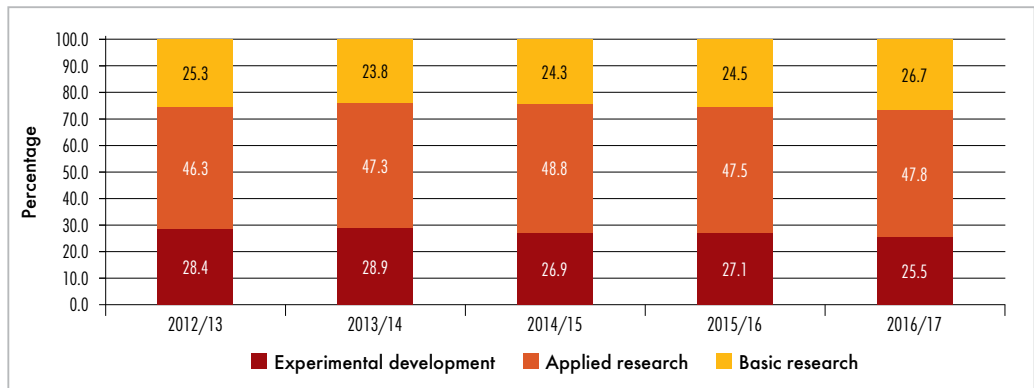


▶ 4. DISAGGREGATION OF R&D EXPENDITURE

4.1 GERD by type of research

The profile of the type of research conducted in South Africa did not change significantly in the 2016/17 reference period. Applied research (47.8%) continued to attract the largest proportion of R&D expenditure (Figure 8). This period saw an increase in the proportion of R&D expenditure devoted to basic research, the highest proportion recorded since the 2012/13 reference period. As a result, the proportional share of expenditure accounted for in the experimental development research category records a slight decrease, from 27.1% in 2015/16 to 25.5% in 2016/17.

Figure 8: GERD by type of research (percentage), South Africa, 2012/13 to 2016/17



Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.





4.2 GERD by type of research and institutional sector of performance

The general profile of R&D activity by sector did not change dramatically in the current reference period. The business sector presented a familiar profile, with the largest proportion of expenditure devoted to the applied sciences (56.8%), a marginal increase from the value recorded in the 2015/16 period. The 2016/17 R&D Survey recorded a minor decrease in the levels of basic research in the business sector — from 39.2% to 37.1% (Figure 9). Continued measurement should be carefully observed to assess ongoing trends in this regard.

Within the government sector, the largest change in the type of research performed was recorded in the experimental development category. In the 2015/16 reference period, government entities recorded a total of 13.1% of R&D devoted to this category of R&D, while the value in the 2016/17 survey increased to 14.5%.

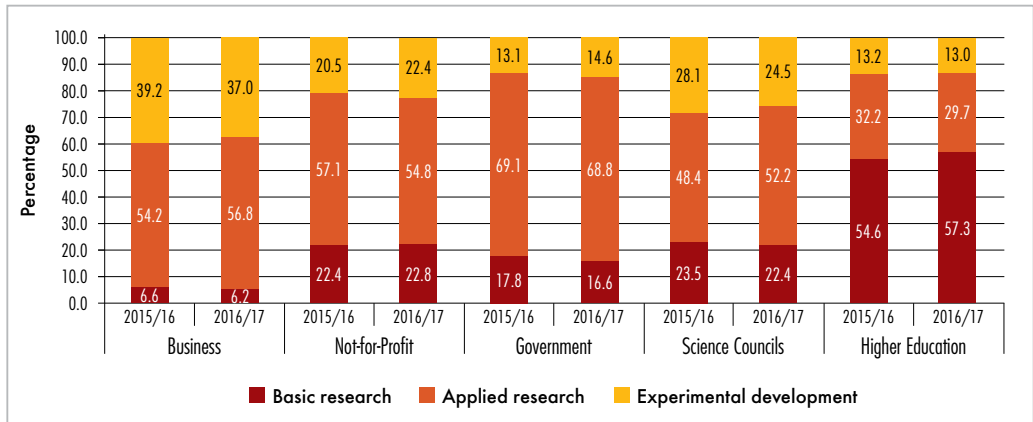
A similar pattern emerged among the science councils where basic research (-1.1%) and experimental development research (-2.1%) both showed proportional decreases year-on-year. Within the category of applied research, however, a proportional increase in expenditure was recorded across all sectors, from 48.4% in 2015/16 to 52.2% 2016/17.

The not-for-profit sector showed a decrease in applied research from 57.1% (2015/16) to 54.8% in the 2016/17 reference period. As a result of this, the proportional change within the basic research and experimental development research categories increased by 16.1 % and 24.6% respectively.

The profile of R&D investment within the higher education sector has been unique compared to that of the other four sectors. This sector continued to invest the largest share of R&D expenditure in basic research at 57.3%, a result that is consistent with its mandate to promote and develop new research areas. This value represents a proportional year-on-year increase of 2.7% in basic research. As a result of the proportional nature of this metric, the investment levels in applied research (29.7%) and experimental development (13.0%) decreased by 2.6% and 0.2% respectively, within the 2016/17 reference period. A growth in basic research provides an important foundation for ensuring South Africa is able to keep up with changing technologies and digitalisation.



Figure 9: GERD by type of research and sector of performance (percentage), South Africa, 2015/16 to 2016/17



Data source National Survey of Research and Experimental Development, 2015/16 to 2016/17.



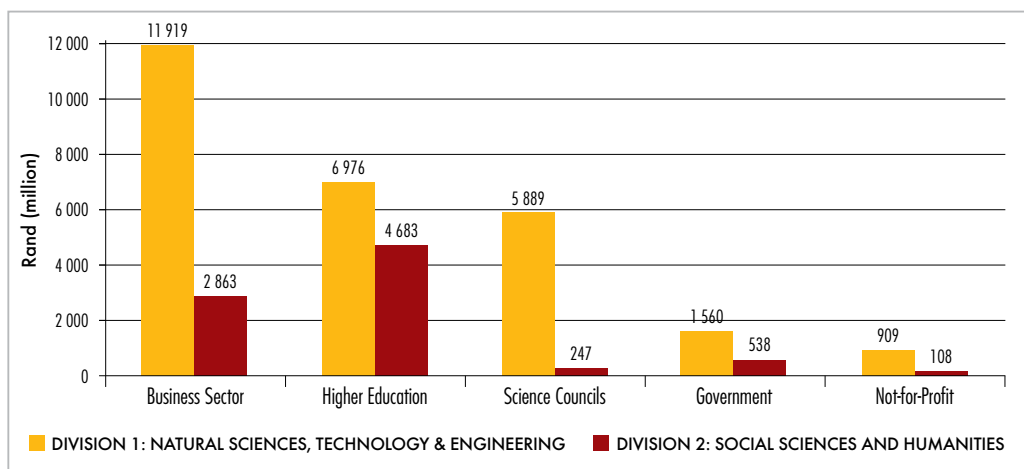


4.3 GERD by division of research field and institutional sector of performance

The South African R&D Survey classifies research fields into two major categories, namely Division 1, which includes natural sciences, and Division 2, which represents social sciences and humanities. Traditionally, the largest share of GERD has been reported within a summation of all natural sciences research fields. While this general trend remains in effect in the 2016/17 R&D Survey, the proportion of GERD devoted to natural sciences compared to the proportion devoted to social sciences and humanities has shifted. Within this reference period, natural sciences accounted for 76.4% of GERD, in comparison with a 79.1% share of GERD in the 2015/16 R&D Survey (Figure 10). The R&D expenditure in the social sciences and humanities increased from 20.9% of GERD in 2015/16 to 23.6% in 2016/17.

Natural sciences research fields remained the largest performers of R&D in 2016/17 across all five institutional sectors (Figure 10). The highest R&D expenditure in natural sciences was in the business sector at 80.6% of total BERD or R11.919 billion. Science councils spent 96.0% of their R&D expenditure on natural science, government spent 74.3%, while the NPO sector spent 89.4% of their total T&D expenditure in division 1. The higher education sector showed a closer balance between natural sciences (59.8%) and social sciences and humanities (40.2%) of total HERD.

Figure 10: R&D expenditure by research fields and sector, South Africa, 2016/17



Data note Research fields codes are used to classify research expenditure into two divisions according to the defined scientific discipline: Division 1 (Natural sciences) and Division 2 (Social sciences and humanities).

Data source National Survey of Research and Experimental Development, 2016/17.



4.4 GERD by major research field using the FORD classification

The 2015 Frascati Manual (OECD, 2015) classifies fields of research according to the Fields of R&D classification (FORD³) system. This refers to fields of research and development grouped in a more consistent manner, whilst still including the elements captured within the research field classifications. This section re-groups the research fields according to the FORD system. According to the FORD classification, the largest R&D investment by field of research was in the natural sciences (Figure 11). The natural sciences category includes: mathematics; computer and information sciences; physical sciences; chemical sciences; earth and related environmental sciences; biological sciences and other natural sciences. Measures for each individual category are listed in the 2016/17 R&D Survey *Statistical Report*.

Under the FORD classification, the social sciences recorded a total investment proportion of 21.0% (R7.496 billion) of GERD in the 2016/17 reference period. This represents a 2.3% year-on-year proportional increase. The social sciences became the second largest area of investment, after the natural sciences at R11.171 or 31.3% of GERD. Caution should be exercised when the social sciences values are interpreted, because over half of R&D expenditure in this broad domain is made up of economics (25.8%), accounting (15.8%), management studies (10.2%) and finance (4.0%). However, this does not imply that there is no R&D expenditure growth in the remaining social science fields.

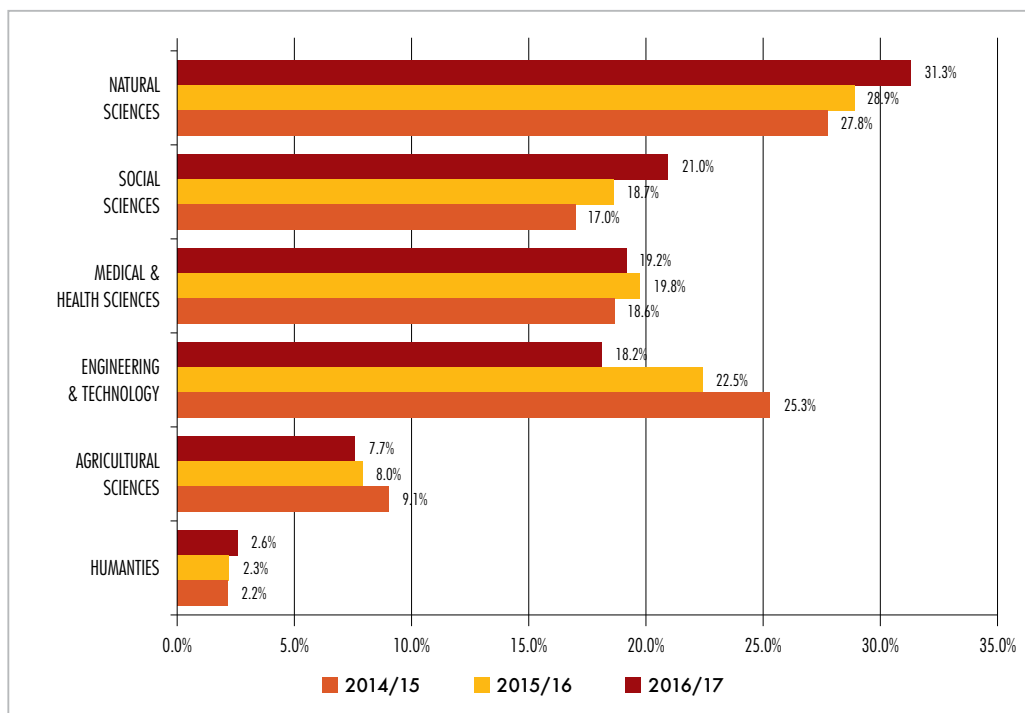
For the first time since the 2010/11 survey period, the medical and health sciences showed a slight decrease in R&D expenditure, from 19.8% in 2015/16 to 19.2% in the 2016/17 reference year. Similarly, the categories for engineering and technology, as well as agricultural sciences, both displayed year-on-year decreases in proportional R&D investment of 4.3% and 0.3% respectively. This is despite the relative economic growth recorded in these sectors during the financial year.

³ The FORD system is developed for R&D measurement purposes where subjects or research fields are grouped where the content of the R&D subject matter is closely related.





Figure 11: R&D expenditure by FORD groups (percentage), South Africa, 2014/15 to 2016/17



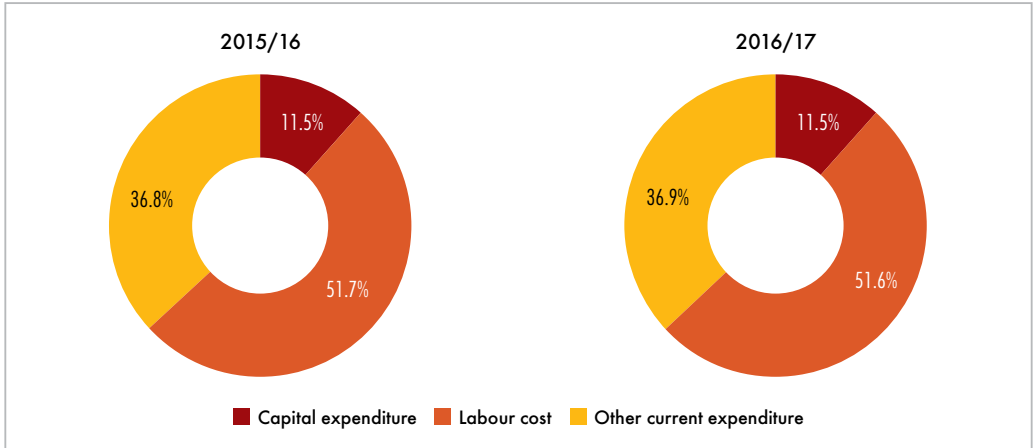
Data note GERD according to FORD groups derived from research field groupings.

Data source National Survey of Research and Experimental Development, 2014/15 to 2016/17.

4.5 R&D expenditure by accounting category

The largest share of R&D in 2016/17 was devoted to labour costs, which amounted to 51.6% of GERD. The proportions of total GERD spent on capital costs amounted to 11.5% of GERD, while other current expenditure costs equalled 36.9% of GERD. R&D expenditure related to other current expenditure has not shifted since the previous reference period (2015/16).

Figure 12: R&D expenditure by accounting category (percentage), South Africa, 2015/16 and 2016/17



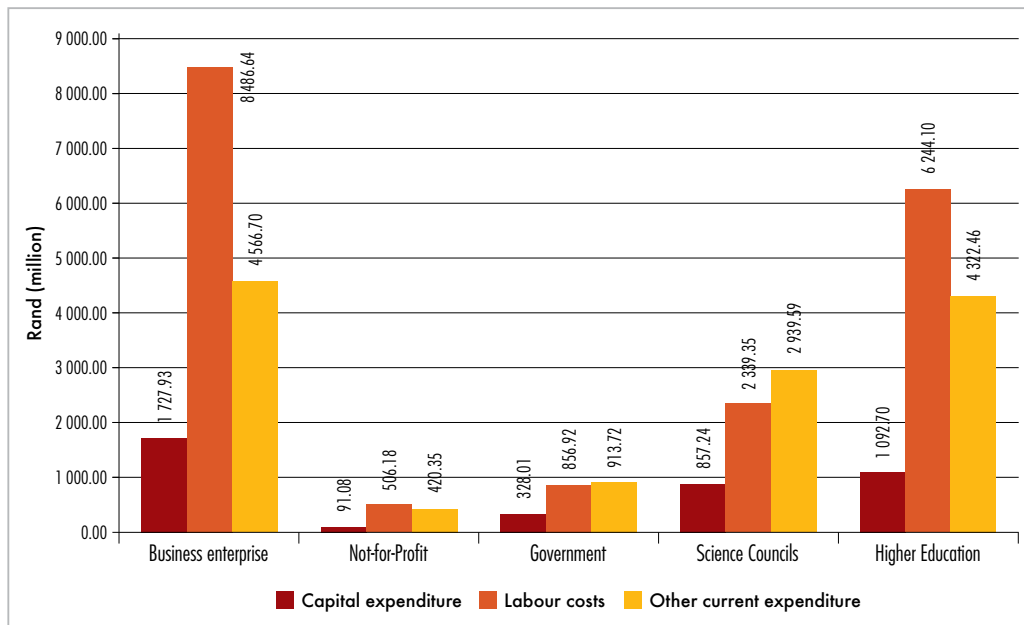
Definition	Other current expenditure comprises non-capital purchases of materials, supplies and equipment to support R&D performed by the statistical unit in a given year.
Data source	National Survey of Research and Experimental Development, 2015/16 and 2016/17.

