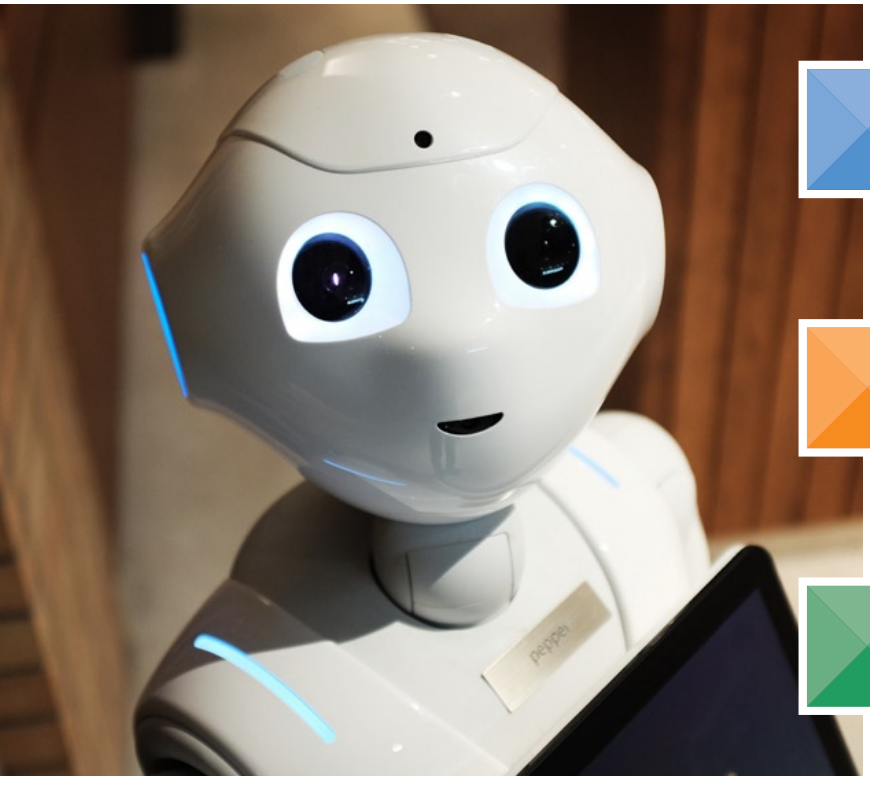
SOUTH AFRICAN NATIONAL SURVEY OF RESEARCH AND EXPERIMENTAL DEVELOPMENT

MAIN REPORT 2019/20



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REVISIONS

Please Note:

The R&D intensity series in this report was revised to take into account the revision of the GDP series (Stats SA 2021a). The R&D expenditure in real terms was also rebased to 2015 constant prices.

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

FOREWORD

South Africa's R&D statistics are key to monitoring the R&D investment and human resource profile of the country and to inform Science, Technology and Innovation (STI) policy implementation by the government. These statistics are also of use as a source of evidence to the private sector, the international community, media, and researchers.

The National Survey of Research and Experimental Development (R&D Survey), which forms a part of the National Statistics System, is published annually by the Department of Science and Innovation (DSI) in partnership with Statistics South Africa, and is in alignment with the Statistics Act (No. 6 of 1999).

The R&D Survey is conducted by the Human Sciences Research Council's Centre for Science, Technology and Innovation Indicators (CeSTII), following the international guidelines published by the Organization for Economic Cooperation and Development (OECD), known as the Frascati Manual. The resulting statistics provide important evidence on the size, growth and composition of R&D expenditure and human resources devoted to R&D.

The R&D Survey project plan is cast according to the phases of the Statistical Value Chain (SVC) promoted by the requirements of the South African Statistical Quality Assessment Framework (SASQAF). The SASQAF is the instrument used for assessing the quality of statistical reports for accreditation as official statistics. Each year the R&D Survey is subjected to a stringent quality process, which is undertaken by a clearance committee comprising of experts from various sectors. This report is the tenth in the series of R&D Survey statistical reports since the inception of a clearance process before the release of the annual data. To validate the quality of the survey, independent data verification by a technical committee was done in support of the clearance committee recommendations.

The clearance process revealed that the 2019/20 R&D Survey was conducted following good practice and was found to meet most of the quality requirements of the R&D Survey assessment tool. Overall the R&D survey process has shown increasing improvements over the past years.

As with the 2018/19 survey, the impact of COVID-19 lockdowns and restrictions has continued to affect fieldwork operations. Several strategies such as more focus on the top 200 R&D performing business companies, were put in place to mitigate against the likelihood of a lower response rate.

Based on the R&D Survey Clearance Committee recommendations, I endorse the 2019/20 R&D Survey, with the caveat that time series analysis of the data using the 2019/20 R&D Survey estimates need to be done with caution and encourage its use by stakeholders.

Risenga Maluleke
STATISTICIAN-GENERAL
REPUBLIC OF SOUTH AFRICA
14 December 2021

PREFACE

Growing our investment in research and development (R&D) across the National System of Innovation (NSI) is integral to South Africa's current science, technology and innovation (STI) policy approach and the National Development Plan (NDP) recognises STI as core drivers of socio-economic development to improve the lives of citizens.

The 2019 White Paper on Science, Technology and Innovation highlights challenges of the Fourth Industrial Revolution as a key imperative placing STI at the centre of South Africa's development agenda. The Decadal Plan – the implementation plan for the White Paper, also highlights the importance of STI to achieve the NDP's priorities.

South Africa has been measuring STI for two decades to better understand the science, technology and research landscape in South Africa and to develop the most useful and relevant indicators of progress. The National Survey of Research and Experimental Development (R&D Survey) monitors the country's performance against targets and tracks changes in the R&D system over time. Effective STI policy implementation involves continuous and progressive changes to improve the absorptive capacities and transformative uses of STI in public, business and civil society sectors to pursue national development goals.

In 2019/20 the gross domestic expenditure on research and experimental development (GERD) amounted to R34.485 billion. In nominal terms, this represents a decrease of R2.299 billion from the R36.784 billion recorded in 2018/19. At constant 2015 Rand values, GERD decreased by R3.227 billion (10.3%) from R31.367 billion in 2018/19 to R28.140 billion in 2019/20. This is clearly not a desirable trend. Growing our capacity for innovation in South Africa not only needs higher investment in R&D to reach GERD/GDP targets, but also entails growing the number of R&D personnel with the skills and expertise to conduct research in key fields. South Africa's R&D personnel headcount declined by 2.3%, from 84 036 to 82 068 between 2018/19 and 2019/20.

In 2019/20 the main sources of funding for R&D in South Africa were government (including science councils and university own funds) and, to declining degrees, the business sector. While government funding of R&D increased by R1.942 billion from the previous year, domestic business funding dropped by R5.175 billion. Funding from abroad, which went mostly to the private sector, increased by R664 million. Government funds the largest proportion of GERD in South Africa which demonstrates its continuous commitment to invest in R&D to tackle the country's socio-economic challenges.

The 2019/20 survey results show that the strongest focus of R&D activity is in medical and health sciences (21.5%), followed by the social sciences (16.9%) and engineering sciences (13.4%).

The Department of Science and Innovation (DSI), recognising the critical role research and innovation plays in South Africa's response to COVID-19, invested in interdisciplinary research, including the

development of point-of-care diagnostics for detection of COVID-19, targeted surveillance and the development of new technologies to prevent or control COVID-19. Our genomic surveillance led to the detection of two variants, and this work has been praised and welcomed globally.

As part of the DSI's concerted effort to turn around further declines in GERD, in the context of recent economic instability, a roundtable policy discussion will be convened to discuss the policy implications and actions to be taken to address the continued decline in R&D investment in South Africa.

On behalf of DSI, I extend my gratitude 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 to assess the quality of the R&D statistics.

A special word of appreciation goes to all the respondents, in both the private and the public sector, who gave their time so willingly to make this survey a success.

DR B E NZIMANDE, MP
MINISTER OF HIGHER EDUCATION, SCIENCE AND INNOVATION

ACKNOWLEDGEMENTS

The South African National Survey of Research and Experimental Development is conducted annually by HSRC-CeSTII on behalf of the Department of Science and Innovation.

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

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

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

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

The HSRC-CeSTII project team for the 2019/20 South African National Survey of Research and Experimental Development comprised: Lindiwe Binda, Mario Clayford, Atoko Kasongo, Lwando Kondlo, Precious Mudavanhu, Jerry Mathekga, Neo Molotja, Audrey Mahlaela, Sintu Mavi, Nokhetho Mhlanga, Nazeem Mustapha, Gerard Ralphs, Theodore Sass, Natasha Saunders, Kgabo Ramoroka, Viwe Sigenu, Moses Sithole, Anele Slater, Natalie Vlotman, Darryn Whisgary, and Luthando Zondi.

We further acknowledge the contributions and support of Fatima Charles, Lizelle van Graan, Katharine McKenzie, Jodi-Joy Ntontholo, Nathan Swartz, Tracey Watson, and CeSTII administrative staff Azwidivhaho Muavha, Bongiwe Ngqaqu, Maria Maluleke, and Zinziswa Hlakula.

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

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
BERD	Business expenditure on R&D
BRICS	Brazil, the Russian Federation, India, China and South Africa
CEO	Chief Executive Officer
CeSTII	Centre for Science, Technology and Innovation Indicators
DACST	Department of Arts, Culture, Science and Technology
DSI	Department of Science and Innovation
DST	Department of Science and Technology
FTE	Full-time equivalent
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GOVERD	Government intramural expenditure on R&D
HERD	Higher education expenditure on R&D
HIV	Human Immunodeficiency Virus
HSRC	Human Sciences Research Council
ICT	Information and communication technology
NESTI	National Experts on Science and Technology Indicators
NPO	Not-for-profit organisation
NSI	National system of innovation
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing power parity
R&D	Research and experimental development
RF	Research field
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SASQAF	South African Statistical Quality Assessment Framework
SEO	Socio-economic objective
SOE	State-owned enterprise
SIC	Standard Industrial Classification
SNA	System of National Accounts
Stats SA	Statistics South Africa
STI	Science, technology and innovation
SVC	Statistical Value Chain
TB	Tuberculosis
UIS	UNESCO Institute for Statistics
UNESCO	United Nations Educational, Scientific and Cultural Organization

DEFINITION OF TERMS

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

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

BERD refers to business expenditure on research and experimental development.

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

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

Constant 2015 Rands is the value of goods and services of a given year using the prices of a determined base reference year, which is 2010 in this case. These values were obtained by deflating with the GDP deflator using data published in the Statistics South Africa GDP survey P0441, Fourth quarter 2021 (Stats SA 2021a).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

State-owned enterprises (SOEs) are public corporations owned by government units mainly engaged in market production and sale of the kind of goods and services often produced by private enterprises.

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

Total employment is the total employment in the economy. This statistic is obtained from the Statistics South Africa Labour Force Survey series P0211 (Stats SA 2021b), where employed persons are those aged 15–64 years who, during the reference week, did any work for at least one hour, or had a job or business but were not at work (temporarily absent).

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

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

EXECUTIVE SUMMARY

This report presents results from the eighteenth South African National Survey of Research and Experimental Development (R&D Survey) 2019/20 conducted by the Centre for Science, Technology and Innovation Indicators (CeSTII) on behalf of the Department of Science and Innovation (DSI).

R&D expenditure decreased to R34.485 billion in 2019/20.

Gross domestic expenditure on research and development (GERD) for 2019/20 was R34.485 billion in current Rand values. At constant 2015 Rand values, GERD decreased by R3.227 billion (-10.3%) from R31.367 billion in 2018/19 to R28.140 billion in 2019/20. GERD as a percentage of GDP decreased by seven basis points from 0.69% in 2018/19 to 0.62% in 2019/20.

South Africa was not alone in experiencing decline and stagnation in GERD.

Statistics from selected countries show South Africa's gross domestic expenditure on research and development is low compared to high-income countries, but at the high end for middle- and high-income countries in Africa and Latin America. Data on GERD as a percentage of GDP in most of the selected countries reflect minor changes from the previous reference period. Generally developing countries, including South Africa, have stagnated or shown declines in R&D intensity.

Expenditure in the higher education, science council, and not-for-profit sectors increased.

The higher education and science council sectors experienced increases in R&D expenditure, while the not-for-profit sector was largely stagnant with an only marginal increase. The higher education sector surpassed the business sector to become the largest performer of R&D in South Africa in 2019/20. In current prices, the higher education sector reported spending R14.179 billion on R&D in 2019/20, an increase of R996 million from the R13.183 billion reported in 2018/19. The second largest increase was in the science council sector which increased its R&D spend by R754 million. The not-for-profit sector experienced a slight increase of R21 million from R1.486 billion in 2018/19 to R1.510 billion in 2019/20.

Business and government sector expenditure declined.

The business sector experienced the largest decrease in R&D expenditure, by far. The business sector constituted 31.0% of GERD, amounted to R10.704 billion, a decrease of R3.744 billion from the R14.448 billion reported in 2018/19. Government expenditure on R&D constituted 5.5% of GERD and amounted to R1.894 billion in current prices, decreasing by R329 million from R2.223 billion to R1.894 billion.

Government funding for R&D increased while the business sector experienced a decrease.

Government (inclusive of science councils and university own funds) is now not only the largest funder, but also the largest performer of R&D, contributing R19.417 billion (56.3%) to GERD in 2019/20, the highest proportion of government funding in more than ten years. The business sector funded R9.359 billion (27.1% of total funding) in 2019/20, a decrease of 12.4 percentage points from the

39.5% share of funding in 2018/19. The business sector mostly funds its own R&D, which amounted to R8.542 billion (91.3%) in 2019/20. The third largest funder of R&D across all sectors was foreign sources, which increased from R3.999 billion in 2018/19 to R4.662 billion in 2019/20, an increase of R663 million. The largest share of foreign funding went to the higher education sector, amounting to R1.979 billion (42.5%) followed by the business sector (25.1%) and the not-for-profit sector (20.2%). Foreign funding to the business sector increased from R400 million in 2018/19 to R1.169 billion in 2019/20. These are significant increases from the funding flows reported in 2018/19.

Growth in R&D personnel continues to show signs of stagnation year-on-year.

The 2019/20 period indicated a decline in headcounts and FTEs of R&D personnel for the second time since 2018/19. Human capacity in R&D measured by headcount declined by 2.3% from 84 036 in 2018/19 to 82 068 in 2019/20. Postgraduate student headcounts in the higher education sector are a significant contributor to total R&D personnel, showing consistent growth year-on-year. Postgraduate students grew from 86 395 in 2018/19 to 87 146 in 2019/20, contributing to the stagnation in R&D personnel and offsetting the decline in researchers across the science council and the business sectors.

The financial and mining sectors experienced large decreases in R&D expenditure.

Within the business sector, the financial intermediation, real estate and business services sector and the mining sector have been the two sectors with the largest R&D expenditure. The financial sector decreased R&D expenditure by R2.370 billion from R6.402 billion in 2018/19 to R4.032 billion in 2019/20. The mining sector decreased R&D expenditure from R1.748 billion to R686 million. This was the direct result of the sale of mining companies and their assets or restructuring in R&D-performing mining entities.

South Africa's spend on the priority areas of health and green R&D continued to grow.

Expenditure on health R&D has been increasing since 2015/16, with 24.9% (R8.583 billion) of GERD going to health R&D in 2019/20. Research in the medical and health sciences accounted for most of the health R&D spending (86.3%). A total of R4.684 billion was spent on communicable diseases (TB, HIV/AIDS, and malaria), a decrease of R422 million compared with the previous year. The public sector invested the most in health R&D (56.2%), followed by the private sector (43.8%). R&D in pharmaceutical performing entities contributed to the high expenditure in the private sector. The steady growth in health R&D is encouraging in the context of the COVID-19 crisis and the challenges the epidemic has brought to light, where R&D needs to play a critical role.

R&D expenditure in the SOE sector continued to rebound.

Over the last two years SOEs increased their contribution to R&D expenditure in the business sector to 19.2%. However, this is still some way off their previous high of 27.9% reached in 2008/09. Because of their strategic location in industrial sectors, and potential for generating growth in these areas of industry, there is substantial propensity for these entities to perform R&D in line with their mandates.

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Growing R&D investment for inclusive and sustainable development

South Africa has adopted international science, technology and innovation (STI) measurement standards to measure progress in the National System of Innovation (NSI). One indicator used to measure progress is the ratio of R&D spent as a percentage of GDP. High levels of R&D intensity are linked to a country being better placed to achieve its Sustainable Development Goals (SDGs).

To adequately create job opportunities and a reduction in poverty requires inclusive economic growth in the country. The path to inclusive growth begins with broad-based transformation that targets the removal of structural impediments to economic development, the deconcentrating of industries dominated by few participants, and the reintroduction of rising per capita income for all South Africans. South Africa needs to increase its efforts to catalyse the kind of transformational innovation that will spur inclusive and sustainable growth and development. In this context, the role of and case for R&D could not be more urgent or compelling.

For the second period in a row, gross domestic expenditure on R&D (GERD) in South Africa declined in 2019/20, even in nominal terms. An indicator of a country's research intensity, GERD as a percentage of GDP fell from 0.69% in 2018/19 to 0.62% in 2019/20, its lowest in the last decade (Table 1). The number of R&D personnel reported in 2019/20 also declined, as did business funding for R&D. The decline in R&D expenditure and human capabilities in South Africa needs to be seen in the context of the economic stagnation experienced in 2019/20. This culminated in decreased government expenditure across the public sector and a countrywide recession characterised by the lowest values of GDP recorded in decades. Even though government funding of R&D was cut, it increased to its highest proportion in the past decade. To reach the target level of 1.5% by 2030, R&D intensity needs to grow from 0.62% in 2019/20. In this report, South Africa's R&D landscape and its strengths and weaknesses are examined through an analysis of trends in R&D investment, performance, and human resources.

GERD/GDP targets in South Africa

The National Development Plan and South Africa's science, technology and innovation policy emphasize investment in R&D across the national innovation system. As an intermediate step towards the target of spending 1.5% of GDP on research and development by 2030, the Department of Science and Innovation has set a national research spending target of 1.1% of GDP by 2024.

Table 1: Key R&D indicators for 2010/11 to 2019/20

KEY INDICATOR	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Gross domestic expenditure on R&D (GERD) (R million)	20 254	22 209	23 871	25 661	29 345	32 337	35 693	38 725	36 784	34 485
Gross domestic expenditure on R&D in constant 2015 prices (R million)	20 254	20 847	21 283	21 552	23 351	24 467	25 191	25 963	23 732	28 140
GERD as a percentage of GDP (%)	0.66	0.67	0.67	0.66	0.71	0.73	0.75	0.76	0.69	0.62
Civil GERD as a percentage of GDP (%)	0.48	0.52	0.54	0.56	0.63	0.69	0.77	0.81	0.77	0.72
Basic research (R million)	4 848 283	5 439 561	6 030 827	6 102 085	7 133 213	8 209 662	9 542 644	10 223 956	10 364 091	11 043 171
Government-funded* R&D (R million)	9 018 874	9 561 917	10 831 893	11 007 083	12 873 458	14 425 992	16 427 596	18 082 182	17 475 173	19 416 933
Business-funded R&D (R million)	8 128 246	8 663 105	9 152 042	10 615 902	11 981 974	12 578 499	14 045 892	16 066 846	14 534 123	9 358 770
Foreign-funded R&D (R million)	2 445 009	3 330 496	3 116 984	3 315 227	3 566 015	4 209 861	4 171 507	3 936 705	3 998 734	4 662 299
Total R&D personnel (FTE)	29 486	30 978	35 050	37 957	38 465	41 055	42 533	44 259	43 774	41 857
Total researchers# (FTE)	18 719.6	20 115.1	21 382.4	23 346.0	23 571.9	26 159.4	27 656	29 515	29 111	28 359
Total researchers# (headcount**)	37 901	40 653	42 828	45 935	48 479	51 877	56 761	61 840	62 166	62 002
Female researchers# (headcount**)	15 794	17 184	18 724	20 231	21 471	23 334	25 591	27 774	28 401	26 015
Total R&D personnel (FTE) per 1 000 in total employment	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8
Total researchers# (FTE) per 1 000 in total employment	1.4	1.5	1.5	1.6	1.5	1.7	1.7	1.8	1.8	1.9
Female researcher# headcount** as a percentage of total researcher headcount (%)	41.7	42.3	43.7	44.0	44.3	44.4	45.1	44.9	45.7	42.0
Gross domestic product level at current prices (R million)	3 055 613	3 327 047	3 566 385	3 868 630	4 133 873	4 420 793	4 759 555	5 078 190	5 357 640	5 605 034
SA employment ('000)	13 118	13 497	14 558	15 055	15 459	15 663	16 212	16 378	16 420	15 024

Data notes
* Government-funded R&D includes science council and university own funds.
\# Includes doctoral students and post-doctoral fellows. Also includes emeritus professors, research fellows and honorary research fellows in 2017/18. These categories of personnel do not incur salary costs, but there are time and other costs associated with their institutional position.
** Headcounts includes non-SA R&D staff in 2019/20.

Data sources
South African National Survey of Research and Experimental Development, 2010/11 to 2019/20.
GDP values: Stats SA, GDP, Fourth quarter 2020, P0441 Series (Stats SA, 2021a).
Total employment values: Stats SA, Quarterly Labour Force Survey, Fourth quarter 2020, P0211 Series (Stats SA, 2021b).

Reading and using this report

The previous 2018/19 R&D Survey Main Report interrogated trends in expenditure and personnel, identifying specific areas of growth, decline and stagnation to prompt policy-relevant questions. The report concluded by emphasizing the need to support business sector R&D; it also highlighted priority research areas, the impact of graduates from the higher education sector on R&D personnel across all sectors, and using R&D Survey data analysis to recommend ways of growing BERD. This report continues this approach and provides an updated, disaggregated analysis of the 2019/20 R&D data in three sections. Section 1 focuses on how R&D is oriented to address national priorities. Section 2 interrogates R&D funding flows and the spatial dimensions of R&D. Section 3 considers trends in the growth of the human capabilities for R&D. Each section highlights evidence that is pertinent to policy concerns.

Actors in the NSI, whether government departments, business groups, universities or civil society organisations, routinely attempt to understand the current R&D trends shaping the future, and the potential R&D growth points in the private and public sectors. This report is thus oriented to the needs of these users, including not exclusively officials in government departments, leaders in businesses and business groups, science council executives, university research leaders, and civil society practitioners.

2019/20 R&D Survey report, at a glance

Purpose

The R&D Survey 2019/20 Main Report provides descriptive analysis and commentary on the latest survey results. It is accompanied by the Statistical Report, which presents data tables for 2019/20 in the form of trend data for the past 10 years, with key findings and commentary placing the results in context. Together, these reports provide R&D data and indicators that enable the reader to explore policy issues and develop research questions for further study.

Scope of the R&D Survey

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 satisfies national data needs and is consistent with the international sector categorisation for measuring R&D recommended by the Organisation for Economic Co-operation and Development 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 data and analysis in the R&D Survey report is presented using categories of statistics, such as:

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

In addition, R&D expenditure in multidisciplinary and selected research fields of policy interest in South Africa is routinely collected. This includes biotechnology; open-source software; new materials; TB, HIV/AIDS and malaria research; and special research priority areas, such as green R&D and health R&D.

R&D figures provided for these financial periods were not impacted by the COVID-19 pandemic. Nevertheless, data collection happened during the COVID-19 pandemic and the data should be interpreted with caution since it is impossible to determine the impact of this pandemic on the entities and individuals providing the data.

1. R&D EXPENDITURE ORIENTED TO ECONOMIC GROWTH AND INCLUSIVE DEVELOPMENT

Section 1:

- Analyses **GERD by institutional sector** and provides **international comparisons**.
- Uses **multi-year data points** to compare **trends in R&D**.
- Presents analyses of **expenditure patterns** by **accounting category and sector**.
- Explores business sector **R&D expenditure by Standard Industrial Classification code**.
- Describes the focus of R&D expenditure by **type and field** of research.
- Highlights trends in **priority areas of green, health, and state-owned enterprise R&D**.

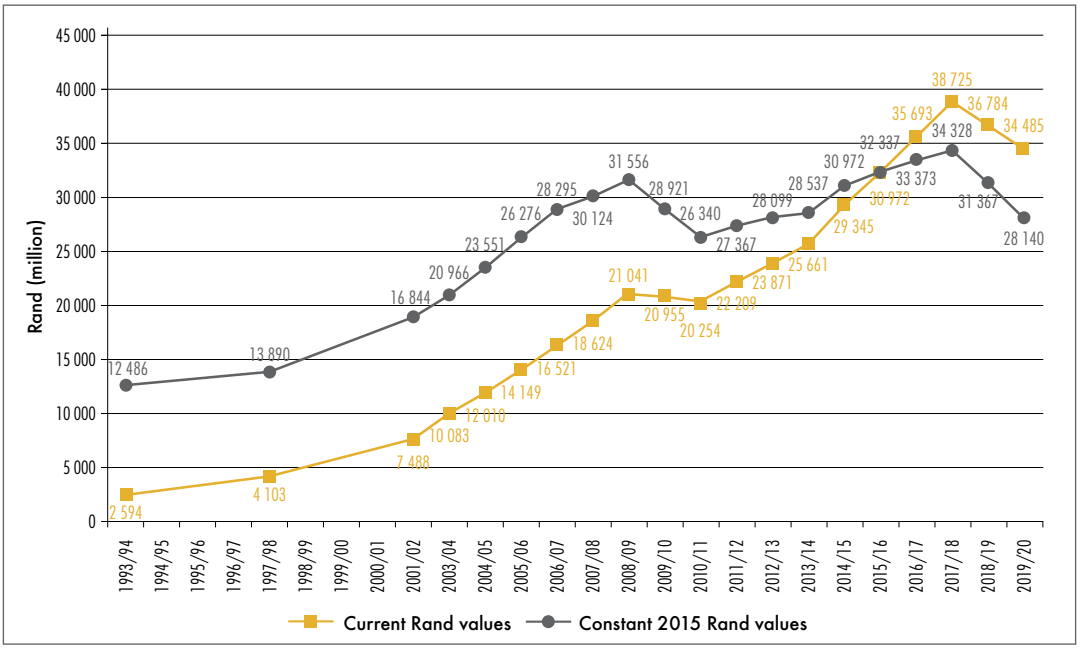
1.1 High-level trends over time

1.1.1 Gross domestic expenditure on R&D

The gross expenditure on research and experimental development (GERD) amounted to R34.485 billion in 2019/20 (Figure 1). In nominal terms, this represents a decrease of R2.299 billion from the R36.784 billion recorded in 2018/19. At constant 2015 Rand value, GERD decreased by R3.227 (-10.3%) from R31.367 billion in 2018/19 to R28.140 billion in 2019/20.

South Africa experienced its second decline in GERD in current terms and GERD/GDP since 2018/19.