The proportion allocated to labour costs was the highest accounting category across all sectors, except the science councils sector, where other current expenditure exceeded labour costs. Except for the years 2012/13 and 2013/14, other current expenditure has been consistently higher than labour costs in the science councils. This can be partly attributed to the nature of the R&D performed in the science councils sector.





Figure 13: R&D expenditure by accounting category (R million), South Africa, 2016/17



Data source National Survey of Research and Experimental Development, 2016/17.

4.6 Business sector R&D expenditure by Standard Industrial Classification

Standard Industrial Classifications (SIC) allow researchers to better understand the industrial clusters within which R&D is being conducted, as well as the source and destination of R&D investment. This is only recorded and reported on for the business sector.

The economic sector investing the largest proportion of BERD in 2016/17 was financial, intermediation, real estate and business services (80 000 code group) (Figure 14, Table 4). Within the reference period, this SIC code group accounted for R6.555 billion worth of R&D, which is 44.3% of BERD, and represented 10.9% increase on the value recorded in the 2015/16 R&D Survey. This was followed by the manufacturing sector (30 000 code group) (Figure 15, Table 5), accounting for 27.8% of BERD, compared to 32.2% in the previous reference period. The decrease 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 the R&D expenditure in the manufacturing sector could well prove to be of consequence for policy makers in future determinations of the impact of the fourth industrial revolution in the manufacturing sector.

Investment in the SIC code group for transport, storage and communication (70 000 code group) contributed to a greater proportion of BERD in 2016/17, compared with previous survey results. This sector saw an increase of 4.6% compared to the value recorded in 2015/16. Mining and quarrying (20 000 code group) was the next SIC code where largest investments in R&D were made in the private sector, accounting for 7.2% of BERD, which is 1.09% lower than the value recorded in 2015/16.





Figure 14: Business R&D expenditure by SIC category (as a percentage of GERD), South Africa, 2015/16 and 2016/17

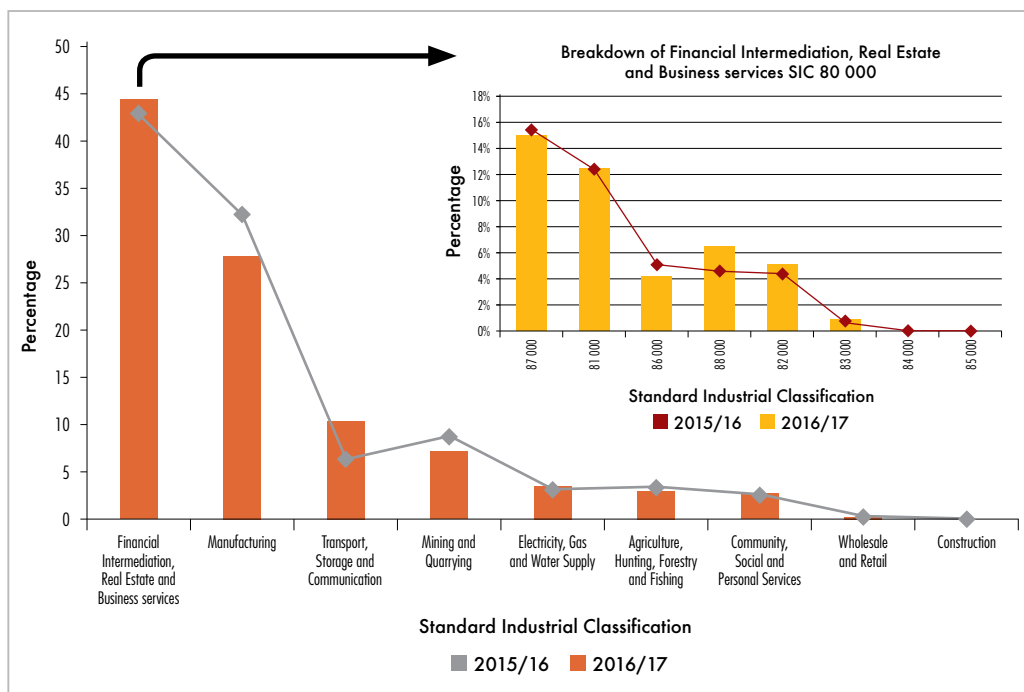


Table 4: Standard Industrial Classification (SIC) categories in the 80000 group

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 Standard Industrial Classification (SIC) codes, which are used to classify businesses according to economic activities.

Data source National Survey of Research and Experimental Development, 2015/16 and 2016/17.

Figure 15: Business R&D expenditure by SIC manufacturing category, South Africa, 2015/16 and 2016/17

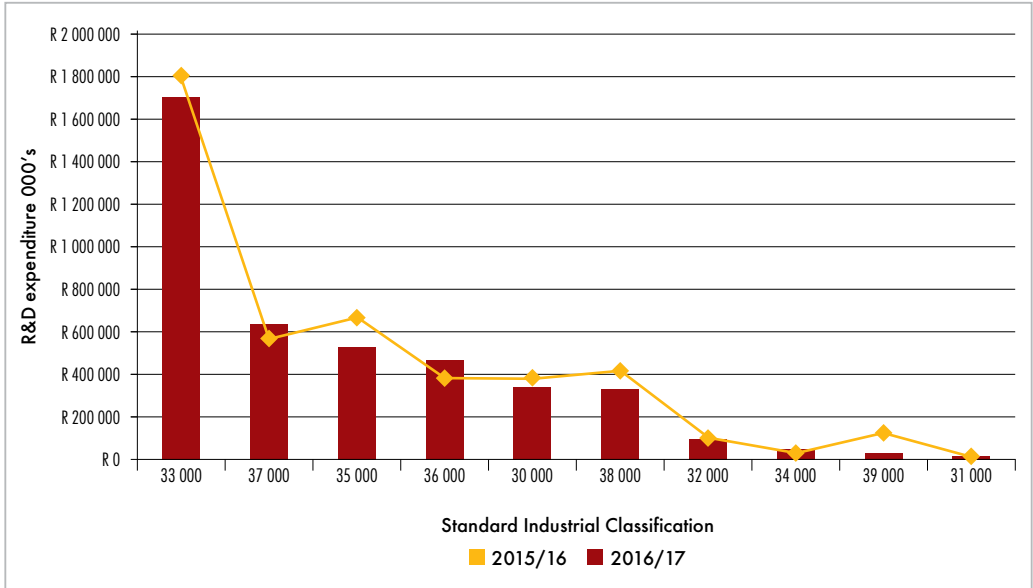


Table 5: Standard Industrial Classification (SIC) codes in the 30000 group

30000	Manufacture of Food Products, Beverages and Tobacco Products
31000	Manufacture of Textiles, Clothing and Leather Goods
32000	Manufacture of Wood Products, except furniture, Paper Products, Publishing & Printing material
33000	Manufacture of Refined Petroleum, Nuclear Fuel, Chemical Products (incl. Pharmaceuticals, Rubber and Plastic)
34000	Manufacture of Non-Metallic Mineral Products
35000	Manufacture of Basic & Fabricated Metal Products, Machinery & Equipment, Office, Accounting and Computing
36000	Manufacture of Electrical Machinery and Apparatus
37000	Manufacture of Communication Equipment & Apparatus, Medical, Precision and Optical Instruments
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 Standard Industrial Classification (SIC) codes, which are used to classify businesses according to their economic activities.

Data source National Survey of Research and Experimental Development, 2015/16 and 2016/17.



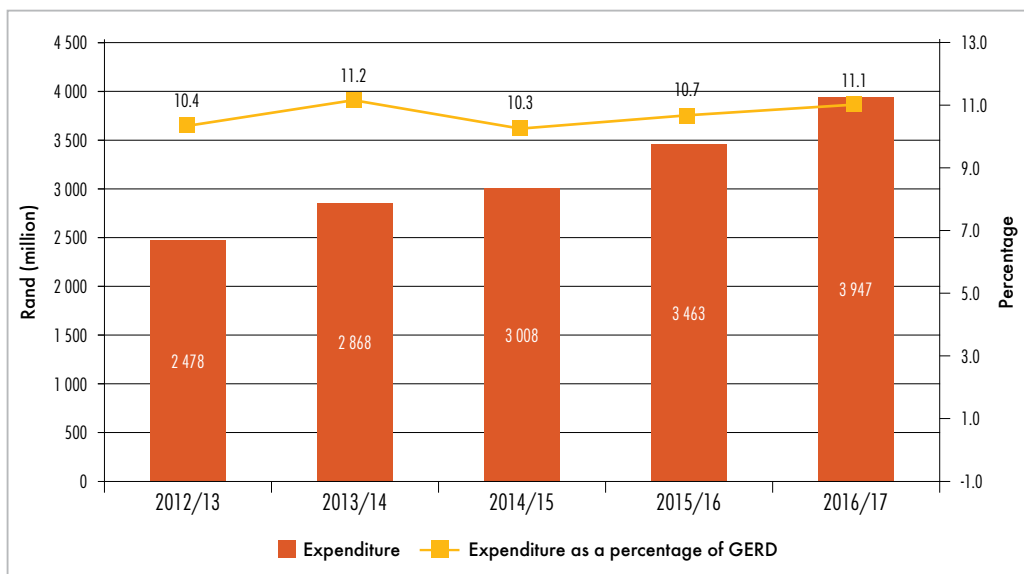


4.7 R&D related to tuberculosis, HIV/AIDS, malaria and biotechnology

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

Despite a nominal decrease in the overall national investment in health-related R&D in South Africa, health and medical research remain critical areas for the country. R&D investment in priority areas of health research, including TB, HIV/AIDS and malaria, amounted to R3.947 billion in the 2016/17 reference period (Figure 16). This represents an increase in the level of investment, compared with the value recorded in the 2015/16 reference period. 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 shown in Figure 16.

Figure 16: R&D expenditure on TB, HIV/AIDS and malaria (R million and as a percentage of GERD), South Africa, 2012/13 to 2016/17



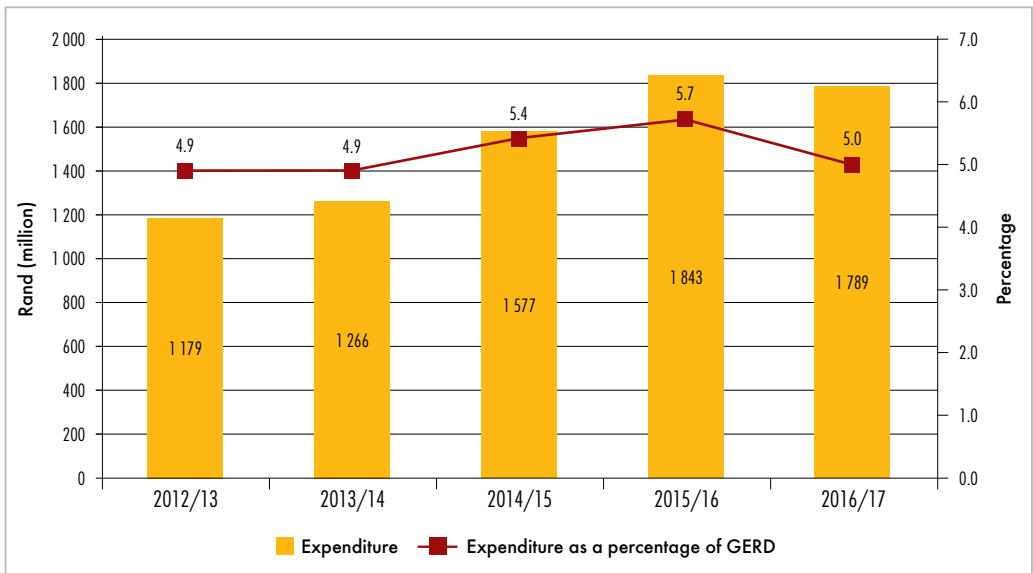
Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



4.7.2 Biotechnology-related R&D

The multidisciplinary area of biotechnology has been of interest to multiple sectoral stakeholders, particularly government, business and higher education. Biotechnology has application in several areas, including health care (pharmaceuticals), crop production, biodegradable plastics, biofuels, mining, as well as various environmental uses. In the 2016/17 R&D Survey, R1.789 billion was invested in biotechnology research, about 3% lower than the value reported in the 2015/16 reference period (Figure 17). Since 2012/13, the value of R&D investment in biotechnology areas increased, and reached the highest value of R1.843 billion in the 2015/16 survey period (Figure 17).

Figure 17: R&D expenditure on biotechnology (R million and as a percentage of GERD), South Africa, 2012/13 to 2016/17



Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.





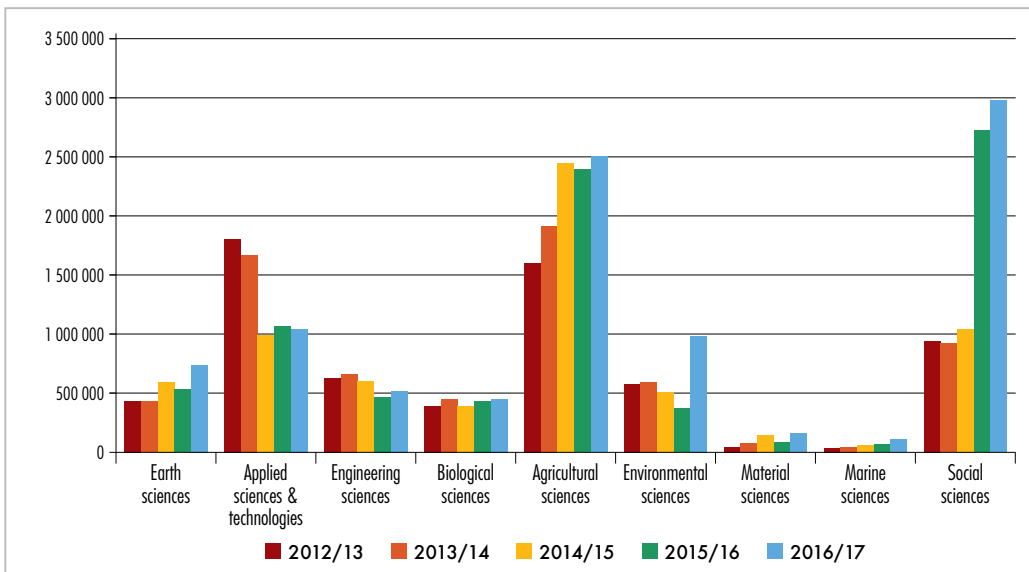
4.8 Green R&D

4.8.1 R&D investment in green R&D by research field

Green R&D includes research and experimental development in areas focused on sustainability of natural resources, environmental impact, animal and plant science, energy research, economic impact, sustainable development, mobility and engineering sciences. For the analysis of R&D Survey 2016/17 results, this is a new concept. The total investment in green R&D, when examined by expenditure within research fields, amounted to R9.572 billion in 2016/17 (Figure 18). This made up 26.80% of total GERD and reflected an increase from R8.230 (25.5%) that was recorded in 2015/16. Green R&D expenditure shown by research field indicates that investments were high in the social sciences, at R2.981 billion, which was 31.1% of total green R&D in 2016/17. This was an increase from R2.731 billion performed in 2015/16. The second largest research field was the agricultural sciences, which accounted for R2.511 billion or 26.2% of total green R&D in 2016/17. In 2015/16, R&D expenditure in the agricultural sector amounted to R2.404 billion or 25.1% of total green R&D. Trend data shows that the R&D expenditure in agricultural sciences has been on the increase over the past five years.