Figure 1: GERD in current and constant 2015 Rand value (R million), South Africa, 1993/94 to 2019/20

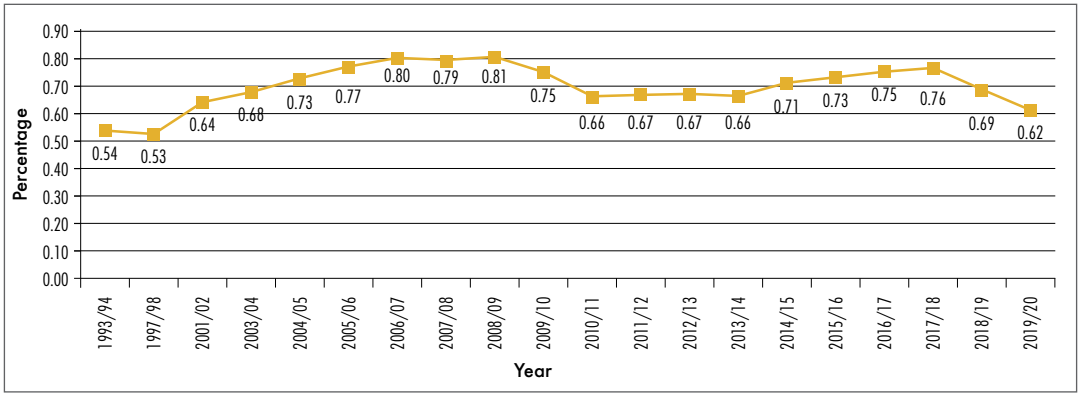


Data note	GDP deflator values derived from the fourth quarter release of the Stats SA GDP series P0441 (Stats SA 2021a) were used to calculate constant 2015 Rand values for R&D expenditure.
Data sources	Revised GDP (current values): Stats SA GDP Statistical Release P0441, Fourth quarter (Stats SA 2021a). R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2019/20. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE 1993; DACST 1996; DACST 2000).

1.1.2 GERD as a percentage of GDP

GERD as a percentage of GDP, a measure of R&D intensity, was 0.62% in 2019/20 (Figure 2). This indicator decreased by seven basis points from 0.69% in 2018/19. The trend data show that GERD as a percentage of GDP in South Africa increased steadily from 0.53% in 1997/98 and peaked at 0.81% in 2008/09. GERD as a percentage of GDP is now far below the maximum level of 0.81% reached in 2008/09, which was closest to the 2024 target of 1.1%. It is now closer to where it was at the turn of the century.

Figure 2: GERD as a percentage of GDP, South Africa, 1993/94 to 2019/20



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 Statistical Release P0441, Fourth quarter (Stats SA 2021a). R&D expenditure: National Survey of Research and Experimental Development, 2001/02 to 2019/20. R&D expenditure for the period prior to 2001/02 was sourced from archived data (DNE 1993; DACST 1996; DACST 2000).

1.1.3 International comparison

Public authorities expect that increased investment in R&D will intensify technological progress and, in turn, accelerate socio-economic growth. South Africa's R&D performance can be evaluated relative to that of comparable countries, bearing in mind the differing economic and structural status of the selected countries, and the availability of data. The selection of countries for comparison includes African, Latin American, OECD and BRICS countries with data for the survey period. In the BRICS grouping, Brazil and India do not have comparable data according to Frascati standards, and data for African and Latin American countries was not available for 2019/20. The groupings consist of middle- or upper-income countries, developed and developing countries, and selected world leaders in R&D performance.

Table 2 shows GERD for the selected countries in current millions PPP$ over the most recent three years to reflect trends over time in a comparable manner. Figure 3 shows changes in GERD as a percentage of GDP in 2018/19 and 2019/20 for selected countries. Table 2 and Figure 3 reflect the reference data that form the basis for comparative discussion of groups of cognate countries, relative to South African trends.

In general, the comparison shows that South Africa's GERD and R&D intensity are low compared to developed countries, such as the OECD countries, and also China and Russia. Its R&D expenditure is at the high end for developing countries. Whereas developed countries have generally increased

GERD as a percentage of GDP, developing economies, including South Africa, experienced declines in R&D intensity in 2019/20.

1.1.3.1 Comparing SA's GERD in current prices (PPP$) to developed and developing countries

The 2019/20 data shows that USA and China are world leaders in GERD investment, and largely maintained their growth trajectory.

The USA, China, Japan, and Germany continued to surpass the $100 000 million dollar mark, measured in current prices PPP$ (OECD 2021). France, Italy, Russia, Spain, and Turkey reported GERD of between $20 million and $60 million in current prices and were on a similar growth trajectory in 2019/20 (Table 2).

The USA, China, and Japan are global leaders in GERD investment (in PPP$).

Developing economies display a decreasing or stagnant growth trend in R&D activity, measured in current PPP$. The available data from developing countries between 2017/18 and 2018/19, such as Chile and Mexico in Latin America, and Egypt and Mauritius in Africa, indicate this.

The latest data on GERD in PPP$ for South Africa is from 2017/18 and 2018/19, which is low and stagnant compared to developed countries such as OECD countries of a similar size, with current GERD of around 6 billion PPP$ in 2017 and 2018. Mexico is the one OECD country similar to South Africa in size of R&D activity and direction of growth in R&D. Mexico is considered a developed economy by some organisations and a developing economy by others. South Africa displays a similar trend to all other developing countries (Table 2).

Table 2: GERD for selected countries (millions in current price PPP$), 2017/18 to 2019/20 or the latest available year

GEOGRAPHIC REGION	ECONOMIC BLOC	COUNTRIES	CURRENT million PPP$		
			2017	2018	2019
	OECD	United States of America	555 343	607 474	657 459
		Japan	166 621	172 785	173 267
		Korea	90 289	99 025	102 521
		Israel	15 873	17 366	18 740
		France	65 730	68 617	73 286
		Italy	34 488	37 044	39 279
		Spain	22 293	23 650	24 874
		Turkey	21 572	23 590	24 243
		Finland	7 147	7 559	7 956
		Poland	11 807	14 680	17 164
		Germany	133 668	142 080	148 149
LATIN AMERICA		Mexico	8 079	7 788	7 193
		Chile	1 608	1 623	b)
		Argentina	5 781	b)	b)
	BRICS	Russian Federation	42 246	41 693	44 500
		China	420 815	465 501	525 693
		South Africa	6 025	5 642	a)
AFRICA		Egypt	7 217	8 289	b)
		Mauritius	99	99	b)

Data note
a) Data not available
b) Time series break

Data source
Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Mexico, Poland, Russian Federation, South Africa, Spain, Turkey, USA: OECD (OECD 2021).
Egypt, Mauritius: UNESCO (UNESCO 2021).

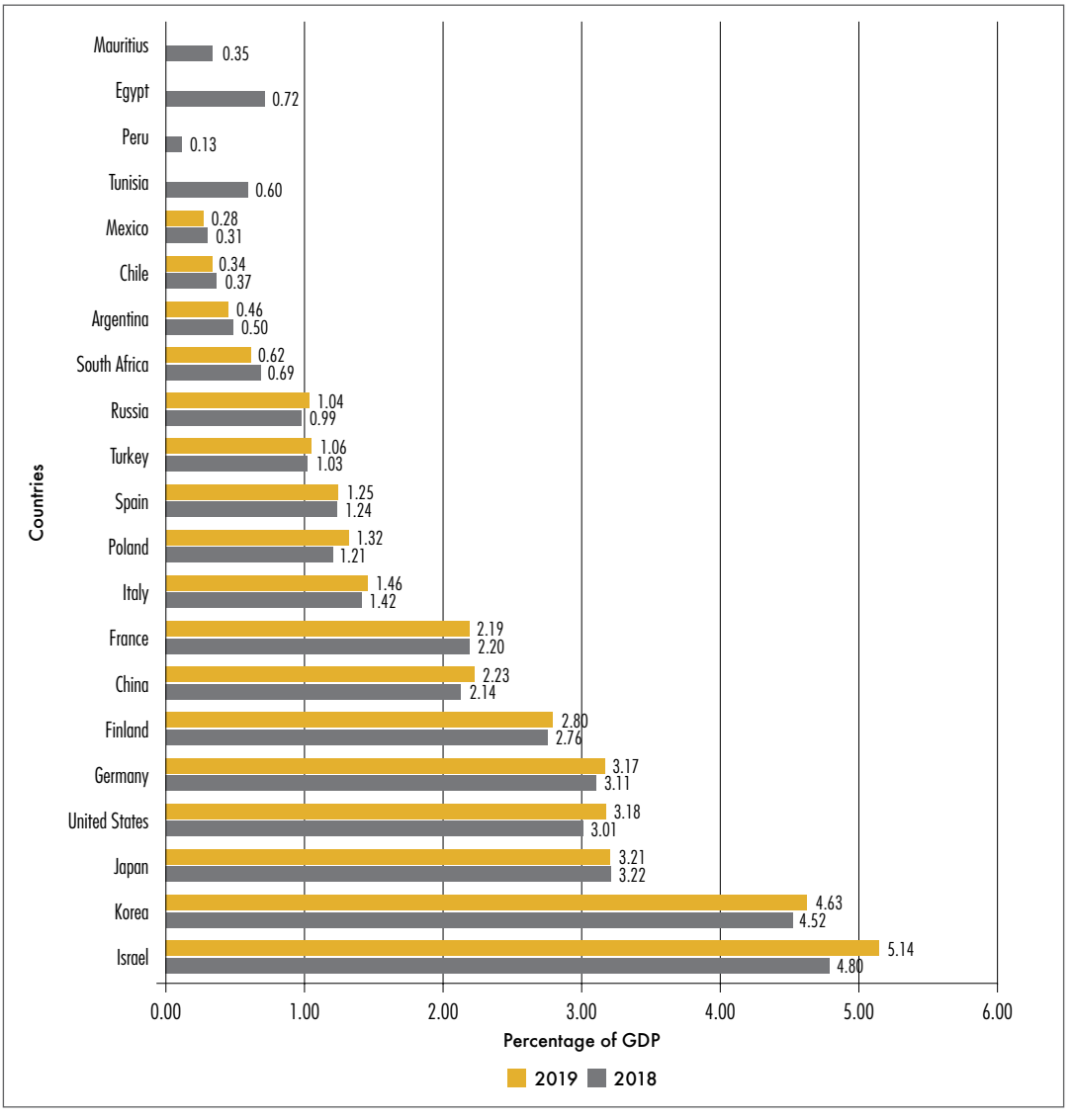
1.1.3.2 Comparing SA's GERD as a percentage of GDP to developed and developing countries

GERD as a percentage of GDP is a key indicator for the intensity of R&D in an economy. Most developed countries experienced increases in R&D intensity over 2018/19 and 2019/20. Some of these such as Spain, Japan and France reported only very slight increases or decreases (Figure 3). The biggest growth came from Israel, which increased their expenditure on R&D as a percentage of GDP by 0.34 percentage points. The USA, Korea, Poland and China also had relatively large increases in R&D intensity ranging from 0.17 to 0.09 percentage point increases.

Like South Africa, some developed countries experienced declines in R&D intensity in 2019/20.

R&D intensity in the developing economies reflected in Figure 3 has declined. Data indicating this is available from Argentina, Chile and Mexico, all of whom registered decreases of around 0.03 percentage points. South Africa recorded a decrease of 0.07 percentage points in 2019/20. At the time of writing this report, there was no available comparative data for other African countries.

Figure 3: GERD as a percentage of GDP for selected countries, 2018/19 and 2019/20 or latest available year



Data source South Africa: National Survey of Research and Experimental Development, 2018/19 and 2019/20.
Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Mexico, Poland, Russian Federation, Spain, Turkey, USA: OECD (OECD 2021).
Egypt, Peru, Tunisia, Mauritius: UNESCO (UIS 2021).

1.2 Patterns of R&D expenditure

1.2.1 R&D expenditure by accounting category

The Frascati Manual (OECD 2015) differentiates between two types of R&D expenditure: current expenditure and capital expenditure. Current expenditure distinguishes between two types of costs: labour costs and other current costs. Capital expenditure comprises all annual gross expenditure on fixed assets used for R&D performance, and includes the acquisition of software and licensing fees, databases lasting for more than one-year, and major repairs and modifications on land and buildings. In the 2019/20 survey, respondents reported on capitalised software as an additional category under capital expenditure.

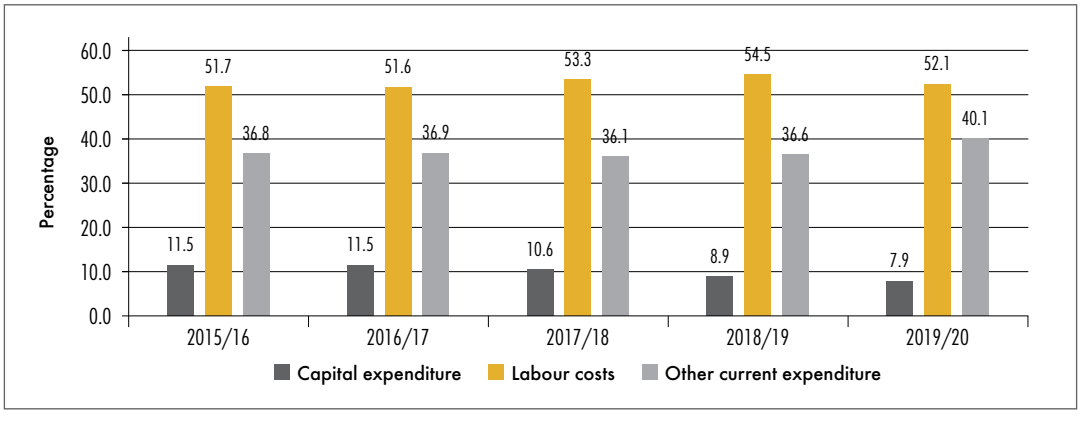
Labour costs of R&D personnel consist of annual wages, salaries, and all associated costs or fringe benefits. The share of R&D labour costs for the five years shown in Figure 4 has been consistently above 50.0% of GERD. In 2019/20 labour costs accounted for 52.1% of all R&D expenses, a decrease of 11.7% from the R20.051 billion reported in 2018/19 to R17.954 billion in 2019/20. This may be partially due to a reduction in the workforce devoted to R&D.

The decline in labour costs may be because of the decline in the R&D workforce.

Other current expenditure includes non-capital purchases of materials, supplies and equipment to support R&D. Other current expenditure equalled 40.1% of GERD, an increase of 3.5 percentage points from the 36.6% reported in 2018/19.

Capital expenditure on R&D has remained stagnant or even declined over the last five years.

Figure 4: R&D expenditure by accounting category (percentage), South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2019/20.

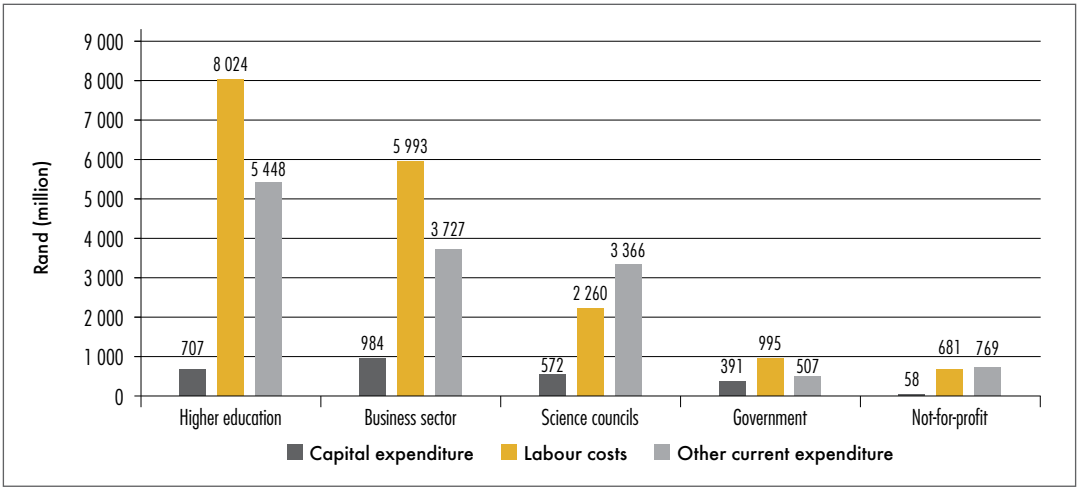
Figure 5 disaggregates R&D expenditure by accounting category for each institutional sector of performance. The business sector allocated the highest proportion of capital expenditure of R984 million, followed by the higher education sector at R707 million. The science council and government sectors had lower investments in capital expenditure of R572 and R391 million respectively. The not-for-profit sector spent the least proportionally on capital expenditure, that is, R58 million in 2019/20 compared to R103 million in 2018/19.

The higher education sector remains the largest spender on other current expenditure (R5.448 billion), followed by the business (R3.727 billion) and science council (R3.366 billion) sectors. The not-for-profit and government sectors reported lower other current expenditures of R769 million and R507 million respectively.

Current expenditure by the science council and not-for-profit sectors was larger than labour and capital expenditure. Labour costs for the higher education sector were the highest at R8.024 billion, followed by the business sector at R5.993 billion.

Science council expenditure increased in 2019/20, reflecting positive support from government for R&D in this sector, which is vital to addressing South Africa's challenges.

Figure 5: R&D expenditure by accounting category (R million), South Africa, 2019/20



Data source National Survey of Research and Experimental Development, 2019/20.

1.2.2 GERD by institutional sector

The higher education sector became the largest performer of R&D in South Africa in 2019/20, overtaking the business sector, and accounting for 41.4% of GERD (Figure 6). Higher education expenditure on R&D (HERD) in current expenditure amounted to R14.179 billion, an increase of R996 million from the R13.183 billion reported in 2018/19. At constant 2015 prices HERD amounted to R11.570 billion, an increase of R329 million from the R11.241 billion reported in 2018/19.

The business sector experienced a significant decline in R&D expenditure.

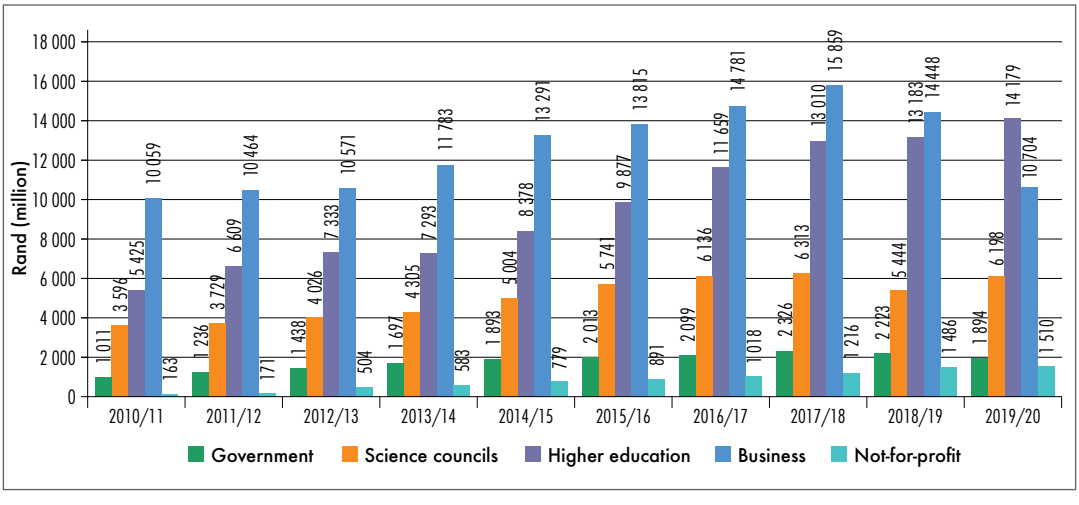
The business sector was the second largest performer of R&D in South Africa. In constant 2015 prices BERD decreased by R3.585 billion to R8.735 billion in 2019/20.

Proportionally, expenditure on R&D by science councils accounted for 18.0% of GERD in 2019/20. In constant 2015 Rand values, science council expenditure increased by 9.0%, from R4.642 billion in 2018/19 to R5.058 billion in 2019/20.

Government expenditure on R&D (GOVERD) constituted 5.5% of GERD. In constant 2015 Rand values, this represented a decrease of 18.5%, from R1.896 billion in 2018/19 to R1.545 billion in 2019/20.

The not-for-profit sector recorded a slight nominal increase of R24 million in expenditure. At constant 2015 Rand values this was in fact a decrease of R35 million from R1.267 billion to R1.232 billion.

Figure 6: R&D expenditure by sector (R million), South Africa, 2010/11 to 2019/20



Definition	The Frascati Manual (OECD 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, 2010/11 to 2019/20.

1.3 Business sector R&D

It is important to focus in greater detail on R&D expenditure to understand the trends within the business sector.

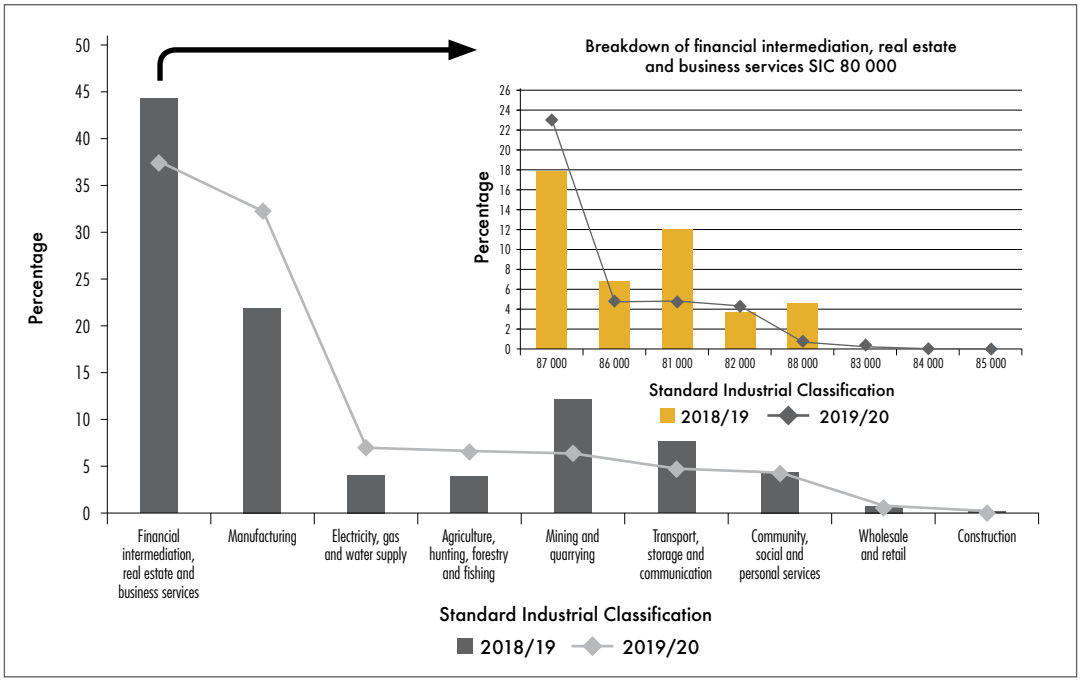
Disaggregation by Standard Industrial Classification codes allows for the identification of the industrial sectors where there was growth or decline in the R&D conducted, as well as shifts in the source and destination of R&D expenditure.

The industrial sector spending the largest proportion of BERD in 2019/20 was financial intermediation, real estate and business services (Table 3), which accounted for 37.7% of BERD (Figure 7). The manufacturing sector (Table 4) accounted for 32.3% of BERD, compared to 21.9% in the previous reference period (Figure 8). Disaggregation of the contribution of different subsectors (Figure 7) shows that research and development services (8700 in Table 3) contributed a higher percentage.

The manufacturing sector experienced a 10.4% increase in 2019/20. The mining sector, however, experienced a decline in expenditure, moving from 12.1% in 2018/19 to 6.4% in 2019/20. Figure 8 and Table 5 show the contribution of different manufacturing subsectors to BERD. There was an increase in R&D expenditure between 2018/19 and 2019/20 in four of the ten manufacturing subsectors (Figure 8), with the largest increase reported for manufacturing of refined petroleum, coke and nuclear fuel; chemical products (incl. pharmaceuticals) and rubber and plastic products (33000 in Table 2).

The manufacturing sector experienced a boom in GERD, while the mining, financial intermediation, real estate and business services and transport sectors experienced decreases.

Figure 7: Business R&D expenditure by Standard Industrial Classification (as a percentage of GERD), South Africa, 2018/19 to 2019/20



Data source National Survey of Research and Experimental Development, 2018/19 to 2019/20.

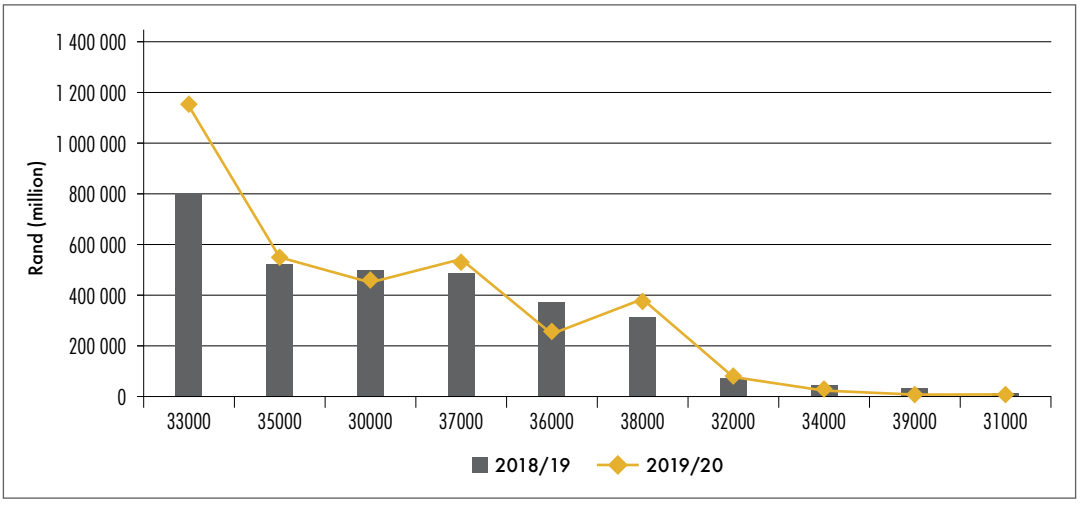
Table 3: Standard Industrial Classification codes in the financial intermediation, real estate and business services sector

81000	Financial intermediation, except insurance and pension funding
82000	Insurance and pension funding, except compulsory social security
83000	Activities auxiliary to financial intermediation
84000	Real estate activities
85000	Renting of machinery and equipment, and of personal and household goods
86000	Computer and related activities
87000	Research and development
88000	Other business activities

Definition Industry classification is based on Stats SA's five-digit SIC codes, which classify businesses according to economic activities.

Data source National Survey of Research and Experimental Development, 2018/19 to 2019/20.

Figure 8: Business R&D expenditure by manufacturing Standard Industrial Classification category (R million), South Africa, 2018/19 to 2019/20



Data source National Survey of Research and Experimental Development, 2018/19 to 2019/20.

Table 4: Standard Industrial Classification codes in the manufacturing sector

30000	Manufacture of food products, beverages and tobacco products
31000	Manufacture of textiles, clothing and leather goods
32000	Manufacture of wood and products, except furniture; paper products; publishing and printing material
33000	Manufacture of refined petroleum, coke and nuclear fuel; chemical products (incl. pharmaceuticals); rubber and plastic products
34000	Manufacture of non-metallic mineral products
35000	Manufacture of basic and fabricated metal products, machinery and equipment; office, accounting and computing machinery
36000	Manufacture of electrical machinery and apparatus
37000	Manufacture of radio, television and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks
38000	Manufacture of transport equipment
39000	Manufacture of furniture; recycling; manufacturing not elsewhere classified

Definition Industry classification is based on Stats SA's five-digit SIC codes, which classify businesses according to economic activities.