Another research field that surpassed the billion-Rand mark is that of applied sciences and technologies, which recorded R1.055 billion spent on green R&D in 2016/17. This was a slight decrease from the R1.071 billion spent in this field of research on green R&D in 2015/16.

Figure 18: R&D investments in green R&D by research fields, South Africa, 2012/13 to 2016/17



Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



4.8.2 Green R&D by socio-economic objectives

Table 6 calculates total green R&D expenditure by socio-economic objective (SEO), where SEO refers to the objectives or aims of a particular R&D activity (for example, environment, agriculture, energy, etc.) as given in the R&D Survey. The combination of these codes into a single 'green R&D' composite reflects that R8.323 billion or 23.3% of GERD was dedicated to green R&D in 2016/17. This reflects an increase from R7.034 billion spent in 2015/16, which was 22.0% of GERD.

The largest amount of R&D expenditure is reflected in the agricultural sector SEO that is aimed at improving plant production and plant primary products. The R&D expenditure in this code totalled R1.475 billion and contributed 17.7% of total expenditure in green R&D. This was an increase from the R1.365 billion recorded in the previous year. The second largest R&D expenditure value was recorded in the SEO of supporting the social sciences, which amounted to R995 million in 2016/17 (12.9% of green R&D) and R889 million (12.9% of green R&D) in 2015/16. The following SEO codes were also classified as contributing to green R&D in 2016/17: natural resources (11.8%), environmental knowledge (11.3%) and natural sciences, technologies and engineering (10.8%).

Table 6: Green R&D expenditure by socio-economic objective, 2012/13 to 2016/17

SOCIO-ECONOMIC OBJECTIVE	2012/13	2013/14	2014/15	2015/16	2016/17
	R'000	R'000	R'000	R'000	R'000
Plant production and plant primary products	1 216 870	1 398 343	1 310 422	1 365 420	1 475 847
Animal production and animal primary products	598 602	803 403	652 398	606 878	666 677
Energy resources	65 504	44 276	60 644	57 616	54 877
Energy supply	425 047	489 423	636 200	491 853	589 811
Commercial services	92 653	70 754	79 377	71 511	66 166
Economic framework	240 859	208 019	262 790	561 954	655 201
Natural resources	867 338	910 880	835 023	898 982	978 439
Environmental knowledge	410 154	383 529	803 407	820 785	943 702
Environmental aspects of development	229 377	224 579	260 568	270 543	323 098
Environmental and other aspects	252 236	246 612	290 650	310 770	675 052
Natural sciences, technologies and engineering	931 413	915 246	684 858	688 016	899 526
Social sciences and humanities	773 565	755 336	727 405	889 433	994 808
Total	6 103 618	6 450 400	6 603 741	7 033 762	8 323 204

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.





4.9 Geographic dimensions of R&D

4.9.1 R&D expenditure by province

R&D expenditure continues to be concentrated within the Gauteng (46.0%), Western Cape (23.3%) and KwaZulu-Natal (10.2%) provinces of South Africa. In the 2016/17 reference period, in monetary terms the Western Cape increased from R7.125 billion in 2015/16 to R8.331 billion in 2016/17, representing an increase of more than R1.2 billion. The growth in R&D expenditure in the Western Cape resulted in a decline in the proportion of R&D expenditure recorded for the Gauteng province. The Northern Cape recorded the largest decline in GERD, at 0.6%, followed by the Eastern Cape and the Free State, each declining by 0.4% year-on-year.

Table 7: R&D expenditure by province (R million and percentage), South Africa, 2015/16 and 2016/17

PROVINCE	2015/16		2016/17	
	R'000	%	R'000	%
GERD	32 336 679	100.0	35 692 973	100.0
EASTERN CAPE	2 142 919	6.6	2 206 473	6.2
FREE STATE	1 778 469	5.5	1 834 572	5.1
GAUTENG	14 666 111	45.4	16 421 582	46.0
KWAZULU-NATAL	3 335 141	10.3	3 639 100	10.2
LIMPOPO	627 125	1.9	728 874	2.0
MPUMALANGA	791 248	2.4	699 720	2.0
NORTHERN CAPE	660 963	2.0	532 530	1.5
NORTH-WEST	1 209 434	3.7	1 298 778	3.6
WESTERN CAPE	7 125 269	22.0	8 331 345	23.3

Data source National Survey of Research and Experimental Development, 2015/16 and 2016/17.

The disaggregation of R&D expenditure by sector of performance and province reveals the strengths of R&D performance by sector (Figure 19). Business sector R&D expenditure was the highest in Gauteng in 2016/17 at R7.876 billion in 2016/17. Higher education R&D expenditure was over half of the business expenditure in Gauteng at R4.105 billion, while science councils were not far off, recording R&D expenditure of R3.221 billion.

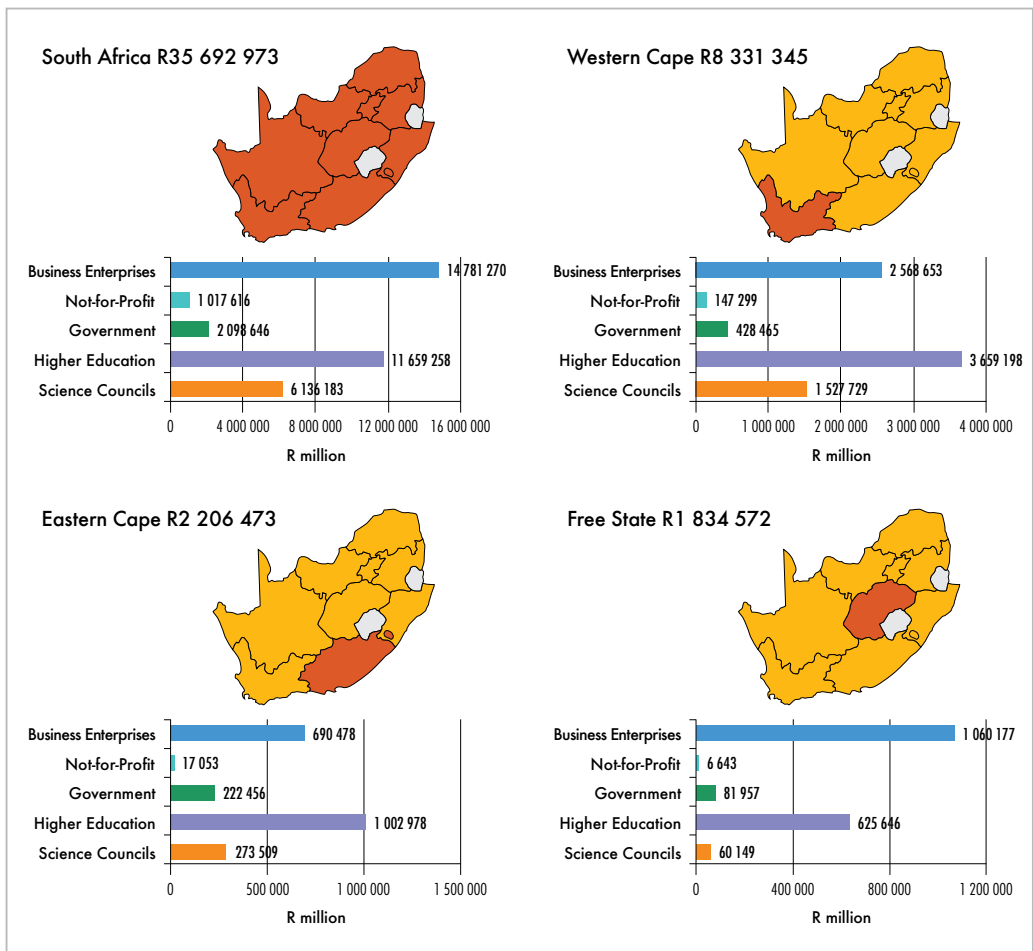
In the Western Cape, the business sector spent R2.567 billion on R&D while the higher education sector in that province recorded R3.659 billion in R&D expenditure. Business R&D expenditure in KwaZulu-Natal amounted to R1.553 billion in 2016/17, an increase from R1.437 billion recorded in 2015/16. Comparatively, business sector R&D in Gauteng is three times that of the Western Cape and five times of the KwaZulu-Natal province.



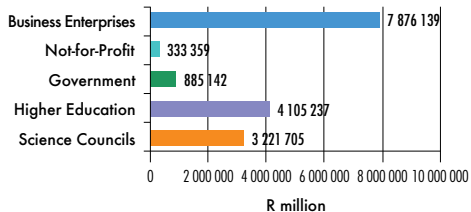
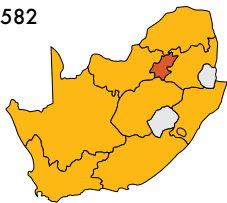
Notably, higher education expenditure on R&D in the Western Cape significantly exceeded business R&D expenditure. In Gauteng, the opposite was true: business R&D expenditure far exceed that of higher education.

Other observations include the role of NPOs in KwaZulu-Natal and North West provinces, where the R&D expenditure of these institutions exceeded government expenditure in both 2015/16 and 2016/17. In KwaZulu-Natal, R&D expenditure in the government sector was R187 million and NPO R&D expenditure was R273 million in 2015/16. Similarly, R&D expenditure for government was R172 million in 2016/17 and NPO R&D expenditure was R278 million. The same trends were observed for the North West province where, in 2015/16 and 2016/17, the R&D expenditure in the NPO sector was higher than the R&D expenditure in the government sector.

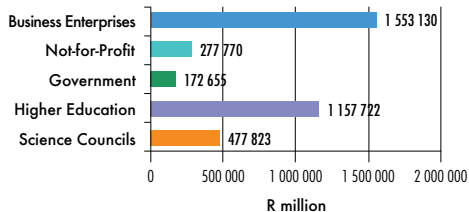
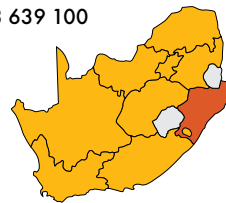
Figure 19: R&D expenditure by province and sector of performance (R million), South Africa



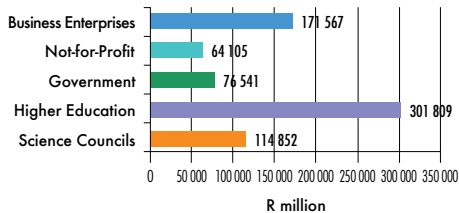
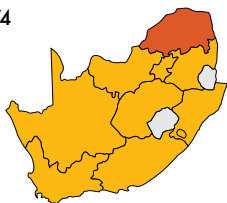
Gauteng R16 421 582



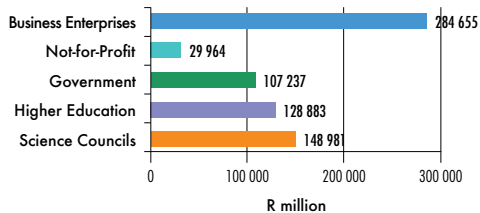
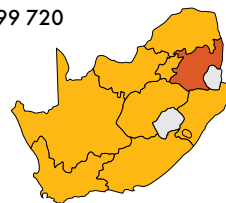
KwaZulu-Natal R3 639 100



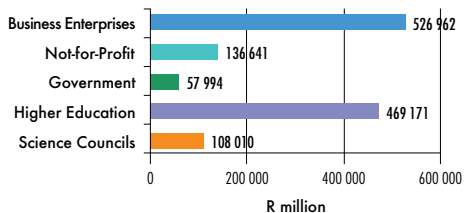
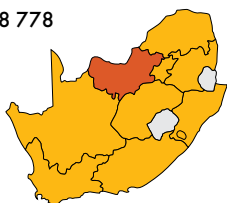
Limpopo R 728 874



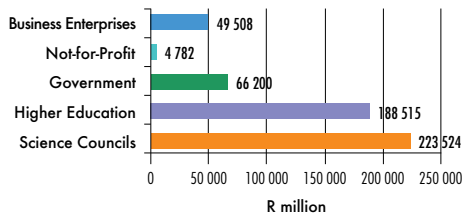
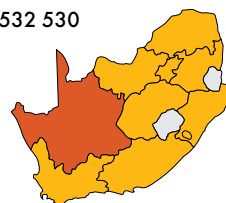
Mpumalanga R 699 720



North West R1 298 778



Northern Cape R 532 530



Data source National Survey of Research and Experimental Development R&D, 2016/17.

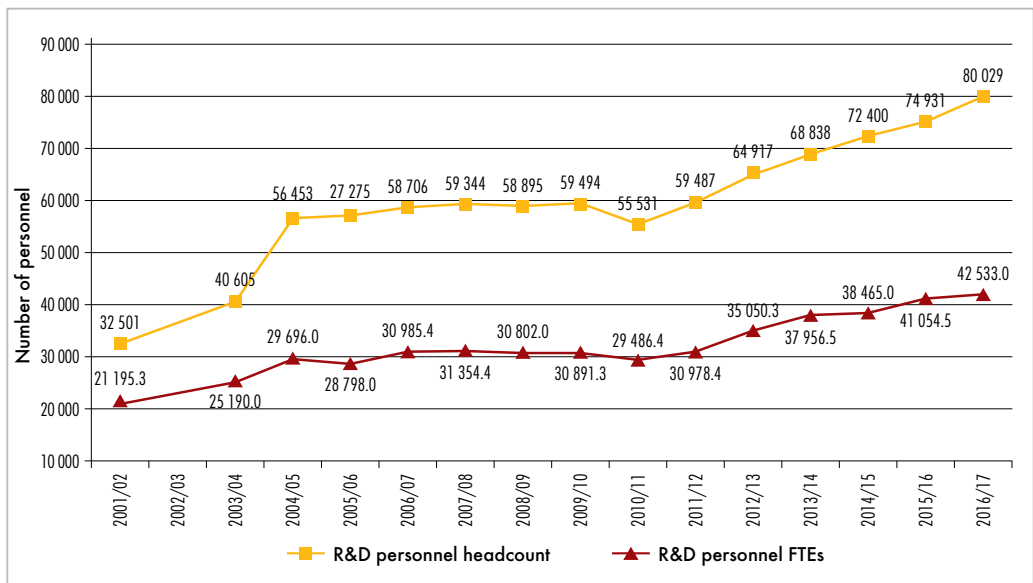


► 5. PEOPLE IN R&D

5.1 R&D personnel

There is a notable upward trend in South Africa's R&D personnel, reflected in both headcount and full-time equivalent (FTE) results for 2016/17. Trends of gradual growth were noted between 2005/06 and 2010/11; and more robust year-on-year growth was recorded between 2010/11 and 2016/17. The R&D personnel headcount increased from 74 931 in 2015/16 to 80 029 in 2016/17, reflecting a 6.8% growth (Figure 20). This is an improvement on the 3.5% growth reported between the previous two periods. The growth in the headcount⁴ is mostly attributed to an increased number of researchers, in particular, growth in postgraduate student numbers in the higher education sector. The 2016/17 R&D Survey introduced new aspects⁵ to the collection of R&D personnel data, which also contributed to the increase in headcount and FTEs observed. The changes in methodology should be considered when making inferences about the human resources devoted to R&D within the country.


Figure 20: R&D personnel (headcount and FTEs), South Africa, 2001/02 to 2016/17



⁴ The increased number of personnel is due to a change in methodology as well as actual increases. The major increase was from master's students (see section on the higher education personnel).

⁵ Specific categories of R&D personnel relevant to higher education only were included in the 2016/17 R&D Survey. These are emeritus professors, research fellows, honorary research associates or equivalent. Master's students were split into those doing a full research master's as well as those doing coursework plus thesis with a research component.