Data source National Survey of Research and Experimental Development, 2018/19 to 2019/20.

Table 5: Manufacturing and services sector R&D expenditure as a percentage of BERD, 2015/16 to 2019/20

SECTOR	2015/16	2016/17	2017/18	2018/19	2019/20
Services	55.5%	61.8%	62.4%	62.1%	54.7%
Manufacturing	32.2%	27.8%	28.2%	21.9%	32.3%

1.4 The focus of GERD expenditure on priority fields

It is increasingly recognised that R&D expenditure that is oriented to priority fields enables actors in the NSI to engage with development priorities. This section considers the focus of expenditure, by analysing the type of research conducted, and provides an overview of the main research field priorities by each institutional sector.

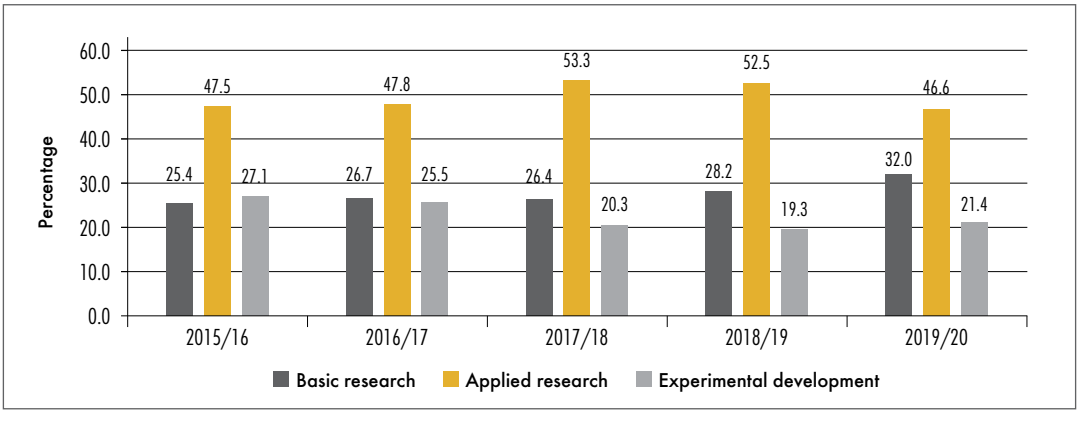
1.4.1 GERD by type of research

Applied research remained the dominant type of R&D conducted in South Africa in 2019/20, with a 46.6% share of GERD. The objective of applied research is to produce marketable products and services by determining possible uses for the results of previous research or finding new ways of achieving a goal. This can be beneficial in solving development challenges in South Africa.

While applied research has been the dominant type of research in South Africa for the past 10 years, basic research is steadily increasing.

Proportionally, there was a decrease in applied research in the 2019/20 reference year, and an increase in basic research and experimental development (Figure 9). Over five years, basic research increased from 25.4% in 2015/16 to 32.0% in 2019/20. However, the relative ranking of the three types of research (basic research, applied research and experimental development) has remained the same. Expenditure allocated to applied research appears to be on a declining trend, decreasing overall by 6.7 percentage points between 2017/18 and 2019/20. Experimental development experienced a slight increase, from 19.3% in 2018/19 to 21.4% in 2019/20.

Figure 9: GERD by type of research (percentage), South Africa, 2015/16 to 2019/20

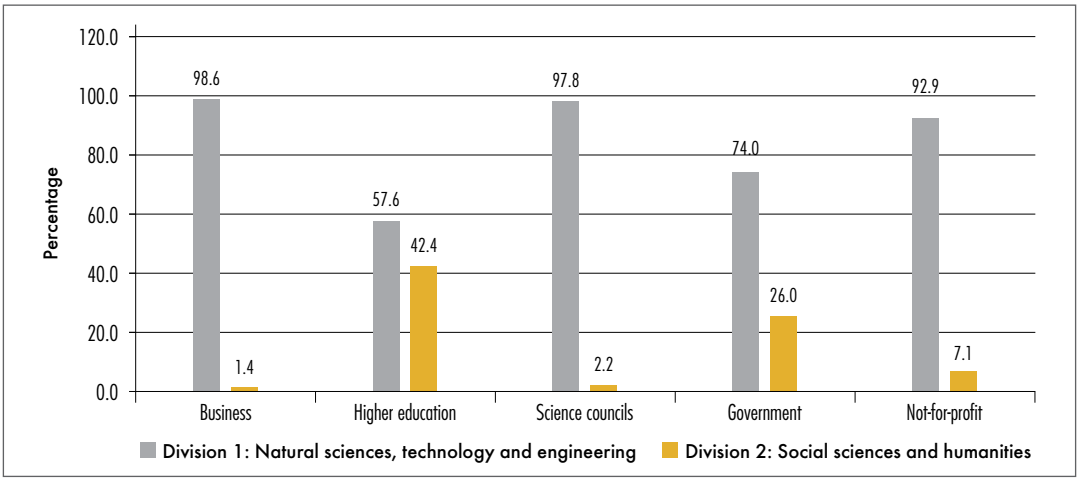


Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

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

The South African R&D Survey classifies research fields into two major categories: Division 1, which includes natural sciences, technology and engineering and Division 2, which represents social sciences and humanities. Across all institutional sectors, the largest share of GERD was reported in the Division 1 research fields, as expected because historically this category has received much more funding than the social sciences and humanities (Figure 10). The business sector devoted the largest share of R&D expenditure to the Division 1 fields (98.6%), closely followed by the science council sector (97.8%). The higher education and government sectors invested the most in the social sciences and humanities fields.

Figure 10: R&D expenditure by research field and sector (percentage), South Africa, 2019/20



Data note	The Frascati Manual (OECD 2015) classifies the fields of research (FORD) as follows: natural sciences, engineering and technology, medical and health sciences, agricultural and veterinary sciences, social sciences and humanities and art sciences. Data in South Africa is collected according to most of the research fields in FORD and can be aggregated or disaggregated in the FORD format.
Data source	National Survey of Research and Experimental Development, 2019/20.

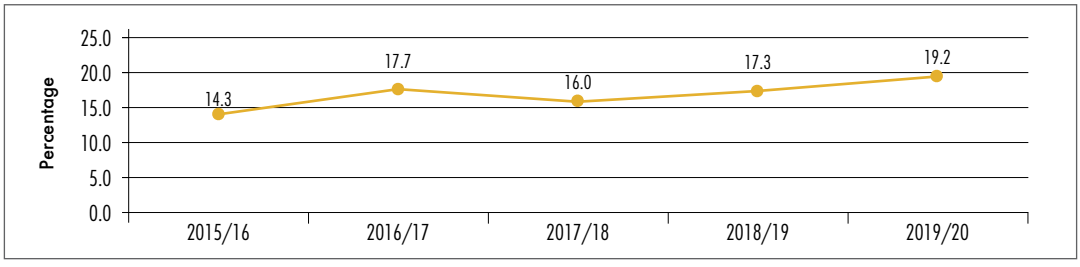
1.4.3 R&D in state-owned enterprises

1.4.3.1 SOE R&D expenditure as a proportion of BERD

Figure 11 presents data on SOE expenditure on R&D as a percentage of BERD over the past five years. This indicates growth between 2015/16 and 2019/20. The last two years shows a potential increase in SOEs R&D spend.

A state-owned entity (SOE) is a legal entity created by government to participate in commercial activities. For two consecutive years R&D expenditure has increased in SOEs.

Figure 11: SOE R&D expenditure as a percentage of BERD, South Africa, 2015/16 to 2019/20

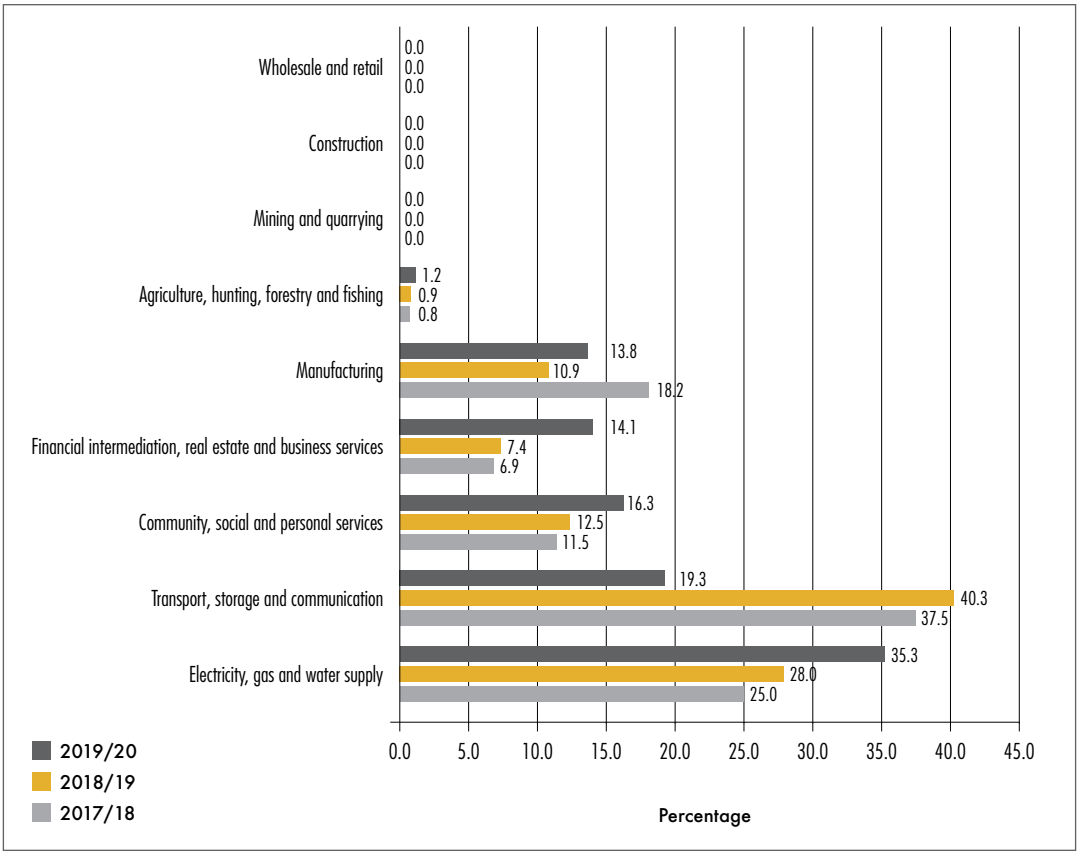


Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

1.4.3.2 Proportional SOE R&D expenditure by SIC code

Figure 13 shows that there are six major industrial sectors where SOE activity in R&D is prominent. The mining and quarrying, construction and wholesale and retail trade sectors do not have significant levels of SOE R&D activity. By contrast, R&D expenditure by SOEs was highest in the transport, storage and communication sector in 2018/19 but recorded a decline to below 20% in 2019/20. There was growth in the electricity, gas and water supply sector, which recorded the highest levels of R&D expenditure in 2019/20. Other sectors such as agriculture and manufacturing recorded R&D expenditure below 20% (Figure 13).

Figure 12: SOEs proportional R&D expenditure by Standard Industrial Classification code (2017/18 to 2019/20)

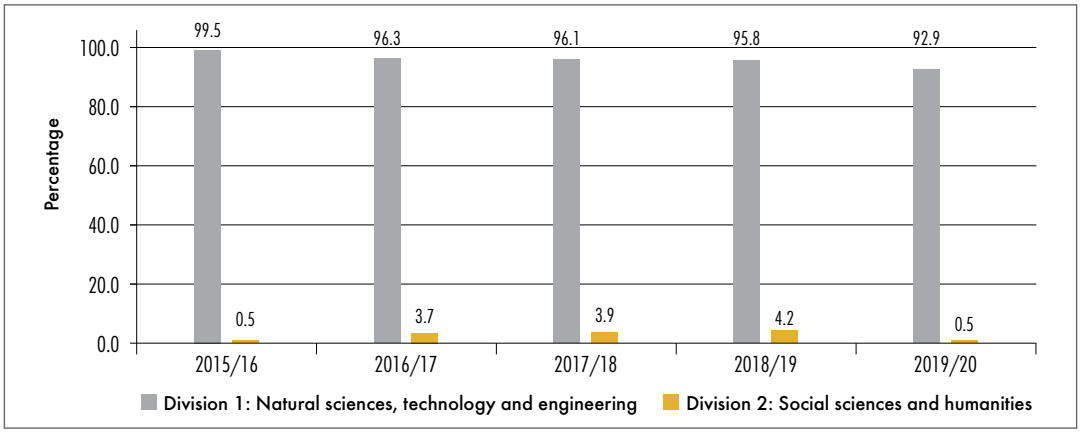


Data source National Survey of Research and Experimental Development, 2017/18 to 2019/20.

1.4.3.3 SOE R&D expenditure by research field

Not surprisingly, given the concentration of SOEs in industrial areas, R&D expenditure by SOEs was significantly higher in Division 1 (natural sciences, technology and engineering), compared with Division 2 (social sciences and humanities) over the five-year period (Figure 12).

Figure 13: SOE R&D expenditure by research field, South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

1.4.4 Select priority areas in R&D: the case of health

Globally, countries are faced with unique health challenges exacerbated by the current COVID-19 pandemic. Health care has long been one of South Africa's most pressing national development priorities. The coronavirus pandemic has heightened the urgent need to grow R&D investment in the domain of health related to the country's burden of disease.

The COVID-19 pandemic highlights the need to invest in health knowledge. Financing for health R&D has grown overall over the past five years.

Health R&D is defined as R&D that is relevant to human health. Data was extracted by extrapolating 'health' codes, based on the fields of research specified within the South African R&D Survey. These research fields are presented at national level across all economic sectors (Table 6).

Table 6: Health R&D by main research field (R million), 2019/20

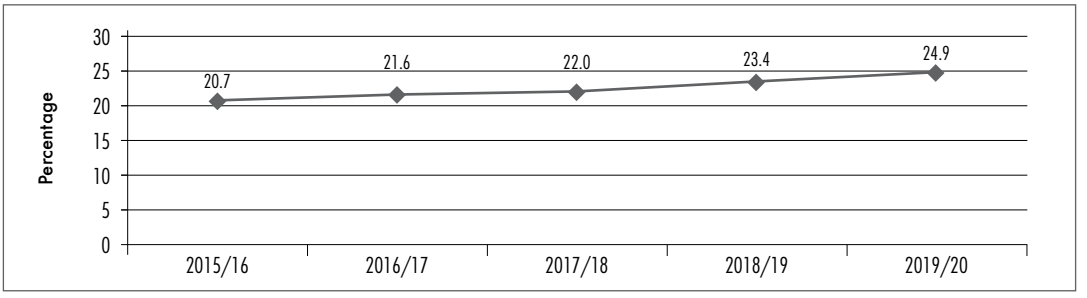
MAIN RESEARCH FIELD	BUSINESS	GOVERNMENT	HIGHER EDUCATION	NOT-FOR-PROFIT	SCIENCE COUNCILS	TOTAL
	R'000	R'000	R'000	R'000	R'000	R'000
Physical sciences	0	0	722	1616	0	**2 338**
Biological sciences	103 950	95 821	585 313	53 734	45 856	**884 675**
Medical and health sciences	2 395 653	167 039	2 759 378	1 200 011	885 544	**7 407 626**
Social sciences	0	0	285 217	498	2 316	**288 031**
Total	2 499 603	262 860	3 630 631	1 255 859	933 716	8 582 668
Total % to GERD	7.2	0.8	10.5	3.6	2.7	24.9

Data source National Survey of Research and Experimental Development, 2019/20.

1.4.4.1 Health R&D over time

Figure 14 presents data on health R&D as a percentage of GERD over the past five years. The five-year trend shows continuous growth in health R&D. This is key to addressing South Africa's health challenges.

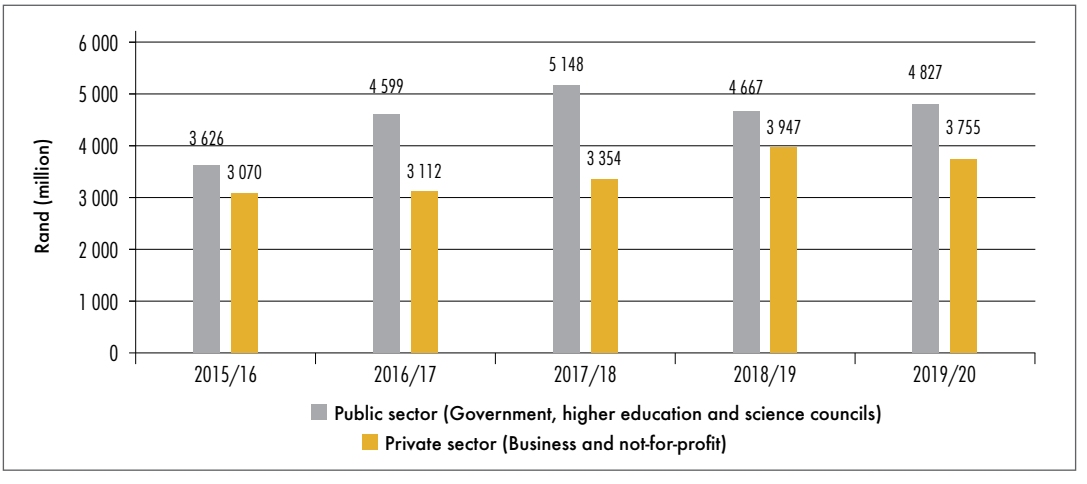
Figure 14: Health R&D as a percentage of GERD, South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

The public sector (government, higher education and science councils) is the largest investor in health R&D in South Africa, a trend that has continued over the past five years (Figure 15). Although decreasing proportionately in 2017/18 as the public purse tightened, expenditure increased slightly from 2018/19. The public sector invested 56.2% of funding in health R&D, and the private sector (business and not-for-profits) 43.8%. Public sector funding for health R&D increased by 3.4% from R4.667 billion in 2018/19 to R4.827 billion in 2019/20. Private sector funding of health R&D, however, decreased by 4.9% to R3.755 billion in 2019/20 (Figure 15).

Figure 15: Public versus private health R&D (R million), South Africa, 2015/16 to 2019/20

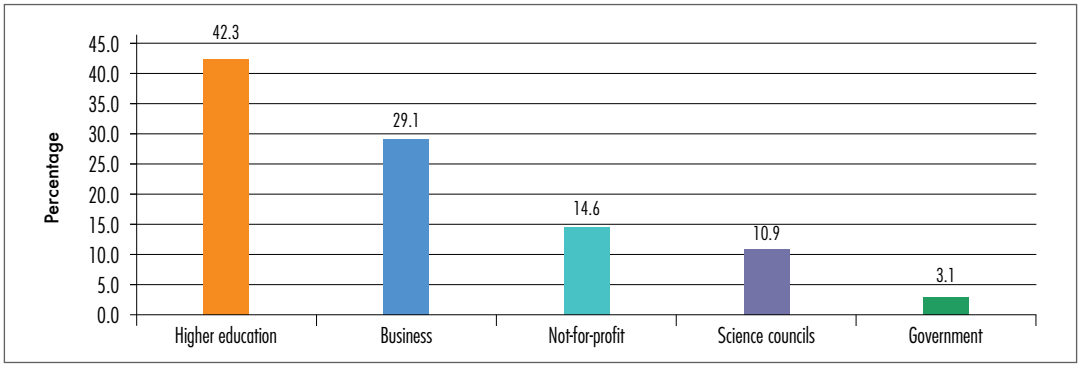


Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

The higher education sector invested the largest share of institutional expenditure in health R&D, investing R3.361 billion (42.3%) in 2019/20. This was followed by the business sector which spent R2.450 billion (29.1%) over the same period. The not-for-profit sector was the third largest contributor to health R&D investment spending R1.256 million (14.6%), followed by science councils with R934 million (10.9%).

The public sector is the main driver of health R&D in the country.

Figure 16: Health R&D by sector (percentage), 2019/20

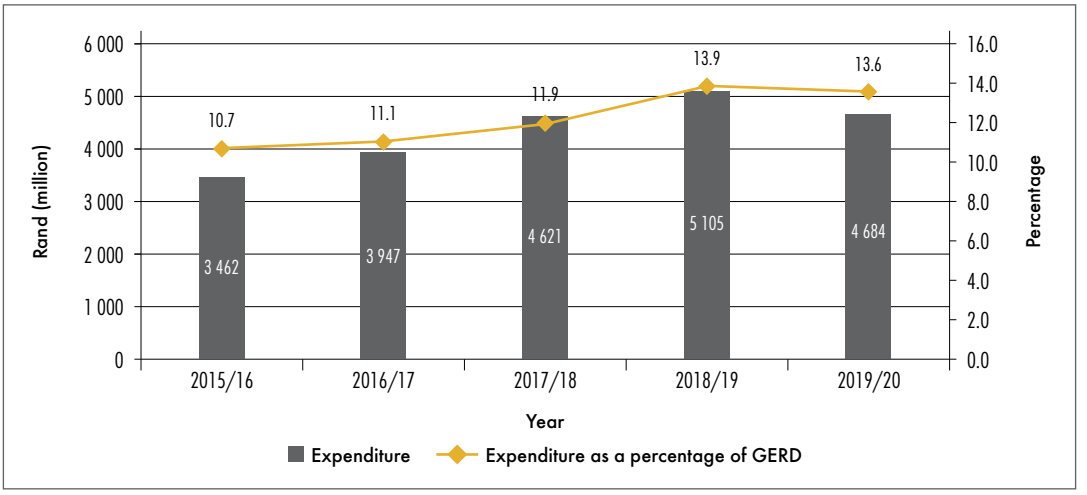


Data source National Survey of Research and Experimental Development, 2019/20.

1.4.3.2. R&D on tuberculosis, HIV/AIDS and malaria

The R&D Survey collects specific indicators relating to communicable and non-communicable health, given the health challenges experienced in the country. Investment in R&D in priority areas of health research related to South Africa's burden of disease, specifically TB, HIV/AIDS and malaria, increased from R3.462 billion in 2015/16 to R4.684 billion in 2019/20 (Figure 17). R&D investment over the last five years in these health-related fields confirms the priority accorded them. This investment lays the foundation for the development of vaccines and effective diagnostic tools to greatly improve health conditions. However, as a percentage of GDP, expenditure decreased by 0.3 of a percentage point from 13.9% in 2018/19 to 13.6% in 2019/20.

Figure 17: R&D expenditure on TB, HIV/AIDS and malaria (R million and as a percentage of GERD), South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

1.4.5 Select priority areas: the case of green R&D

Research and experimental development focused on sustainability of natural resources, environmental impact, animal and plant sciences, energy research, economic impact, sustainable development, mobility, and engineering science are considered 'green R&D'. Reducing pollution, implementing green technologies for waste disposal, mitigating climate change and adapting to it, as well as improving water scarcity management all contribute to a greener economy. The R&D Survey contributes to understanding efforts to green the economy by providing relevant green R&D indicators.

Investment in green R&D in South Africa supports the transition to a green economy.

1.4.5.1 Investment in green R&D by research field and sector of performance

Green R&D expenditure amounted to 20.1% (R6.932 billion) of GERD, an increase of R534 million from the R6.398 billion reported in 2018/19. Division 1 (natural sciences, technology and engineering) spent R6.597 billion. By comparison, not much expenditure was reported in Division 2 (social sciences and humanities), which was R336 million in 2019/20 (Table 7).

Green R&D activity is shared equally between the higher education, business and science council sectors. More precisely, the largest share of green R&D expenditure was in the higher education sector, with R2.111 billion, followed by the business and science council sectors, spending R1.990 and R1.662 billion respectively. Government is also a relatively big spender on green R&D, although the

growth is stagnant. The government and not-for-profit sectors had similar expenditure on green R&D in 2019/20 as in 2018/19: R1.069 billion (R1.013 billion in 2018/19) and R100 million (R102 million in 2018/19) respectively.

The areas of spending in the different sectors do not overlap entirely, although agricultural sciences are common areas of research in the leading sectors. Within Division 1, higher education led with R&D investment in agricultural sciences (R518 million), biological sciences (R515 million) and earth sciences (R333 million). Business sector expenditure was higher for agricultural science, at R1.071 billion, and engineering at R325 million.

The science council sector's highest green R&D expenditure was in agricultural sciences at R886 million, environmental sciences (R283 million), and earth sciences (R231 million). Government expenditure on green R&D was highest in the agricultural sciences at R591 million, biological sciences and earth sciences, with R173 million and R163 million respectively.

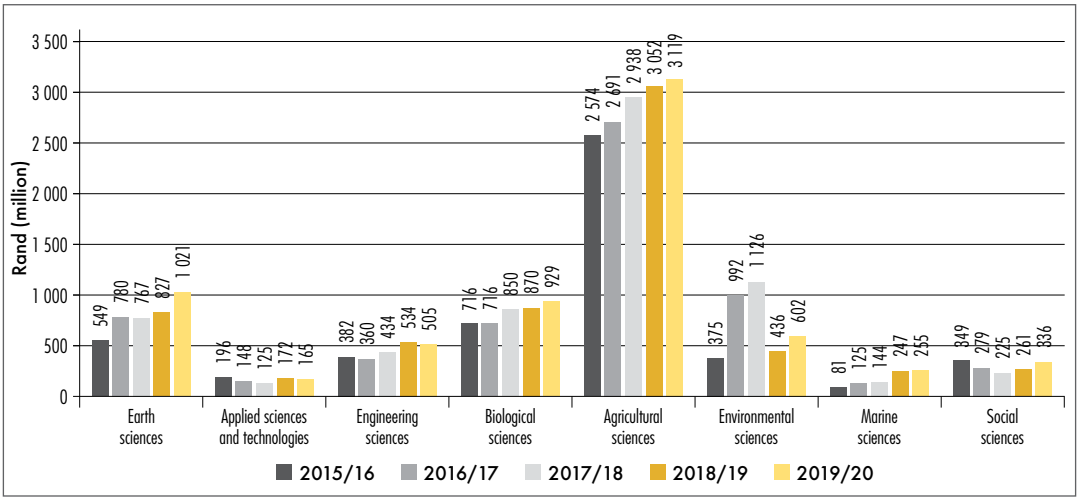
The expenditure on green R&D in the social sciences and humanities came from higher education (R318 million), government (R15 million), and business (R2 million) sectors.

Table 7: Green R&D expenditure by research field, 2019/20

MAIN RESEARCH FIELD	BUSINESS	NOT-FOR-PROFIT	GOVERNMENT	SCIENCE COUNCILS	HIGHER EDUCATION	TOTAL
	R'000	R'000	R'000	R'000	R'000	R'000
Division 1: Natural sciences, technology and engineering	1 988 257	99 757	1 053 776	1 661 803	1 793 055	6 596 647
Earth sciences	285 180	7 532	163 319	231 490	333 039	1 020 560
Applied sciences and technologies	70 746	0	17 226	0	76 838	164 810
Engineering sciences	325 453	0	5 010	0	174 764	505 227
Biological sciences	105 448	13 986	172 617	122 425	515 244	929 718
Agricultural sciences	1 070 593	52 884	591 668	886 212	517 978	3 119 335
Environmental sciences	130 311	23 586	29 249	283 782	135 137	602 065
Marine sciences	526	1 770	74 686	137 894	40 056	254 931
Division 2: Social sciences and humanities	2 121	0	15 203	0	318 370	335 694
Social sciences	2 121	0	15 203	0	318 370	335 694
Total	1 990 378	99 757	1 068 978	1 661 803	2 111 425	6 932 341

Data source National Survey of Research and Experimental Development, 2019/20.