Data note	Following OECD practice, doctoral students and post-doctoral fellows are counted as researchers. Non-South African personnel are classified as those that are not from South Africa but undertaking research in South Africa 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. Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
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Data source	National Survey of Research and Experimental Development, 2001/02 to 2016/17.
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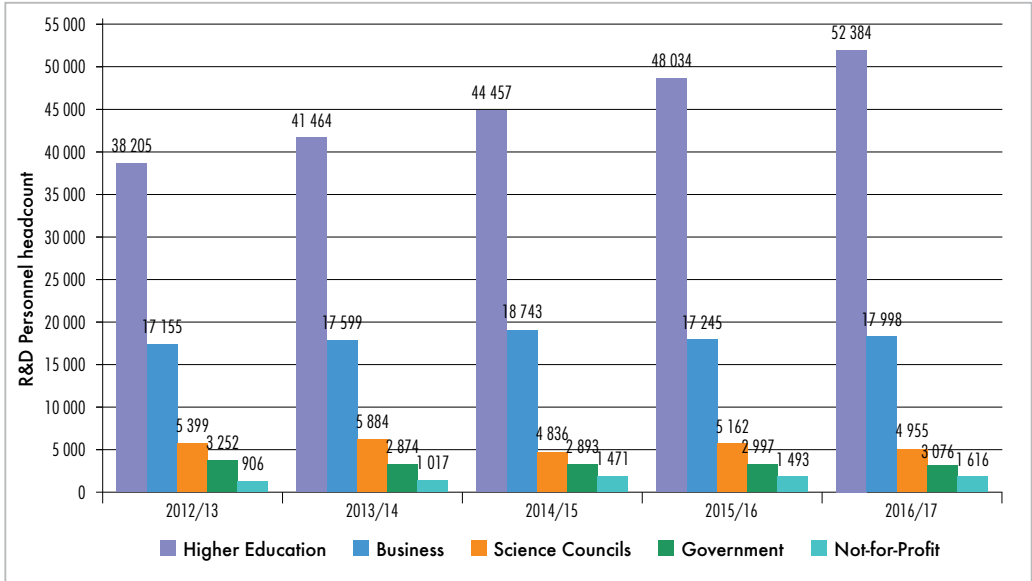
5.1.1 R&D personnel headcount by sector of performance

An increase in researchers, particularly at the level of postgraduate students within the higher education sector, contributed significantly towards the growth of the total R&D personnel. The largest proportion of R&D personnel remains located in the higher education and business sectors, with 52 384 and 17 998 headcounts recorded respectively in 2016/17 (Figure 21). The higher education sector reflected the greatest growth, where total R&D personnel increased from 48 034 in 2015/16 to 52 384 in 2016/17.

Minor headcount increases were noted in the business, not-for-profit, and government sectors, showing relatively small year-on-year growth between 2015/16 and 2016/17. In the 2016/17 R&D Survey, the science councils sector reflected a decrease in headcount from 5 162 in 2015/16 to 4 955 in 2016/17. The decline was observed in the 'other personnel supporting R&D' and may be linked to the conclusion of contracts for short-term staff.

To note, an additional category measuring non-South African R&D personnel was introduced to all the sectors in 2016/17. In addition, the higher education sector also introduced more specific categories of R&D personnel, including professors emeritus and research fellows, with subsequent adjustments to previous values that may have been undercounted.

Figure 21: R&D personnel by sector (headcount), South Africa, 2012/13 to 2016/17



Data note Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.

5.1.2 R&D personnel FTEs by sector of performance

The total R&D personnel FTEs increased by 3.6% between 2015/16 and 2016/17. This represents a smaller increase than the previous years, where a 6.7% increase was noted between 2014/15 and 2015/16 (Figure 22).

The indicator measuring R&D personnel FTEs per thousand in total employment remained static over the five-year period, reaching 2.4 in 2012/13, 2.5 in 2013/14 and 2014/15, and remained at 2.6 in the years 2015/16 and 2016/17.

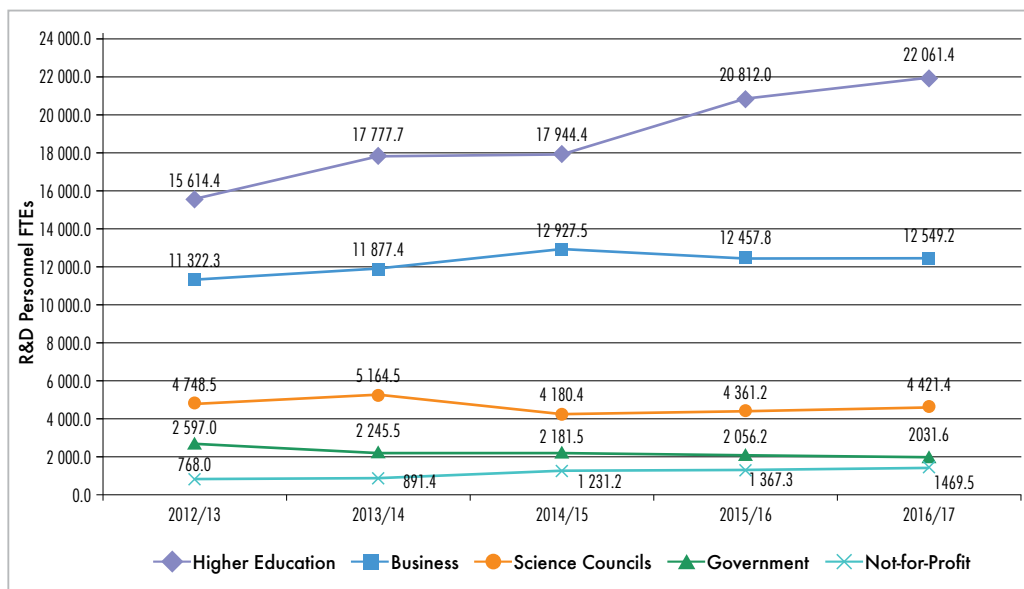
Minimal changes in overall R&D personnel FTEs were noted between 2015/16 and 2016/17. The government sector displayed a slight decrease, while business, science councils and not-for-profit sectors all indicated minimal increases in their FTEs in 2016/17. The highest FTEs and greatest year-on-year changes were noted in the higher education sector, where a 6.0% growth, from 20 812.0 FTEs in 2015/16 to 22 061.4 FTEs in 2016/17, was recorded.





The continued growth of the headcount and FTEs in R&D personnel is reassuring for the capacity of the national system of innovation. However, survey data reveals that just over half of R&D personnel time was actually spent on R&D activities. This is evident in the figures obtained in 2015/16 and 2016/17, where 54.8% and 53.1% of time was spent on research respectively (calculated as FTEs as a % of headcounts).

Figure 22: R&D personnel by sector (FTEs), South Africa, 2012/13 to 2016/17



Data note Following OECD practice, doctoral students and post-doctoral fellows are counted as researchers. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.

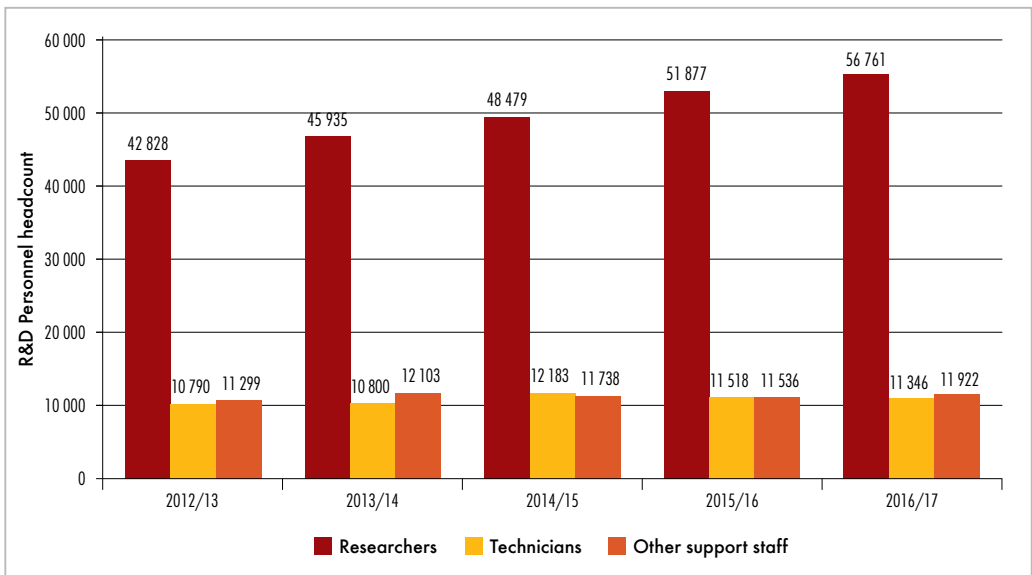


5.1.3 R&D personnel by occupation

The 2016/17 R&D Survey revealed that the personnel contingent was made up of 70.9% researchers, 14.2% technicians and 14.9% other R&D support staff (Figure 23).

The proportional increase in researchers was accounted for by a 9.4% increase in the researcher headcount from 51 877 to 56 761 between 2015/16 and 2016/17. The technician headcount continued to decline, from 11 518 in 2015/16 to 11 346 in 2016/17. The headcount of other support staff showed an increase to 11 922 in 2016/17, after year-on-year decreases in the previous two survey cycles.

Figure 23: R&D personnel by occupation (headcount), South Africa, 2012/13 to 2016/17



Data note Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.

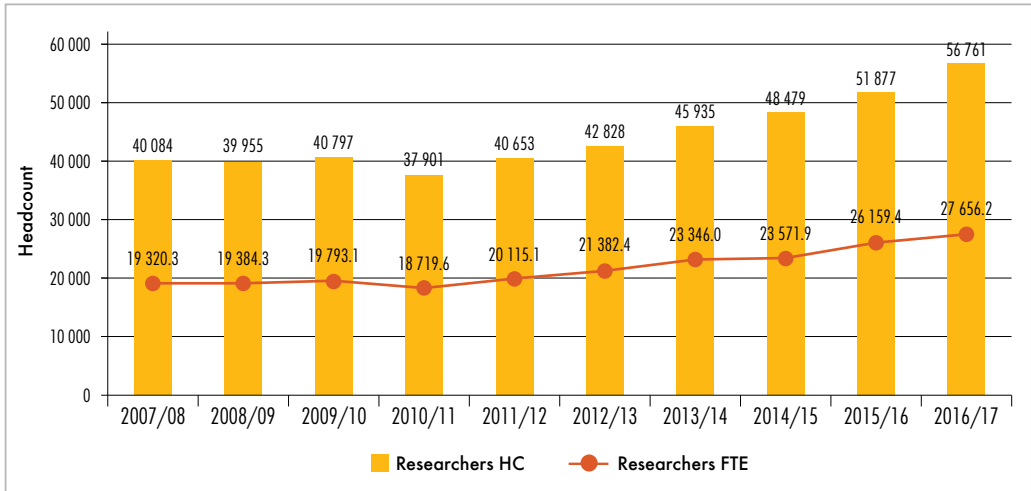




5.2 Researchers

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 2016/17 showed steady growth in the researcher headcount and FTEs, after relatively slow growth attained between 2007/08 and 2010/11 (Figure 24). The total researcher headcount reached 56 761 in 2016/17, with 27 656.2 FTEs for the same period.

Figure 24: Researchers (headcount & FTE), South Africa, 2007/08 to 2016/17



Data note Following OECD practice, doctoral students and post-doctoral fellows are counted as researchers. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

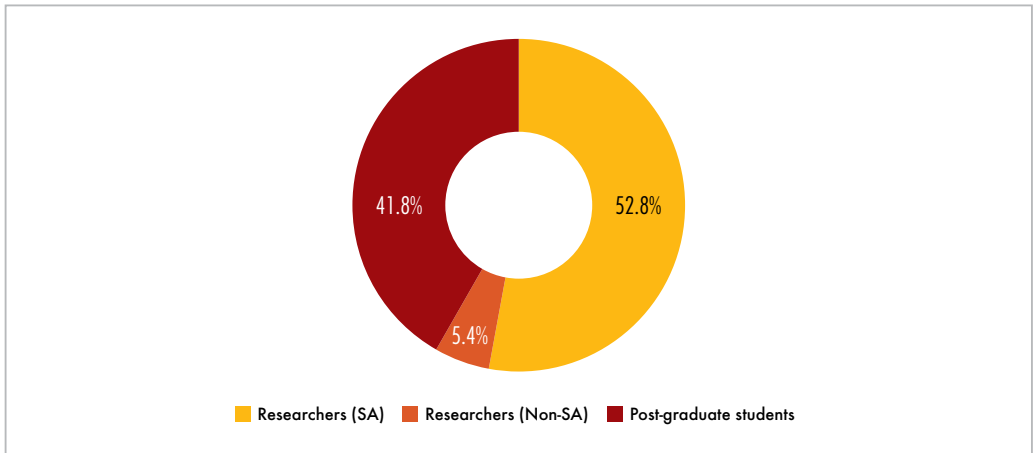
Data source National Survey of Research and Experimental Development, 2007/08 to 2016/17.



5.2.1 Distribution of researchers by headcount and nationality

The 2016/17 R&D Survey for the first time disaggregated R&D personnel in terms of South African and foreign nationals. The researcher category includes researchers of South African origin, non-South African researchers and postgraduate students (post-doctoral fellows and doctoral students). South African researchers comprised 52.8% of the total researchers, with a smaller representation of non-South African researchers at 5.4%. Postgraduate students made up 41.8% of the research personnel in the R&D Survey for the 2016/17 financial year. Detailed analyses of postgraduate students by nationality are included in the higher education R&D personnel section of this report.

Figure 25: Distribution of researchers (headcount, %), South Africa, 2016/17



Data note Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2016/17.



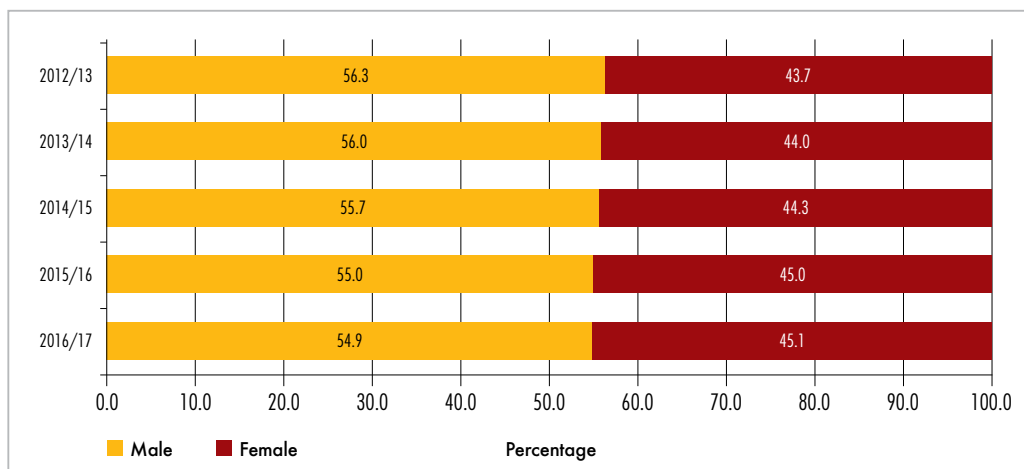


5.2.2 Researcher headcount by gender

In 2016/17, women researchers accounted for 45.1% of all researchers. There has been a very slow but steady growth of female researchers in the last five years, from 43.7% in 2012/13 to 45.1% in 2016/17 (Figure 26).

Of the total researchers, approximately 27.0% are females holding a PhD plus students enrolled for a PhD.

Figure 26: Researchers by gender (percentage), South Africa, 2012/13 to 2016/17



Data note Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.

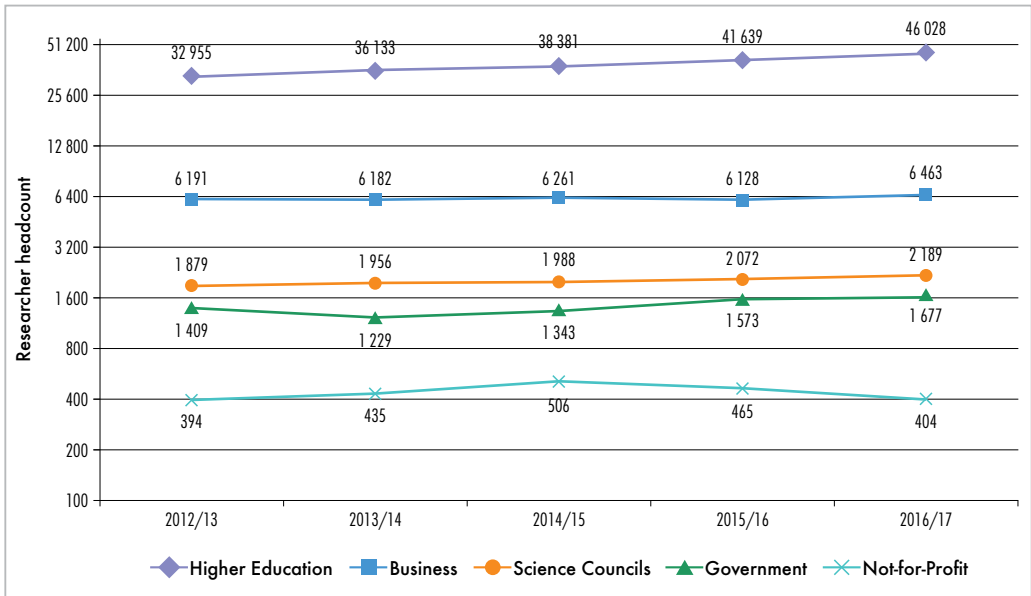
5.2.3 Researcher headcount by sector of performance

Higher education remained the sector with the greatest concentration of researchers. The number of researchers in 2016/17 increased to 46 028, a 10.5% increase from the 41 639 recorded in 2015/16 (Figure 27).

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 in 2016/17, accompanied by increases in the number of technicians and other supporting personnel. The changes in the sector have been influenced by a combination of factors, including internal restructuring resulting in the reduction in the number of researchers. Accompanied by these changes, there has also been improved reporting from respondents on technicians and other personnel directly supporting R&D.

The minimal change in the headcount of researchers persisted in the business, science councils and government sectors, with percentage increases of 5.5%, 5.6% and 6.6% respectively between 2015/16 and 2016/17.

Figure 27: Researchers by sector (headcount), South Africa, 2012/13 to 2016/17



Data note Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.





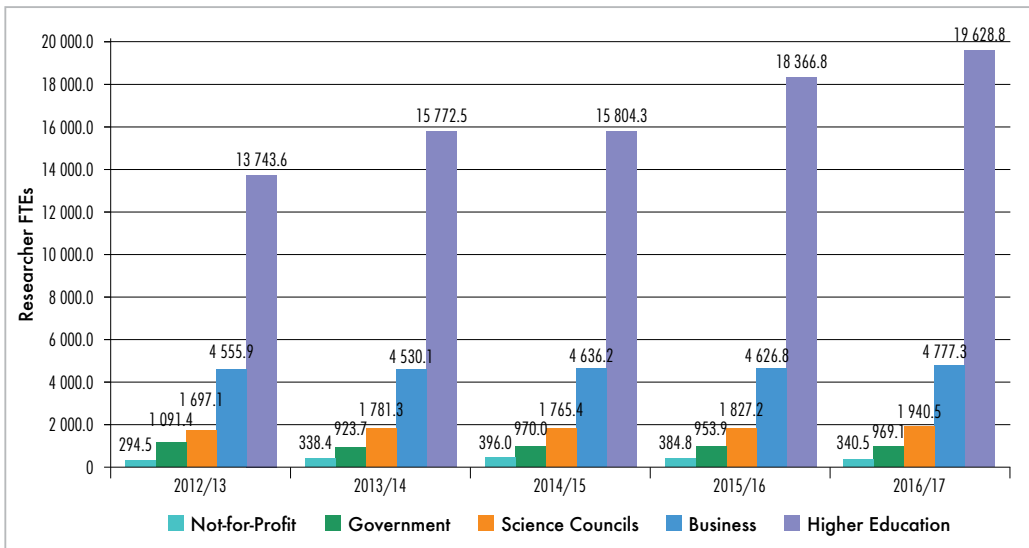
5.2.4 Researcher full-time equivalent (FTEs) by sector of performance

The upward trend of researcher FTEs in the higher education sector continued in 2016/17, increasing by 6.9% from 18 366.8 in 2015/16 to 19 628.8 in 2016/17 (Figure 28). These increases are associated with expanded postgraduate student numbers. The FTEs of researchers in the business, science councils and government sectors remained fairly constant, with minor changes between 2012/13 and 2016/17.

Science council researcher FTEs increased from 1 827.2 (2015/16) to 1 940.5 (2016/17). A much smaller year-on-year increase in government sector researcher headcounts was noted in 2016/17, with a similar small increase of 1.6% researcher FTEs between 2015/16 to 2016/17.

In the business sector, the researcher headcount and FTEs did not change between 2012/13 and 2016/17. For the same period, the not-for-profit sector reflected minimal fluctuations in their researcher headcounts and FTEs. This could be indicative of the economic pressures these sectors were exposed to.

Figure 28: Researchers by sector (FTEs), South Africa, 2012/13 to 2016/17



Data note Higher education researchers include post-doctoral fellows and doctoral students under the 'researcher' category. Full-time equivalent (FTE) refers to the number of hours (in terms of person years of effort) spent on R&D activities. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

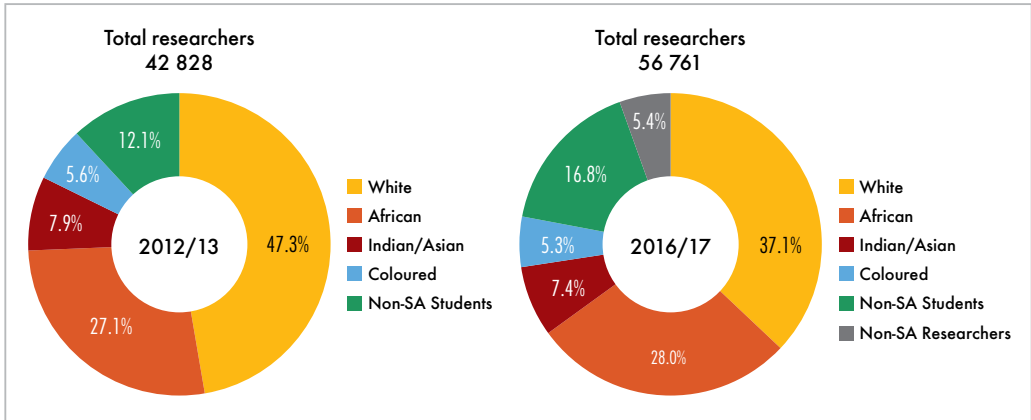
Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



5.2.5 Researchers by population group

Just over one third of researchers are drawn from the White population group, 37.1% in 2016/17, compared to the 47.3% recorded in 2012/13 (Figure 29). The collective representation of other population groups (African, Coloured and Indian/Asian) constituted 40.7% in 2016/17, which shows a nominal increase from 40.6% in 2012/13. 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 5.4% of the R&D researchers, which may previously have been recorded under other population groupings. A total of 22.2% of the researchers actively involved in South African R&D are non-South Africans (including foreign students).

Figure 29: Researchers by population group (percentage), South Africa, 2012/13 and 2016/17



Data notes	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. Non-SA 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 the SNA. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.
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, 2012/13 and 2016/17.

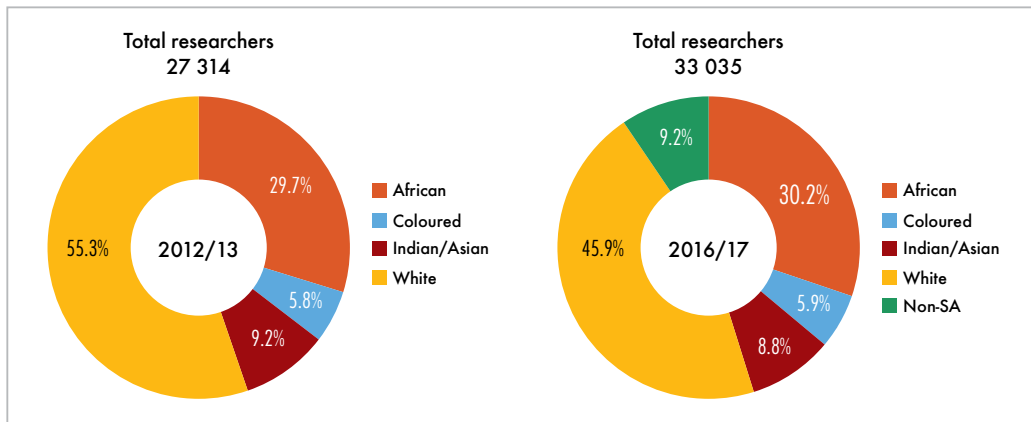


5.2.6 Researchers (excluding doctoral students and post-doctoral fellows) by population group

Calculating the number of R&D researchers, excluding doctoral and post-doctoral fellows, more accurately reflects the R&D-active workforce (Figure 30). The five-year trend shows a marked increase in total researchers, as well as a year-on-year growth of 12.2% from 29 454 in 2015/16 to 33 035 in 2016/17. This constitutes a greater rate of growth, compared to the 9.4% growth of researchers including postgraduate students for the same period.

The decrease in the proportion of White researchers from 55.3% in 2012/13 to 45.9% in 2016/17 is an indication of demographic transformation of the R&D workforce. Transformation among the previously disadvantaged population groups is evident; 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 has increased, from 29.7% in 2012/13 to 30.2% in 2016/17. Coloured and Indian/Asian researchers remained almost unchanged, increasing from 5.8% to 5.9% and declining from 9.2% to 8.8% respectively. The inclusion of a non-South African researcher category accounts for 9.2% of the researchers for 2016/17. As above, this methodological change may account for the relative change in some of the other population groupings, when comparing demographics between 2012/13 to 2016/17.

Figure 30: Researchers (excluding doctoral students and post-doctoral fellows) by population group (percentage), South Africa, 2012/13 and 2016/17



Data note For this section only the higher education researchers do not include post-doctoral fellows and doctoral students under the 'researcher' category. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

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, 2012/13 and 2016/17.

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

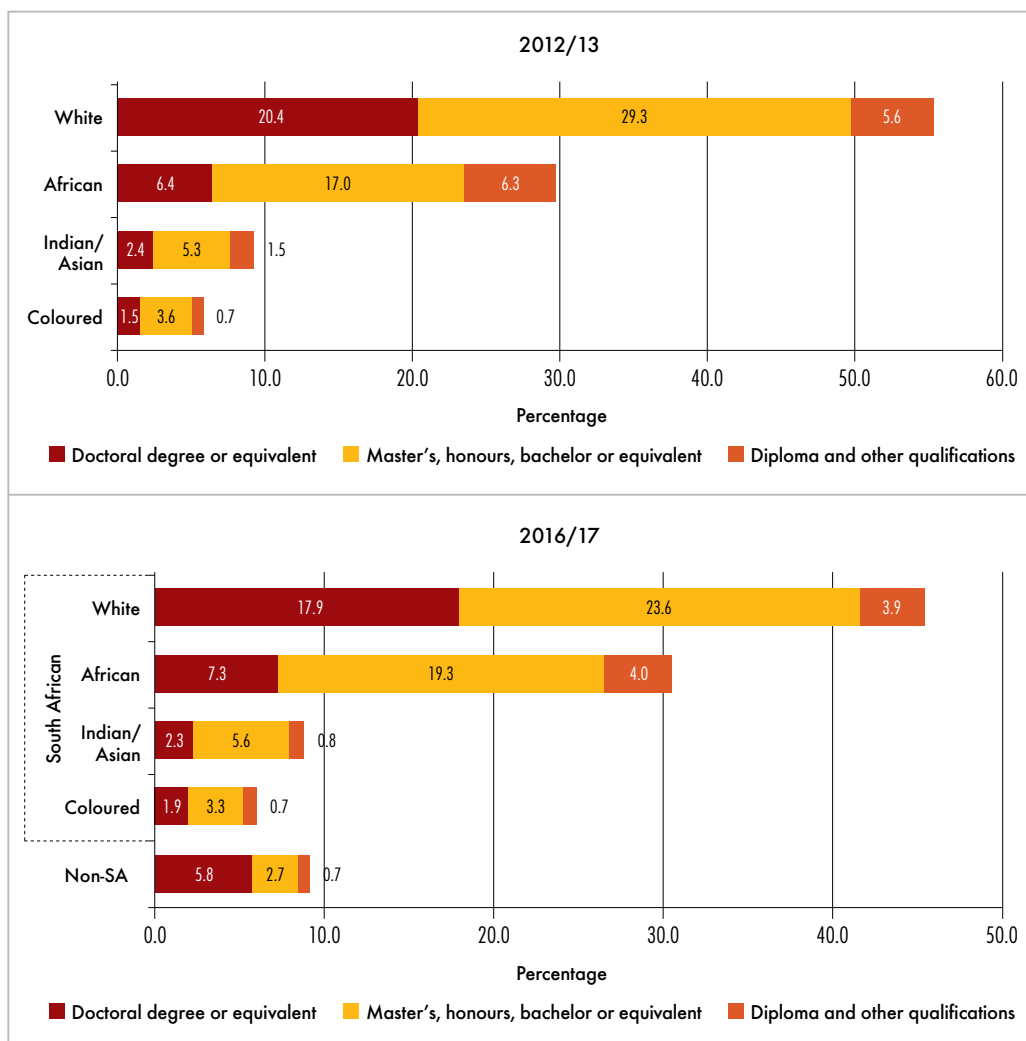
There appears to be a longitudinal trend of an increase in the proportion of African researchers with doctoral degrees, which has increased from 6.4% in 2012/13 to 7.3% in 2016/17 (Figure 31). The greatest proportion of doctoral degree qualifications, 17.9%, remains clustered in the White population group in 2016/17. The general trend remains that the greatest proportion of research personnel, 54.6%, hold a Master's, Honours, Bachelors or equivalent degree qualification, which is a slight proportional decline from the 55.2% in 2012/13. The smallest proportion of researcher personnel held diplomas or other qualifications, at 10.2% in 2016/17, down from 14.1% in 2012/13.

A total of 35.3% of the researchers held doctoral degrees or equivalent in 2016/17, which showed an increase from 30.8% in 2012/13. It is evident that non-South African doctoral holders have contributed to the increase of the total number of researchers with PhDs.





Figure 31: Researchers (excluding doctoral students and post-doctoral fellows) by qualification and population group (percentage), South Africa, 2012/13 and 2016/17



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 and White.

Data source National Survey of Research and Experimental Development, 2012/13 and 2016/17.



5.3 Higher education personnel

5.3.1 Higher education personnel FTEs as percentage of headcount

The 2016/17 R&D Survey data reflected increases in the headcount and FTEs results in both the R&D personnel and researcher categories. Higher education researchers (excluding post-doctoral fellows and postgraduate students) increased from 19 217 in 2015/16 to 22 302 in 2016/17. Larger margins of increase of researchers in the higher education sector were evident in the 2016/17 survey, in comparison with the rate of growth observed in postgraduate student numbers. This increase could be ascribed to the addition of the non-South African researchers explicitly measured for the first time in this survey period.