Figure 18: Green R&D expenditure by research field (R million), South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

Figure 18 shows the disaggregation of green R&D by research field over five years. The largest share was in the agricultural sciences with R3.119 billion spent in 2019/20. The agricultural sciences field has shown consistent growth since 2015/16. Earth sciences was the second largest field, spending R1.021 billion in 2019/20, followed by biological sciences, which spent R929 million over the same period. Environmental sciences showed some growth, with spend increasing from R436 million to R602 million in 2019/20. This is a positive indication given the 61.3% decrease, from R1.126 billion in 2017/18 to R436 million in 2018/19.

Agriculture remains a viable option to boost R&D in South Africa through promoting growth of existing linkages across sectors.

1.4.5.2 Green R&D investments by socio-economic objective and sector of performance

Table 8: Green R&D by socio-economic objective from 2015/16 to 2019/20

SOCIO-ECONOMIC OBJECTIVE	2015/16	2016/17	2017/18	2018/19	2019/20
	R'000	R'000	R'000	R'000	R'000
Economic development	3 834 899	4 288 313	4 516 366	4 621 638	4 881 165
Plant production and plant primary products	1 414 277	1 539 767	1 584 868	1 672 631	1 795 170
Animal production and animal primary products	655 059	729 713	696 895	675 314	681 260
Energy resources	35 179	38 710	6 682	16 901	84 627
Energy supply	332 137	398 643	441 429	488 798	519 597
Commercial services	68 565	62 324	60 321	65 698	73 735
Economic framework	565 782	660 209	824 174	678 769	619 762
Natural resources	763 900	858 947	901 997	1 023 527	1 107 014
Environment	1 458 273	2 015 344	1 999 703	2 081 419	1 800 511
Environmental knowledge	840 485	969 476	983 976	934 482	995 835
Environmental aspects of development	299 812	361 391	309 051	411 672	375 020
Environmental and other aspects	317 975	684 478	706 676	735 265	485 686
Advancement of knowledge	640 544	791 520	797 471	954 788	876 562
Natural sciences, technologies and engineering	640 544	791 520	797 471	954 788	876 562
Total	5 933 715	7 095 177	7 313 540	7 657 845	7 614 269

Data source National Survey of Research and Experimental Development, 2019/20.

More green R&D investment in energy resources is required to address South Africa's energy crisis.

Table 8 shows expenditure on green R&D by socio-economic objective from 2015/16 to 2019/20, reflecting a steady increase over the five-year period, from R5.934 billion in 2015/16 to R7.614 billion in 2019/20. Over five years, R&D expenditure remained consistent across all the fields. In 2019/20 R&D was concentrated within plant production and plant primary products (23.6%) followed by natural resources (14.5%), environmental knowledge (13.0%) and the natural sciences, technologies and engineering (11.5%). Only 1.1% of green R&D was devoted to energy resources. Although this proportion has grown from 0.2% in 2018/19, more investment is needed given the country's energy supply shortage and resultant loadshedding. This field of research and sector of performance should be closely monitored to address the energy crisis and provide alternative energy sources.

Table 9 shows expenditure on green R&D by socio-economic objective and sector of performance. The sector with the largest share of green R&D is higher education with 42.6% (R3.247 billion) of total green expenditure. The second largest sector was business with 24.4% (R1.855 billion), followed by

the science council sector at 19.3% (R1.466 billion) and government sector at 12.4% (R0.941 billion). Green R&D was more prevalent in plant production and plant primary products, energy supply, economic framework and natural resources.

Economic development accounts for most green R&D spending at R4.881 billion, followed by the environment at R1.857 billion, and knowledge advancement at R877 million. For green R&D that contributed to economic development, the largest expenditure was in the plant production and plant primary products SEO, at R1.585 billion. A total of R1.632 billion came from business investment, while R1.585 billion came from higher education.

Green R&D is mostly invested in the public sector (government, higher education and science councils) (74.3%). Further R&D investment within the private sector (business and not-for profit organisations) is needed to assist South Africa to reduce environmental risks and ecological scarcities to protect the environment.

Table 9: Green R&D expenditure by SEO and sector of performance, 2019/20

SOCIO-ECONOMIC OBJECTIVES	BUSINESS	NOT-FOR-PROFIT	GOVERN-MENT	SCIENCE COUNCILS	HIGHER EDUCATION	TOTAL
	R'000	R'000	R'000	R'000	R'000	R'000
Economic development	1 632 274	44 479	700 748	918 289	1 585 375	4 881 165
Plant production and plant primary products	919 470	23 124	127 551	290 267	434 759	1 795 170
Animal production and animal primary products	45 062	2 378	141 189	207 333	285 298	681 260
Energy resources	58 990	0	0	11 155	14 483	84 627
Energy supply	371 810	3 454	9 475	2 036	132 823	519 597
Commercial services	61 156	0	1 871	0	10 708	73 735
Economic framework	151 232	8 272	151 887	90 884	217 486	619 762
Natural resources	24 554	7 251	268 776	316 614	489 819	1 107 014
Environment	195 663	37 194	191 622	423 727	1 008 336	1 856 541
Environmental knowledge	57 772	22 225	123 194	373 973	418 671	995 835
Environmental aspects of development	16 820	6 393	48 503	0	303 303	375 020
Environmental and other aspects	121 070	8 576	19 924	49 754	286 362	485 686
Advancement of knowledge	27 335	22 988	49 063	124 298	652 879	876 562
Natural sciences, technologies and engineering	27 335	22 988	49 063	124 298	652 879	876 562
Total	1 855 271	104 660	941 433	1 466 314	3 246 590	7 614 269

Data source National Survey of Research and Experimental Development, 2019/20.

Section 2:

- Analyses **major flows** between R&D funders and performers.
- Explores government, business, and **foreign sources** of R&D funding.
- Compares **international funding** flows.
- Maps the **spatial dimension** of R&D funding in South Africa's provinces.

2.1 Major flows of R&D funding

Funding from government increased by 11.1% in 2019/20 and continues to fund the largest proportion of R&D in South Africa (Figure 19). This funding increased from R17.475 billion in 2018/19 to R19.417 billion in 2019/20 and represented 56.3% of total R&D funding. Higher education institutions received the largest share of total government funding at 67.9% (R13.183 billion), followed by science councils at 28.3% (R5.493 billion), and government institutions at 8.7% (R1.682 billion). Funding to the government sector decreased from R1.898 billion in 2018/19 to R1.682 billion in 2019/20. The business sector's share of government funding increased significantly from R215 million in 2018/19 to R649 million in 2019/20. The not-for-profit sector was the smallest recipient of government funding, receiving R212 million in 2019/20.

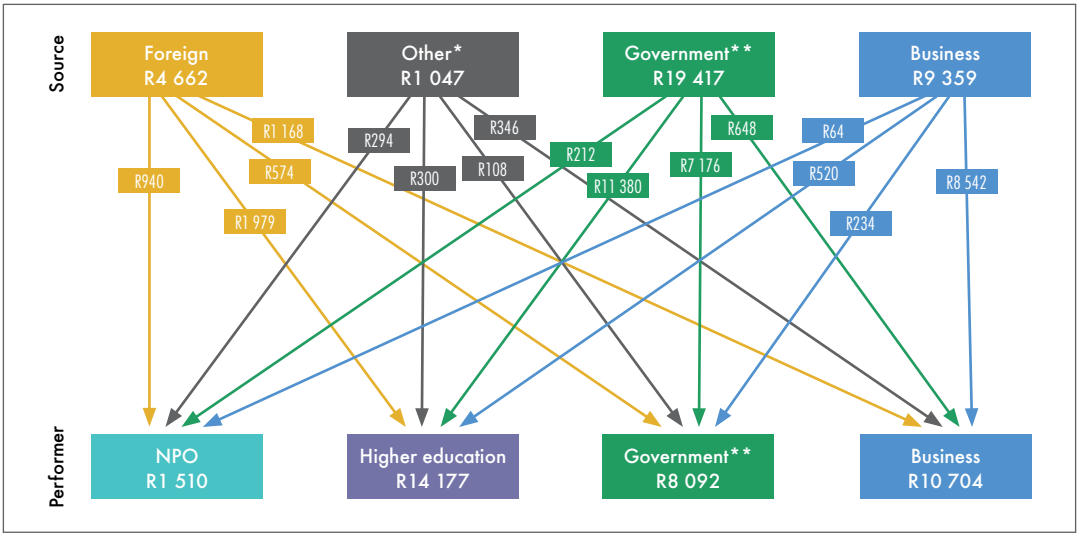
The South African government funded 56.3% of R&D in South Africa in 2019/20, an increase from the 47.5% funded in 2018/19.

The business sector (including SOEs) was the second-largest funder of R&D, contributing 27.1% (R9.359 billion) towards total domestic R&D funding. This was a large decrease from the 39.5% (R14.534 billion) funded in 2018/19. The business sector continued to fund R&D using its own sources of funds, which amounted to 91.3% (R9.359 billion) of total business R&D funding. The rest was allocated mainly to the higher education and science council sectors, with R520 million (5.6%) and R192 million (2.0 %) respectively.

Funding from the business sector decreased from 39.5% to 27.1% whereas foreign funding continued to increase year-on-year.

Foreign sources were the third largest funder of R&D, amounting to 24.1% (R4.662 billion) in 2019/20, which was more than double that recorded in 2018/19. Most of the foreign funding was directed to the higher education sector (42.6%).

Figure 19: Major flows of funding for R&D (R million), South Africa, 2019/20



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, 2019/20.

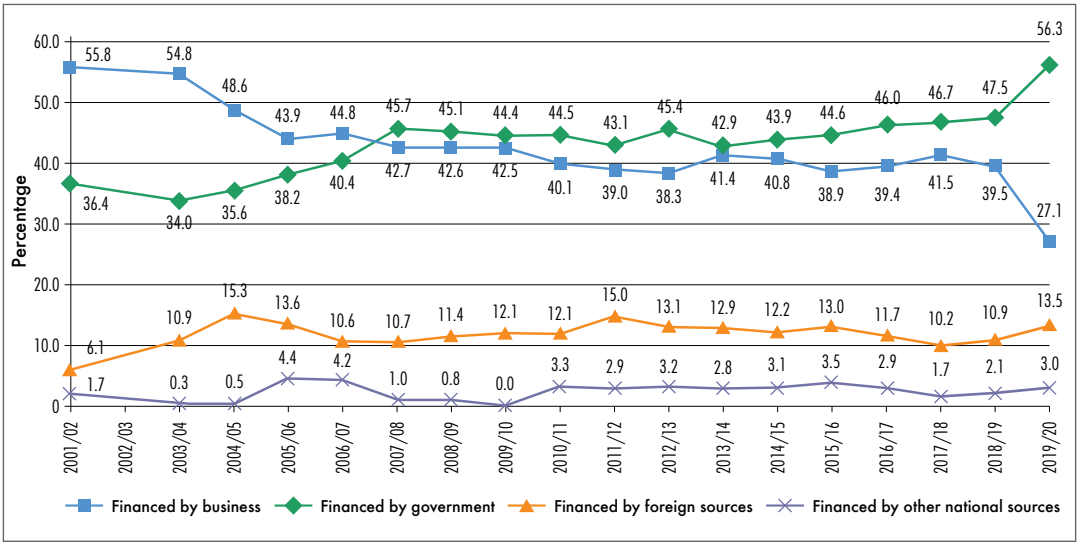
2.2 GERD by sources of funds

2.2.1 Trends over time

Government and business enterprises continued to fund the largest proportion of GERD in South Africa in 2019/20 (Figure 20). Government has remained the largest funder of R&D activity since 2007/08 and increased the proportion of R&D it funds in 2019/20. Funding of R&D from the business sector decreased by a relatively large 12.4 percentage points from 2018/19 (39.5%) to 2019/20 (27.1%). This was the lowest proportion of funding from the business sector since 2001/02. Foreign funding is significant, and increased by 13.2%, from 10.9% in 2018/19, while contributions from higher education, not-for-profit organisations and individual donations increased by 0.9% from 2.1% in 2018/19 to 3.0% in 2019/20.

Business funding for R&D in 2019/20 decreased by 12.4% year-on-year but remained the second largest R&D funder after government.

Figure 20: GERD by source of funds (percentage), South Africa, 2001/02 to 2019/20



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 2019/20.

2.2.2 Business-funded R&D

In 2019/20, business sector funding decreased by R5.246 billion from 2018/19. Higher education received a 2.0% increase from the business sector, whereas government received a substantial increase in R&D funding from business from R4 million in 2018/19 to R43 million in 2019/20. Business funding for R&D in the science council sector decreased by 7.3%, from R207 million in 2018/19 to R192 million in 2019/20. Similarly, funding of R&D from business sources to the not-for-profit sector decreased by 12.0% (Figure 21).