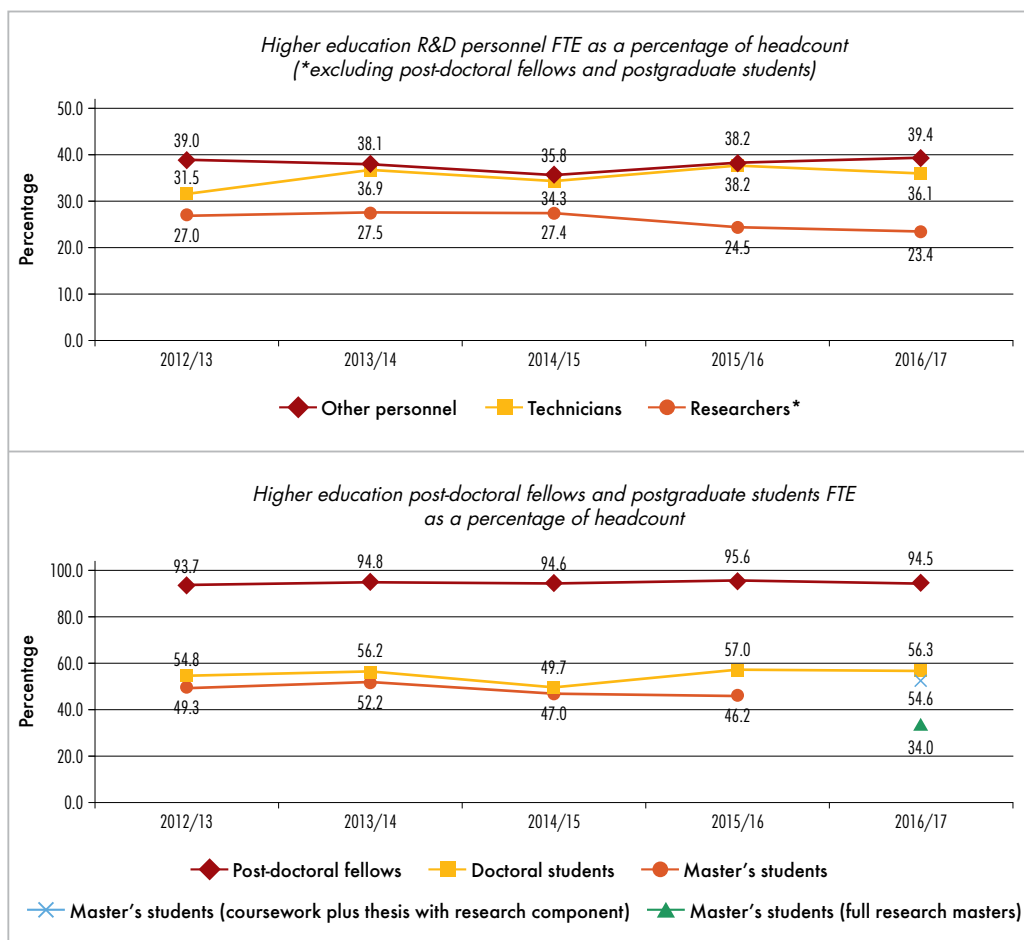
The observed decline in the time spent by researchers (excluding post-doctoral fellows and postgraduate students) from 27.4% in 2014/15 to 24.5% in 2015/16, further decreased to 23.4% in 2016/17 (Figure 32). While the researcher headcounts observed in the same reference period increased, the relative time spent on R&D activities has decreased.

Post-doctoral fellows continue to spend the majority of their time on R&D activities, at 94.5% in 2016/17, remaining relatively stable across the previous five survey cycles. Doctoral students continue to spend just over half of their time on R&D activities, with 56.8% FTE as a percentage of headcount recorded in 2016/17. For the first time in 2016/17, the R&D Survey differentiated between full research master's students, and master's degrees with a coursework and a thesis component. The master's-by-thesis-only students spent 54.6% of their time on R&D activities, while master's-by-coursework-and-thesis students spent 34.0% of their time on R&D activities.





Figure 32: Higher education R&D personnel and students (FTEs as a percentage of headcount), South Africa, 2012/13 to 2016/17



Data note	Researchers include emeritus professors, research fellows, honorary research associates or equivalent.
Data source	National Survey of Research and Experimental Development, 2012/13 to 2016/17.



5.3.2 Post-doctoral fellow and postgraduate student headcount and FTEs

The overall number of post-doctoral fellows and postgraduate students (doctoral and Master's students) engaged in R&D grew from 61 025 in 2015/16 to 78 931 in 2016/17, an increase of 29.3% (Figure 33).

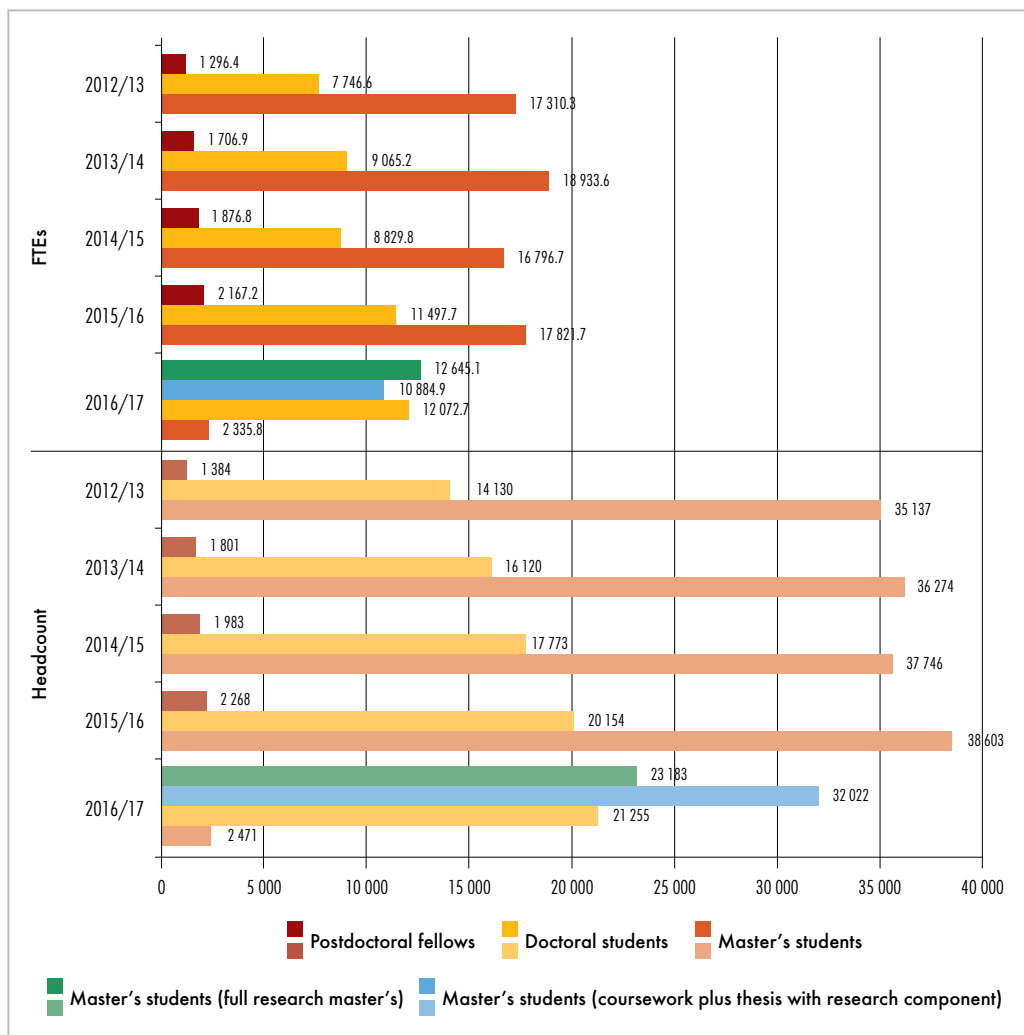
Post-doctoral fellows and doctoral student numbers combined grew by 5.8% between 2015/16 and 2016/17. The headcount of doctoral students increased by 50.4% from 14 130 in 2012/13 and reached 21 255 in 2016/17. An increase of 9.0% in post-doctoral fellows was recorded reflecting an improvement from 2 268 in 2015/16 to 2 471 in 2016/17.

As noted above, the 2016/17 R&D Survey disaggregated master's students by the structure of degrees in terms of dissertation and coursework components. As a result, a marked increase in the total number of master's students is reported. It is recommended that caution be applied when reviewing the increase in the master's student totals, as a large proportion of students doing "course work plus thesis" was included; yet on average these students spend approximately a third of their time performing R&D activities.





Figure 33: Higher education post-doctoral fellows and postgraduate students (headcount and FTEs), South Africa, 2012/13 to 2016/17



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 will be implemented in future R&D surveys. Researchers include emeritus professors, research fellows, honorary research associates or equivalent.

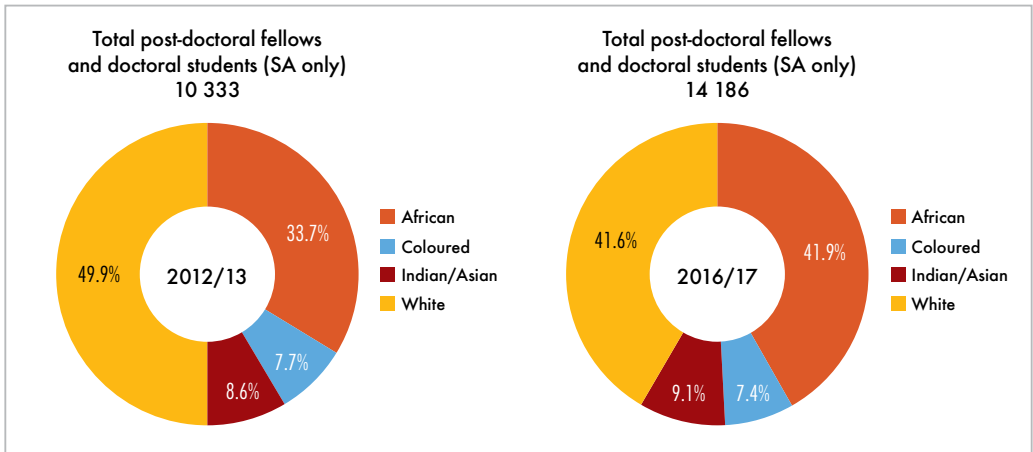
Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



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: the proportion of White post-doctoral fellows and doctoral students decreased from 49.9% in 2012/13 to 41.6% in 2016/17 and the African population representation increased from 33.7% to 41.9% over the same period (Figure 34). The Indian/Asian population showed an increase from 8.6% in 2012/13 to 9.15% in 2016/17, and the Coloured population group showed a slight decrease from 7.7% to 7.4% for the same period. The trend data shows improvement in the transformation within the population groups; however, these numbers are still far from being representative of the national population demographics.

Figure 34: Higher education post-doctoral fellows and doctoral students by population group (percentage), South Africa, 2012/13 and 2016/17



Data note	Non-SA 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 the SNA.
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, 2012/13 and 2016/17.

5.3.4 Profile of South African and non-South African postgraduate students

Analyses of postgraduate students by nationality revealed that 23 726 post-doctoral fellows and doctoral students (headcounts) were enrolled at the higher education institutions represented in the 2016/17 R&D Survey, of which 59.8% are South African nationals, and the remaining 40.2%





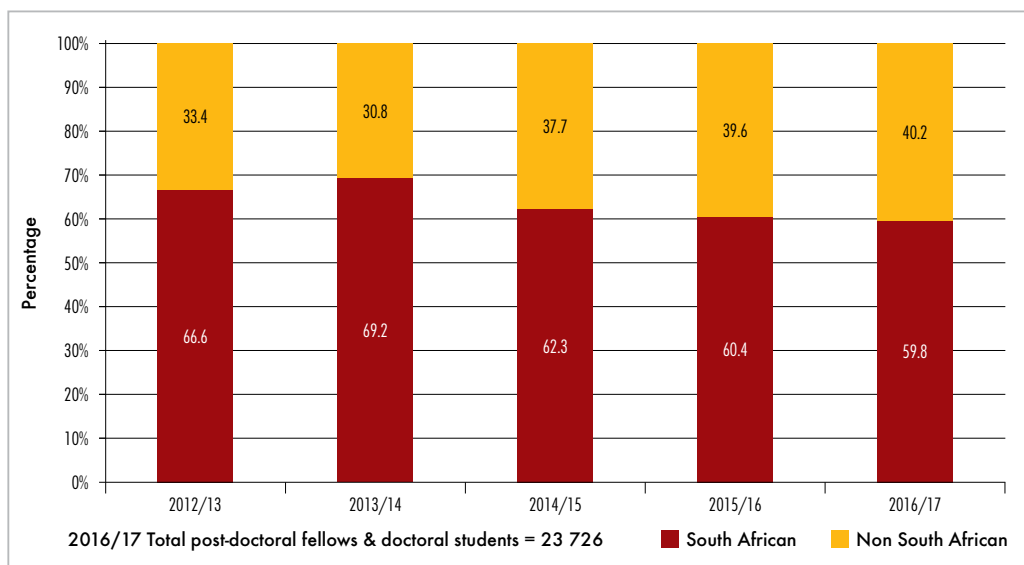
were non-South African (Figure 35). This shows a minor increase from the 39.6% non-South African nationals for this group in 2015/16.

The proportion of South African to non-South African nationals observed among doctoral students for 2016/17 reflected values of 62.2% and 37.8% respectively. An inverted trend was observed for post-doctoral fellows, with 38.7% being South African nationals to 61.3% non-South African nationals in 2016/17 (Figure 36).

The majority of master’s students were South African nationals in 2016/17, broken down as 83.0% of the master’s-by-thesis-only students and 80.9% of the master’s-by-coursework-and-thesis (Table 8).

The observed increases in headcounts at the level of post-doctoral fellows, doctoral students and master’s students have continued from 2014/15 to 2016/17. The number of non-South African researchers at each of these levels continued to increase between 2014/15 and 2016/17.

Figure 35: Higher education post-doctoral fellows and doctoral students by nationality (headcount), South Africa, 2012/13 to 2016/17

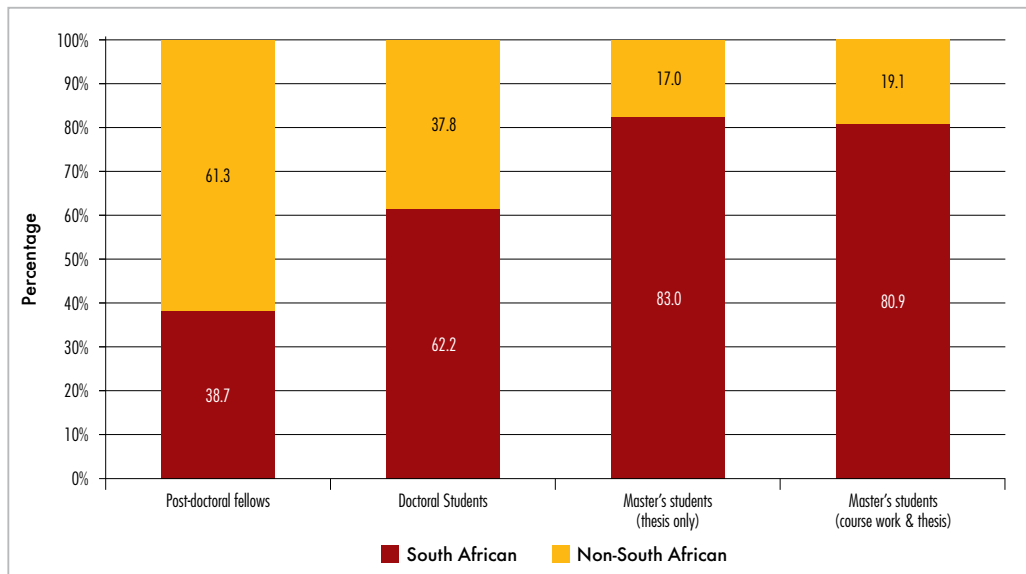


Data note The 2016/17 R&D Survey distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master’s students. Non-SA personnel are classified as those that are not from South Africa but are undertaking research in South Africa for a period exceeding six months. They can be temporary or permanent residents as described by the SNA.

Data source National Survey of Research and Experimental Development, 2012/13 to 2016/17.



Figure 36: Higher education postgraduates by qualification (headcount), South Africa, 2016/17



Data note The 2016/17 survey distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master's students. Non-SA 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 the SNA.

Data source National Survey of Research and Experimental Development, 2016/17.





Table 8: Higher education postgraduates by qualification and nationality (headcount), South Africa, 2012/13 to 2016/17

QUALIFICATION	HEADCOUNT		
	SOUTH AFRICAN	NON-SOUTH AFRICAN	TOTAL
2012/13			
Post-doctoral fellows	511	873	1 384
Doctoral students	9 822	4 308	14 130
Master's students	29 364	5 773	35 137
Total	39 697	10 954	50 651
2013/14			
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 (thesis only)	19 236	3 947	23 183
Master's students (course work & thesis)	25 906	6 116	32 022
Total	59 328	19 603	78 931

Data note The 2012/13 to 2016/17 surveys captured postgraduate students according to race and gender, and distinguished between South African and non-South African nationals for post-doctoral fellows, doctoral and master's students.

Data source National Survey of Research and Experimental Development, 2016/17.

▶ 6. INTERNATIONAL COMPARISONS

6.1 Gross domestic expenditure on R&D

The aim of this section is to interrogate South Africa's R&D performance in relation to its international counterparts. The comparison acknowledges the differences in economic status of countries and sectors within the selected countries, as well as the limited availability of the latest data. Country selection encompassed: a combination of the few African countries that had datasets for the survey period or latest available data that can still be reasonably used for comparisons; Brazil, China, the Russian Federation, India and South Africa (BRICS) countries; and a group of countries selected from the developed nationals of the OECD. This selection will assist in identifying the strengths and weaknesses of the South African R&D landscape.

6.1.1 GERD for selected countries

Table 9 illustrates GERD of several countries (2014-2016) at constant values and in purchasing power parity (PPP). It shows that R&D is concentrated in very few countries and mostly in the developed ones. The OECD group has a mixture of developed and developing countries, with the developing countries mostly emanating from Latin America. Within the OECD countries, the USA, Japan and Germany reported GERD exceeding \$100 000 million. Of the three countries, R&D expenditure for the USA and Germany show slight increases over the period 2014-2016, while Japan's GERD is dropping. This is also illustrated by the modest growth rates of less than 3% (Table 9a). Countries with GERD between \$15 000 million and \$60 000 million include Spain, Turkey, Italy, Portugal and France, all classified as developed countries. Among these, Turkey showed the highest growth rate in its investment on R&D at 10.6%, but off a lower base. South Africa's GERD ranked among the lowest when compared with the developed economies. It matches that of Argentina, which, like South Africa, has observer status in the OECD. Both have GERD higher than that of Chile, the only country in Latin America considered to be developed, although it still has characteristics of a developing country.

It may be more appropriate to benchmark South Africa's performance against the BRICs group of countries (Table 9b). These have highly varied GERD values, with China leading the pack at \$410 188 in 2016, with a high growth rate of 9.4%. In fact, China's R&D expenditure exceeds all other countries included in Table 9, except for the USA. In the absence of recent data for Brazil and India, Russia appeared to have the second highest GERD of \$37 170. However, data for 2015 shows that India was the second largest R&D performer among the BRICS countries, followed by Russia and Brazil. South Africa's R&D expenditure is clearly very low compared to all four BRICS counterparts.

Data for African countries is still scarce. South Africa's GERD is second to Egypt in terms of R&D performance, although its growth rate is higher than that of Egypt. In contrast, South Africa's GERD far exceeds that of Tunisia, where investment in R&D decreased in 2016, reflecting negative growth of -3.5%. (Table 9c) The lack of data for African countries makes it difficult to make more concrete comparisons to reflect how South Africa fares on the continent, and particularly in Sub-Saharan Africa.





Table 9: GERD for selected countries (million current PPP\$), 2014/15 to 2016/17 or the latest available year

a. OECD							COMPOSITE GROWTH RATE
COUNTRY		2014		2015		2016	2016
Argentina	b	4 690		5 030	p	4253	-15.40
Chile		1 377		1 430	bp	1 379	3.84
Finland	b	6 572		6 014		5824	-3.15
France	e	55 220		55 591	ep	55 780	0.34
Germany		98 330		101 578		104 076	2.46
Italy	p	28 826		27 035	p	226 148	-3.28
Japan	ep	158 296		154 552		149 495	-3.27
Mexico	e	10 355	ep	10 568	ep	10 094	-4.49
Poland		8 420		9 335		9 246	-0.95
Portugal		3 508		3 436	p	3 557	3.50
Spain		18 049		17 980		17 608	0.38
Turkey		17 330		15 673	d	14 426	10.57
United States of America	dp	464 324	dp	456 903		443 140	1.62

b. BRICS				◆ COMP-OSITE GROWTH RATE
COUNTRY	2014	2015	2016	2016
Brazil	35 606	34 302	*	-3.8
Russia	37 401	37 222	37 170	-0.41
India	*	41 826	*	*
China	344 691	374 910	410 188	9.41
South Africa	4 639	4 860	4 311	3.50

c. AFRICA				◆ COMP-OSITE GROWTH RATE
COUNTRY	2014	2015	2016	2016
Egypt	5 141	6 057	6 232	2.88
Tunisia	699	679	655	-3.5
Madagascar	5	*	4	*
South Africa	4 630	4 860	4 311	3.5

*Data not available.

◆: The composite growth rates were calculated on R&D data based on national currencies at constant prices.

Data sources South Africa: South Africa: National Survey of Research and Experimental Development, 2016/17.
 Argentina, Chile, China, Finland, France, Germany, Italy, Japan, Mexico, Poland, Russian Federation, Spain, Turkey, USA: OECD, 2018
 Brazil, Egypt, India, Mali, Madagascar, Mozambique, Peru, Tunisia, Seychelles: UNESCO UIS 2018

b = break in services
 d = definition differs

e = estimated value
 p = provisional value



6.1.2 GERD as a percentage of GDP

South Africa spent 0.82% of its GDP on R&D during the 2016/17 financial cycle. South Africa ranks highest among other African countries that record GERD as a percentage of GDP, followed by Egypt (0.71%) and Tunisia (0.60%) (Figure 37). Although low- and middle-income countries have seen negligible increases in terms of R&D expenditure (Soete et al, 2015), Egypt, South Africa and Tunisia have the potential to reach the African Union target of 1.0%. Commentators on R&D expenditure in South Africa, including the Minister of Science and Technology, have repeatedly reinforced the need for the country to boost its research intensity ratio in line with national and regional targets.

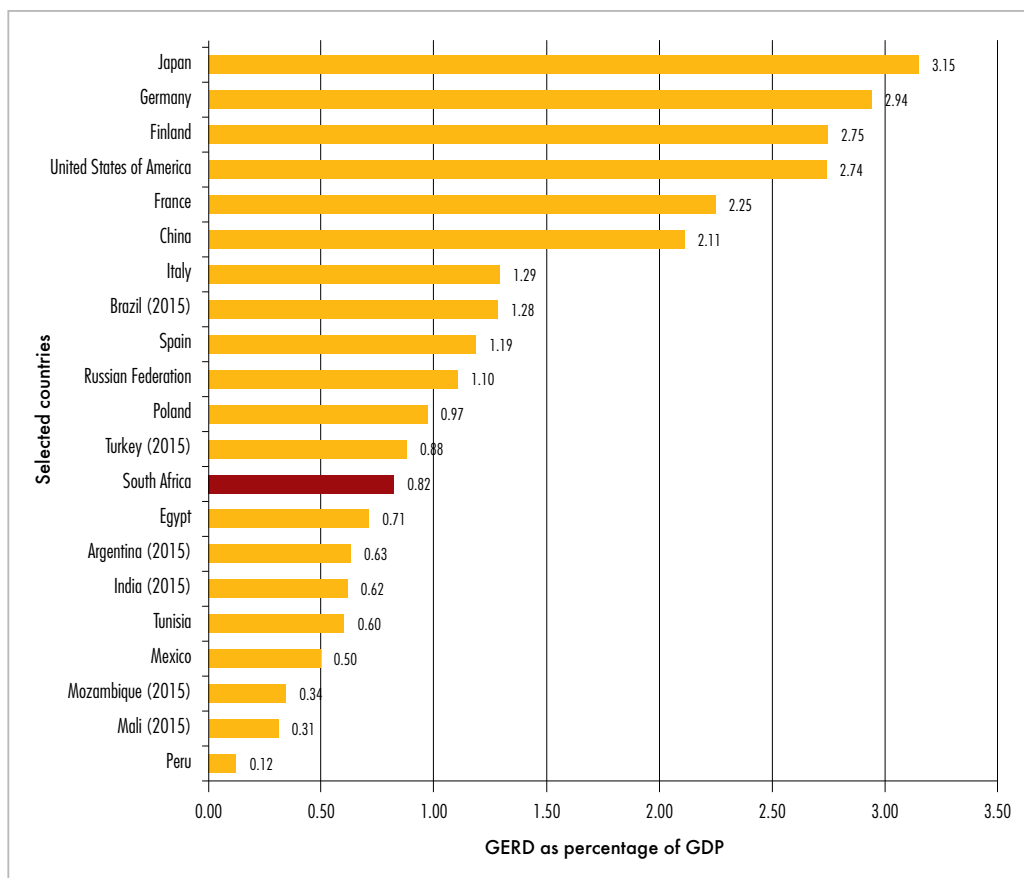
Within the BRICS bloc, China ranked highest, attaining GERD as a percentage of GDP of 2.11%; while Russia and Brazil attained 1.10% and 1.28% respectively. India fell below South Africa at 0.62% (2015), although it has a larger GERD overall (Table 9). The BRICS's R&D performance, with the exception of China, falls far below R&D intensity of most of the developed countries.

Globally, Japan was the country with the highest GERD as percentage of GDP expenditure, at 3.15%. This surpassed the 3% target set for the countries within the European Union. Countries that surpassed the GERD intensity threshold of 2.50% mark include Finland (2.75%), Germany (2.94%) and the USA (2.74%). These are R&D intensive countries with mature economies and demonstrate that R&D is important for growth.





Figure 37: GERD as a percentage of GDP for selected countries, 2016/17 or latest available year



Data note Reported data are for the 2016/17 year or the latest available year as indicated in brackets. Calculations are based on current national currencies

Data sources South Africa: National Survey of Research and Experimental Development, 2016/17. Argentina, China, Finland, France, Germany, Italy, Japan, Mexico, Poland, Russian Federation, Spain, Turkey, USA: OECD, 2018. Brazil, Egypt, India, Mali, Mozambique, Peru, Tunisia: UNESCO UIS, 2018.

6.1.3 GERD by source of funds

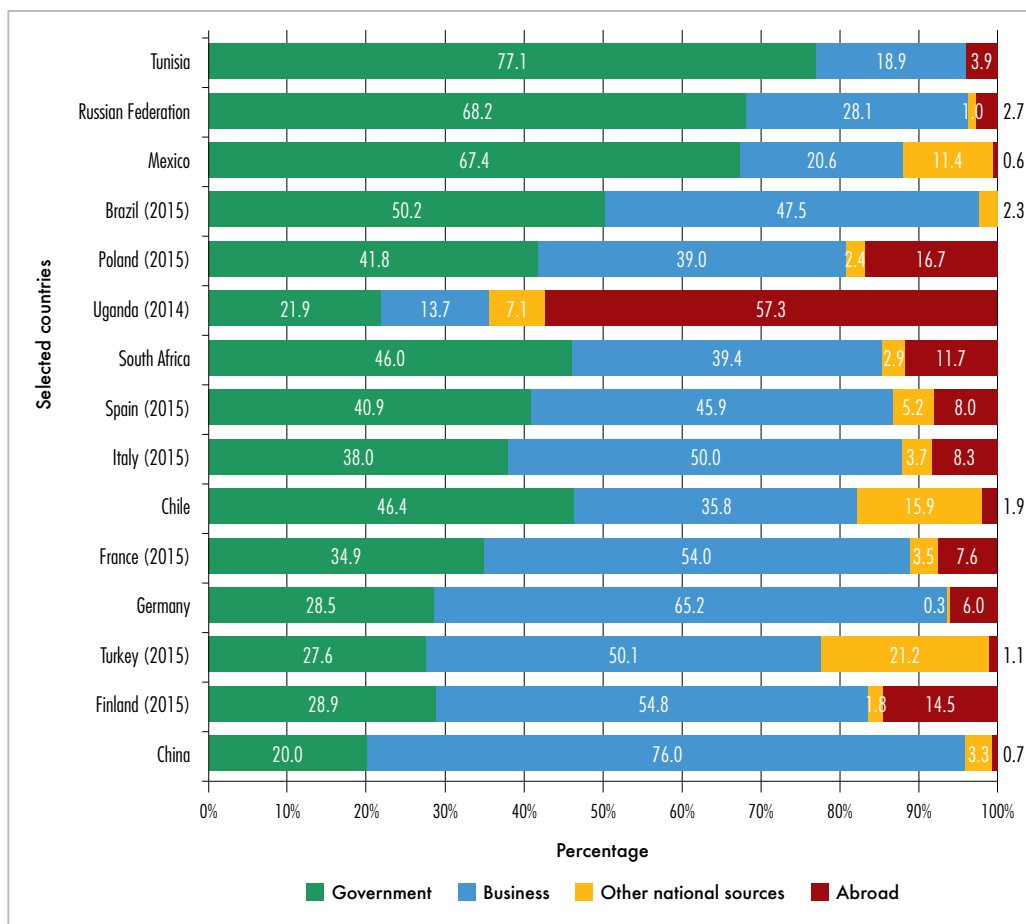
The sources of funding for the R&D-performing sectors differ between countries. Government funding is usually predominant in low- and middle-income countries, where the NPO sector also plays a major role in funding R&D. Business is typically most active in funding R&D in research-intensive countries.

Tunisia, Russia, Mexico, Brazil and Chile reported that more than 40% of their R&D funding came from the government sector. Countries that received the largest share of R&D funding from the business sector were China (76.1%), Germany (65.2%), Finland (54.8%) and France (54.0%). Comparatively, South Africa falls between these two patterns (Figure 38): government is the main funder of R&D (46.0% in 2016/17), but there is also considerable funding for R&D from and for the business sector (39.4% in 2016/17).





Figure 38: GERD by source of funds in selected countries (percentage), 2016/17 or latest available year



Data note Reported data are for the 2016/17 year or the latest available year as indicated in brackets. Calculations are based on current national currencies.

Data sources South Africa: National Survey of Research and Experimental Development, 2016/17.
 Argentina, Chile, China, Finland, France, Germany, Italy, Japan, Mexico, Poland, Russian Federation, Spain, Turkey, USA: OECD, 2018.
 Brazil, Tunisia, Uganda: UNESCO UIS, 2018.

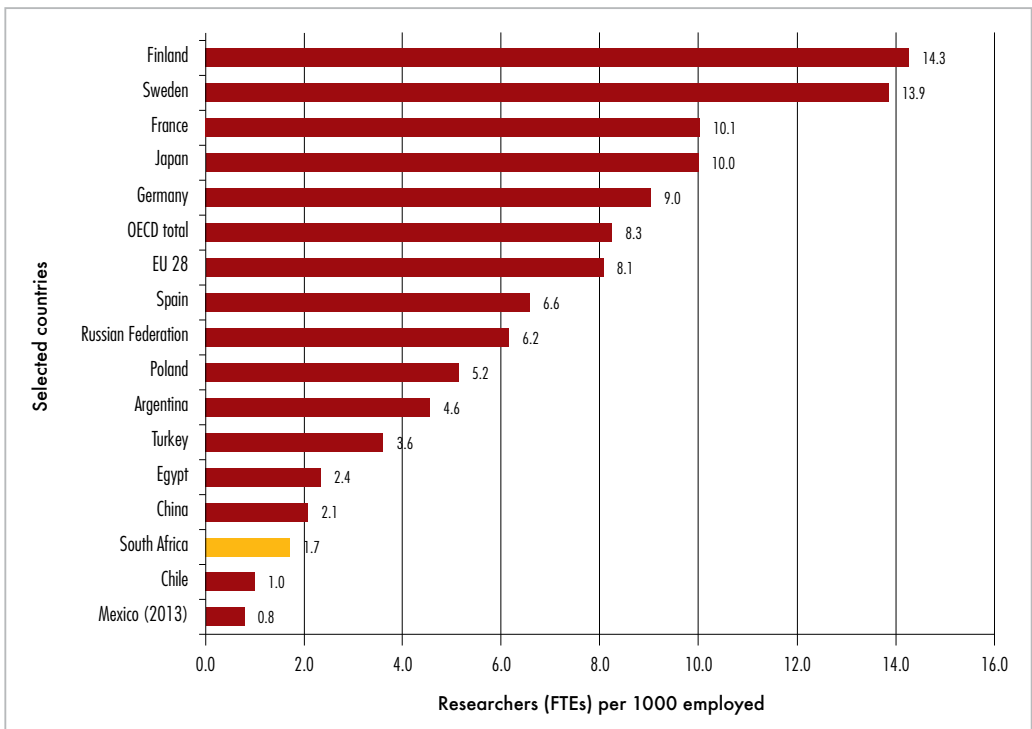


6.2 R&D personnel

6.2.1 Researcher full-time equivalents (FTEs) per thousands in total employment

South Africa's figure of 1.7 researcher FTEs per thousand employed (Figure 39) in 2016/17 was comparable with that of China (Figure 39). The surge in R&D personnel in the higher education sector as reported above does not however seem to impact on this figure in any significant manner. Although China has the largest overall number of researchers among the BRICS countries, it measures particularly low on this indicator given the country's very large population. In Russia, the number of researchers per thousand employed (6.2) was much higher in comparison to any of the other BRICS countries. In contrast to the BRICS, in high-income countries, Sweden reported 14.4 in 2016 and Japan reported 10.0 researchers per thousand employed in 2016, which is the same as in 2015. Finland reported 14.3, a slight drop from 15.0 in 2015.