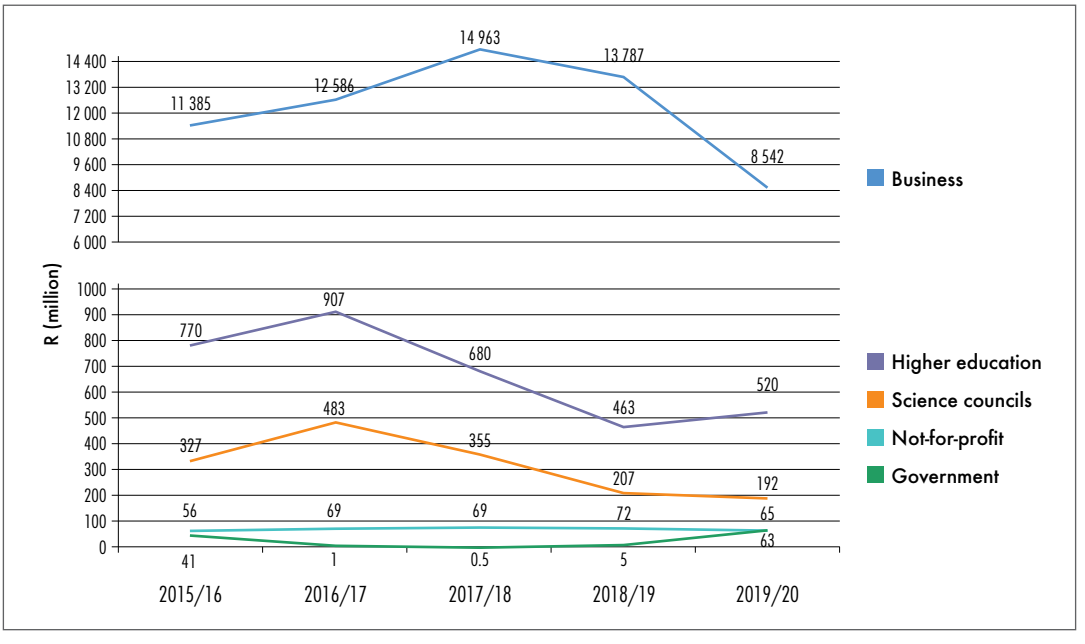
Table 10: Business-funded R&D by sector of performance (R'000), South Africa, 2015/16 to 2019/20

SECTOR	2015/16	2016/17	2017/18	2018/19	2019/20
Business	11 384 709	12 586 109	14 963 198	13 787 512	8 541 773
Not-for-profit	55 584	68 705	68 747	71 937	62 965
Government	41 109	1 261	519	4 614	64 664
Science councils	326 647	483 166	354 820	206 648	191 520
Higher education	770 448	906 651	679 563	463 413	519 848
Total (current Rand value)	12 578 497	14 045 892	16 066 846	14 534 123	9 358 770
*Total (constant 2015 Rand value)	9 513 948	9 957 895	10 771 991	9 377 117	8 735 099

Data note *GDP deflator values derived from Stats SA (2021a) were used to calculate constant 2015 Rand values for R&D expenditure.

Data source Revised GDP (current values) Stats SA GDP statistical release P0441 (2020, Fourth quarter) (Stats SA 2021a).
National Survey of Research and Experimental Development, 2015/16 to 2019/20.

Figure 21: Business-funded R&D by sector of performance (R million), South Africa, 2015/16 to 2019/20



Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

2.2.3 Government funding of local R&D

Government funding increased by R1.942 billion in 2019/20 and is still the largest funder (56.3%) of R&D nationally (Table 11). Higher education institutions and science councils continued to be the largest recipients of government funding. The higher education sector received the highest proportion of government funding, R11.380 billion in 2019/20, an increase of R879 million (8.0%). Similarly, government funding of R&D to the science council sector increased by 18.0%, from R4.644 billion in 2018/19 to R5.493 billion in 2019/20. Funding from government to business nearly tripled over one year, increasing from R215 million to R649 million in 2019/20. Funding of R&D for other government departments, such as research institutions and museums (excluding science councils), decreased by 11.0%, whereas funding for the not-for-profit sector decreased by R4 million.

Table 11: Government-funded R&D (R'000), South Africa, 2015/16 to 2019/20

SECTOR	2015/16	2016/17	2017/18	2018/19	2019/20
Business	522 631	453 958	371 165	214 541	648 604
Not-for-profit	161 682	143 623	142 908	216 922	212 118
Government	1 425 598	1 530 964	1 769 929	1 898 230	1 682 484
Science councils	4 922 222	5 076 805	5 311 190	4 644 414	5 493 352
Higher education	7 393 857	9 222 246	10 486 989	10 501 066	11 380 375
Total (current Rand value)	14 425 990	16 427 596	18 082 182	17 475 173	19 416 933
*Total (constant 2015 Rand value)	10 911 329	11 593 995	12 123 170	11 274 621	15 844 658

Data note: *GDP deflator values derived from Stats SA (2021a) were used to calculate constant 2015 Rand values for R&D expenditure.

Data source: Revised GDP (current values) Stats SA GDP statistical release P0441 (2020, Fourth quarter)
National Survey of Research and Experimental Development, 2015/16 to 2019/20.

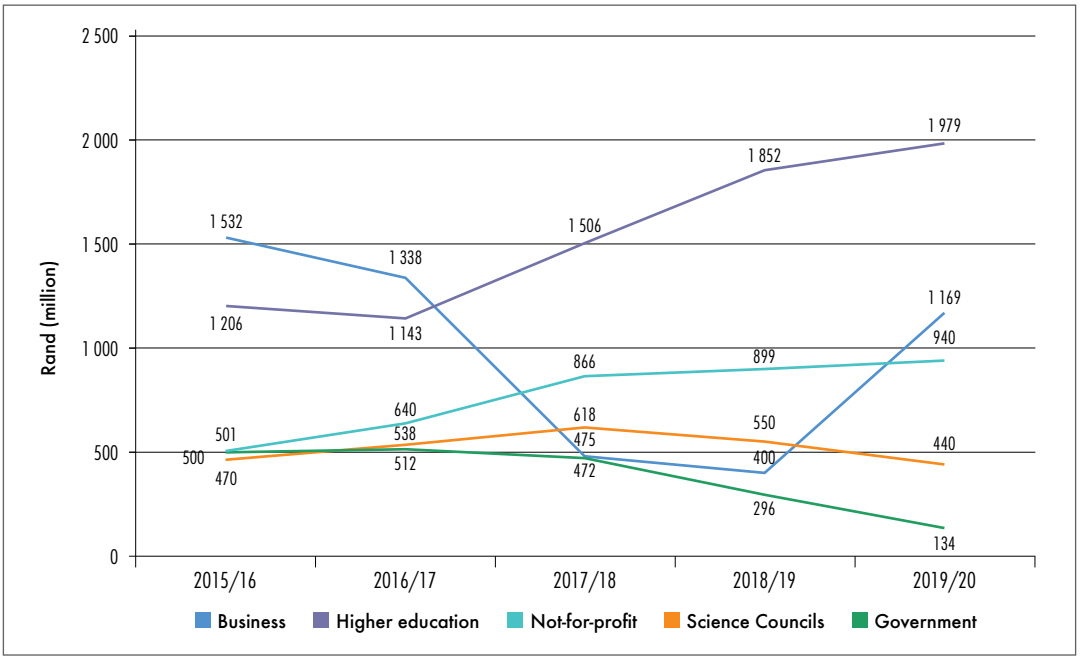
2.2.4 Foreign funding of local R&D

R&D funding from abroad increased by 16.6% from R3.999 billion in 2018/19 to R4.662 billion in 2019/20 (Figure 22). The higher education sector received the largest share of foreign funding at R1.979 billion (42.5%), followed by the business sector at R1.169 billion (25.0%). The proportion of funding to the business sector represents 191.8% growth from the R400 million allocated in 2018/19. Foreign funding of R&D to the not-for-profit sector increased slightly by 4.6%.

Foreign funding for R&D increased in 2019/20, with large investments directed to the higher education and business sectors.

Foreign funding for R&D in the government and science council sectors declined. The government sector experienced the largest decline in foreign funding for R&D by 54.9%, from R297 million in 2018/19 to R134 million in 2019/20, while the science council sector experienced a 20.1% decrease (R111 million).

Figure 22: Foreign-funded R&D by sector of performance (R million), South Africa, 2015/16 to 2019/20

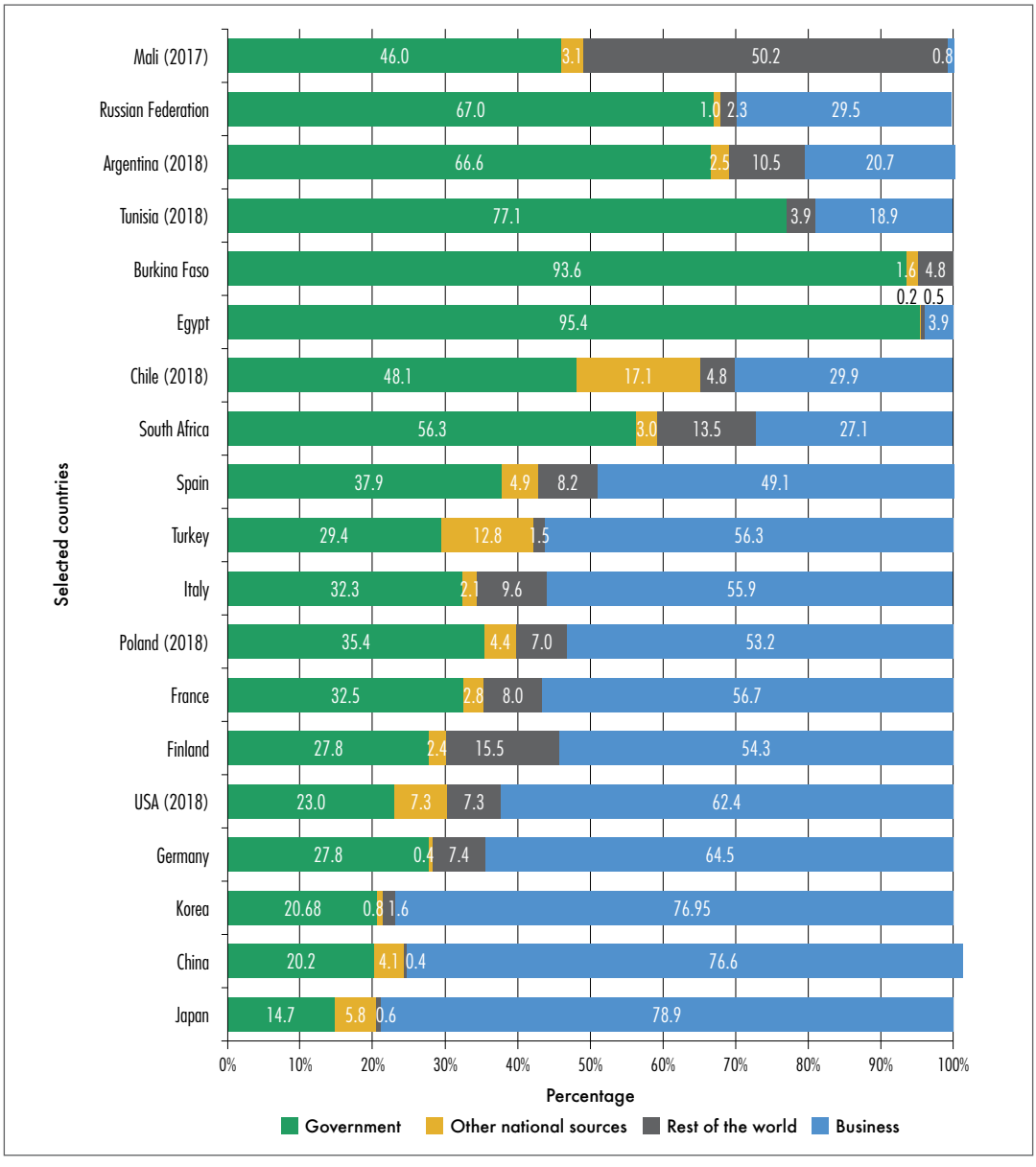


Data note	Foreign sources include all funding from foreign sources from all sectors.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

2.3. Comparing GERD by source of funds for selected countries

The business sector funds most of the R&D activity in research-intensive, high-income countries, in contrast to low- and middle-income countries (LMICs) (Figure 2). Government funds most R&D activity in LMICs, while funding by the NPO sector is minimal. Countries that received more than 60% of R&D funding from the business sector were Japan (78.9%), China (76.6%), Germany (64.5%) and the USA (62.4%). By contrast, Argentina, Chile, Mali, Russia and Egypt reported that more than 45% of their R&D funding emanated from the government sector.

Figure 23: GERD by source of funds in selected countries (percentage), 2019/20 or latest available year



Data sources South Africa: National Survey of Research and Experimental Development, 2019/20. Argentina, Chile, China, Finland, France, Germany, Israel, Italy, Japan, Korea, Poland, Russian Federation, Spain, Turkey, USA: OECD (OECD 2021).
Burkina Faso, Egypt, Mali, Peru, Tunisia: UNESCO (UIS 2021).

2.4 Spatial dimensions of R&D

While R&D takes place in all provinces in South Africa, it is skewed by the size and composition of research institutions, the location of major universities and firms and the level of funding. This section assesses R&D expenditure in provinces by institutional sector and traces the extent to which patterns of expenditure have changed.

R&D expenditure is concentrated in Gauteng, Western Cape, and KwaZulu-Natal. A trend that has remained constant since 2015/16.

Table 12 presents an overview of R&D expenditure by province from 2015/16 to 2019/20. R&D expenditure was concentrated in three provinces in 2019/20, namely Gauteng (41.7%), Western Cape (24.5%) and KwaZulu-Natal (10.5%). While Gauteng recorded the largest R&D expenditure, there has been a decline in the relative proportion of its R&D expenditure, which stood at 45.4% in 2015/16, but declined to 41.7% in 2019/20, the lowest proportion in over five years.

The second largest expenditure on R&D activities in 2019/20 was in the Western Cape, which recorded its highest proportion of GERD in five years. Western Cape expenditure on R&D increased proportionally from 2015/16 (22.0%) to 2019/20 (24.5%). A large proportion of this GERD can be attributed to activities of universities in the higher education sector and science councils in the Western Cape.

The proportion of R&D expenditure in KwaZulu-Natal showed a decrease from 11.1% in 2018/19 to 10.5% in 2019/20, as shown in Table 12. R&D in Mpumalanga, Northern Cape, North West, Northern Cape and Eastern Cape showed increases from 2018/19. The lowest R&D expenditure was recorded in Limpopo, Mpumalanga and Northern