Figure 39: Researchers per 1 000 in total employment in selected countries, 2016/17



Data sources: South Africa: National Survey of Research and Experimental Development, 2016/17. Argentina, Chile, China, EU 28, Finland, France, Germany, Japan, Mexico, OECD total, Poland, Russian Federation, Spain, Sweden: OECD, 2018. Egypt: UNESCO UIS, 2018.

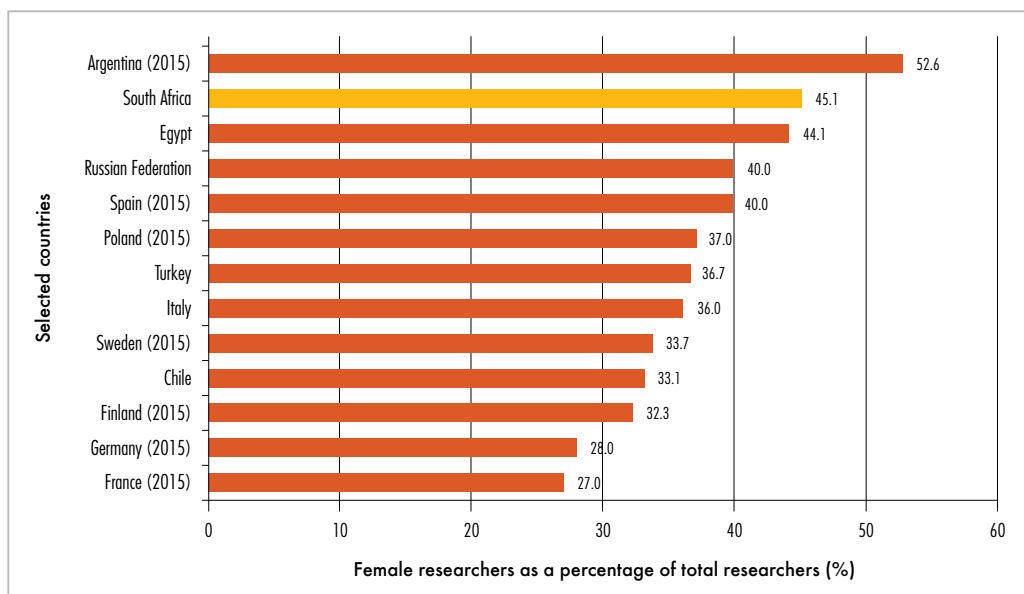




6.2.2 Female researchers as a percentage of total researchers

In South Africa, a higher proportion of researchers are female compared to most of the countries with high R&D expenditure, such as Germany and France (Figure 40). The proportion of female researchers in South Africa is 45.1% of the total researchers in 2016/17, above the level of 44.4% achieved in 2015/16. South Africa has improved on this indicator gradually over the last eight years. From the comparative data presented below, female researchers appear to form a higher proportion of total researchers in developing countries than in most of the developed countries.

Figure 40: Female researchers as a percentage of total researchers (headcount) in selected countries, 2016/17 or latest available year



Data note Data are for 2016/17 or the latest available year as indicated in bracket. Other national sources include the not-for-profit and higher education sectors.

Data sources South Africa: National Survey of Research and Experimental Development, 2016/17.
Argentina, Chile, Finland, France, Germany, Italy, Poland, Russian Federation, Spain, Sweden, Turkey: OECD, 2018.
Egypt: UNESCO UIS, 2018.

▶ 7. CONCLUDING REMARKS

The South African government has invested in R&D for a number of decades and, since the dawn of democracy, has reinforced the importance of R&D for the country's social and economic development. The Draft White Paper on Science, Technology and Innovation, circulated in 2018 for public comment, re-emphasises the objectives of investing in R&D, seeing R&D as an enabler of economic growth and inclusive development, and as critical to not falling behind with intensifying digitalisation of all sectors and business processes.

The introduction to this report raised two key questions to inform interrogation of the evidence generated by the 2016/17 and, indeed, future surveys: Are sufficient resources allocated to domestic R&D, so that South Africa can keep pace with the potentially disruptive changes in STI? Does the national system of innovation system produce sufficient personnel for these tasks?

7.1 The need for continuous investment in R&D

Investment in R&D in South Africa still lags behind the world's major economies and the BRICS countries. The country has to strive to achieve its targets amidst sluggish economic growth. Business sector expenditure on R&D increased only marginally in real terms in 2016/17. This is not sufficient if the country is to keep up with the unfolding of the 'fourth industrial revolution'. To attain the objectives set out in the 2018 Draft White Paper on Science, Technology and Innovation, government must support R&D in its entirety and help boost R&D especially the business sector.

The 2016/17 R&D Survey results show that there has been an increase in total R&D expenditure in nominal terms, but growth is slow in real terms. Nevertheless, over the past decade, there have been increases in funding for R&D from government to the extent that this has nearly doubled in nominal terms. This is a positive sign and it augurs well for the national system of innovation.

However, R&D funding from abroad decreased for the first time since 2010/11, affecting the business and higher education sectors specifically. This situation has to be addressed, as it has the potential to negatively impact international collaborations, as well as deter future foreign investment in R&D and innovation.

7.2 Changes in the composition of R&D performed in the provinces

R&D is a concentrated phenomenon globally. This is also the case in South Africa where R&D is mainly performed in three provinces, namely Gauteng, Western Cape and KwaZulu-Natal. This is a long-term trend reflected in each of the past R&D datasets produced by CeSTII.





Looking more closely at the data patterns over the past decade, the share of R&D performed in Gauteng has fluctuated to a limited extent since 2007/08 to date; while that of KwaZulu-Natal decreased in 2013/14 and has since then remained relatively stable. The Western Cape's proportion of R&D expenditure increased from 2007/08 year-on-year, but decreased in 2010/11 and 2011/12 and then increased from 2012/13 to 2016/17. There has also been steady growth in R&D expenditure in the Eastern Cape province since 2007/08, with some fluctuations; while the Northern Cape, Mpumalanga, North-West, Limpopo and Free State, have remained fairly static.

The high proportions of expenditure in Gauteng, KwaZulu-Natal, and the Western Cape are attributed to the presence of large universities and research organisations in these economically and demographically concentrated geographic areas. They also have a more balanced combination of large firms, and small-and-medium enterprises, as well as skilled personnel. The low R&D expenditure in other provinces may in some cases be attributed to the unfavourable industry structure, in particular where provinces have large agricultural and service sectors. A set of questions that emerges from these results for further research is: What might be done to boost expenditure in the other provinces of South Africa where there is existing R&D capability that could be developed and enhanced through strategic investment. How can spill-overs from R&D performing provinces can be harnessed to trigger R&D in the lower performing regions?

7.3 Growing and supporting emerging technologies and taking advantage of South Africa's strengths

The R&D Survey has collected data on nanotechnology and biotechnology for the past ten years across all the sectors. Nanotechnology has multiple definitions, but may be defined as the science of manipulating materials on an atomic or molecular scale, to build microscopic devices and to improve computational advances. Biotechnology is a 'crosscutter' technology that uses biomolecules and organisms to develop pharmaceutical therapies, medical treatments and research, and agricultural innovations. Both provide a critical foundation for the 'fourth industrial revolution'.

The ten-year trend shows an increase in R&D expenditure in biotechnology, with the highest expenditure recorded in the 2015/16 survey year, 5.7% of GERD. The 2016/17 contribution to GERD was 5.0%. Nanotechnology R&D expenditure contributed 2.7% and 2.4% in 2015/16 and 2016/17 respectively. Digitalisation of these and other technologies does not only spell impacts for R&D, but also for innovation as it provides opportunities for faster innovation, potentially at lower costs. This will be a positive result for developing countries such as South Africa, though research on the effects of innovation on employment growth in different industries in South Africa will be necessary to help mitigate negative impacts on livelihoods and to promote inclusive socio-economic development.



7.4 Green R&D for sustainable development

There are unique demands for each sector of the economy in South Africa: Government must serve its citizens' needs, business enterprises must attain their profits, and Higher education must produce good research and education evidenced by their graduates. All these have to be done in the ambit of environmental consciousness. "Going green" is often referred to as the creation of knowledge and practices that are responsible, with the aim of preserving the environment and natural resources for the current and future generations.

South African policy makers are aware of this growing niche of green R&D. From the perspective of green R&D, the interesting trend to note from the R&D Survey 2016/17 is the growing portion of R&D expenditure in broad social sciences domain and, in particular, business sciences (including management, accounting, finance, economics, etc), which could suggest that organisations are beginning to consider more seriously their role within the global sustainable development agenda.

7.5 R&D personnel is on the increase in the past three consecutive years

South Africa saw a surge of more than 5 000 R&D personnel between the current survey and the previous year, specifically concentrated in the higher education sector. Part of the growth in R&D personnel is due to a relatively high number of foreign postgraduates in the South African higher education system, notably, the post-doctoral fellows; while yet another explanation for the growth in R&D personnel is due to the increase in master's students owing to a recognition of the diverse structure of master's degree programmes and the role of R&D therein. Whatever the drivers, this is a positive result, given the current levels of unemployment and skills shortage in the country. The increase in the number of doctoral students is a good signal of future potential, as doctoral students play a key role in R&D and other scientific activities. They are specifically trained to create new knowledge and apply it for the betterment of the economy and society as a whole. The knowledge created may be tacit, meaning it will be embedded in graduates, and can be diffused through their movements across the economy. This creates opportunities for the increased performance and impact of R&D.

The business sector is key to the 'fourth industrial revolution' in terms of R&D and innovation, which requires highly skilled personnel. Higher education is partly the answer, because the 'fourth industrial revolution' is a collaborative endeavour that will require participation by all sectors. It has long been a policy goal in South Africa to strengthen the relationship between higher education and the business sector, so that universities produce graduates that are relevant to the needs of industry. The role of technicians in this regard should not be overlooked, as technicians will undoubtedly play a crucial though possibly differentiated role in the economies of the future. Government has mechanisms to assist with this bridging of skills, such as the South African





Research Chairs Initiative (SARChI) and the Tertiary and Vocational Education and Training (TVET) institutions, which could be productive mechanisms through which skilled and knowledgeable personnel can be recruited to train others. Perhaps concerning is that the business sector has the second highest number of R&D personnel, but these numbers appear low if considered in relation to the overall R&D personnel numbers within the higher education sector. The policy concerns worthy of further investigation, in this regard, could be whether the higher education system is preparing suitable graduates to enter R&D positions within the business sector and/or whether businesses have sufficient absorptive capacity for R&D personnel.



► REFERENCES

- DACST. 1996. *Resources for R&D, 1993/94, Results of Survey No. 18 in South Africa*. Pretoria: Department of Arts, Culture, Science and Technology.
- DACST. 2000. *Survey of Resources Allocated to Research and Development, 1997/8*. Pretoria: Department of Arts, Culture, Science and Technology.
- DACST. 2002. *South Africa's National Research and Development Strategy*. Pretoria: Department of Arts, Culture, Science and Technology.
- DNE. 1993. *Resources for R&D, 1991/2, Results of Survey Programme No. 17*. Pretoria: Science Planning, Department of National Education.
- OECD. 2002. *The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys on Research and Experimental Development (Frascati Manual)*. Paris: OECD Publishing.
- OECD. 2015. *The Measurement of Scientific, Technology and Innovation Activities: Guidelines for Collecting and Reporting Data on Research and Experimental Development (Frascati Manual)*. Paris: OECD Publishing.
- OECD. 2017. "Business R&D", in *OECD Science, Technology and Industry Scoreboard 2017: The digital*. Paris: OECD Publishing.
- PwC (2016). *Industry 4.0: Building the digital enterprise South Africa highlights*. Johannesburg: PricewaterhouseCoopers.
- Schwab, K. (2016). *The fourth industrial revolution*. Geneva: World Economic Forum.
- Soete, L., Schneegans, S., Erockal, D., Angathevar, B., & Rasiah, R. 2015. *UNESCO Science Report: Towards 2030*. Paris: UNESCO.





Stats SA. 2015. *Gross Domestic Product: P0441, Fourth Quarter 2015*. Pretoria: Statistics South Africa.

Stats SA. 2018a. *Gross Domestic Product: P0441, First Quarter 2018*. Pretoria: Statistics South Africa.

Stats SA. 2018b. *Quarterly Labour Force Survey: P0211, First Quarter 2018*. Pretoria: Statistics South Africa.

UNESCO UIS. 2018. *United Nations Educational, Scientific and Cultural Organization institute for Statistics Database*. Retrieved from <http://www.uis.unesco.org/>



► METHODOLOGICAL NOTES

The 2016/17 R&D Survey was conducted according to the OECD's guidelines presented in the 2002 Frascati Manual. The Frascati Manual defines R&D as follows:

Research and experimental development (R&D) is creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. (OECD, 2002).

The Frascati Manual proposes several approaches to surveying R&D-performing entities, including a census, a sample survey, or a hybrid of the census and sample survey approaches, comprising a census of all large R&D performers and a stratified random sample survey of the remaining R&D-performing entities. In South Africa, the R&D Survey is currently conducted using the census approach in all the sectors, except the business and not-for-profit sectors, where in each case, a purposive sample of the entities is surveyed. As with the previous R&D surveys, the 2016/17 survey followed this approach.

For each sector, units were verified as R&D performers to determine which ones to be surveyed in 2016/17.

There were also changes made to the 2016/17 R&D Survey collection instrument, in alignment with recommendations in the revised Frascati Manual (OECD, 2015). This was done in an effort to report on foreign employees that could not be categorised by population groups during previous surveys. The R&D personnel changes included an additional classification of population group of R&D personnel, as non-South African personnel. The full-time equivalent (FTE) value of the non-South African R&D personnel cannot be estimated with sufficient precision, due to the model that the R&D Survey employs for calculating labour costs from average costs of labour in terms of FTEs. Non-SA 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 the SNA.

Further amendments to the collection instrument included specific categories of R&D personnel relevant to higher education only — these are emeritus professors, research fellows, honorary research associates or equivalent. They do not incur a salary at the university but there are time and costs associated with them, therefore the separate headcount and FTE category. These changes did not contribute to the calculation of any of the statistics estimated in the R&D Survey, but merely provided an additional categorisation of researchers.

Furthermore, reporting units were asked whether they participate in space science.

A detailed chapter on methodology and some metadata are illustrated in the 2016/17 *Statistical Report*.





Department of Science and Technology (DST)

Private Bag X894, Pretoria, 0001
Republic of South Africa
www.dst.gov.za

Dr Phil Mjwara

Director-General: DST
Phil.Mjwara@dst.gov.za

Mr Imraan Patel

Deputy Director-General: Socio-Economic Partnerships, DST
Imraan.Patel@dst.gov.za

Mr Godfrey Mashamba

Chief Director: Science and Technology Investment, DST
Godfrey.Mashamba@dst.gov.za

Ms Tshidi Mamogobo

Director: Science and Technology Indicators, DST
Tshidi.Mamogobo@dst.gov.za

Centre for Science, Technology and Innovation Indicators (CeSTII)

Human Sciences Research Council
P O Box 15200, Vlaeberg, Cape Town, 8018
www.hsrc.ac.za

Dr Glenda Kruss

Deputy Executive Director: CeSTII
gkruss@hsrc.ac.za

Dr Neo Molotja

Senior Research Specialist: CeSTII
nmolotja@hsrc.ac.za

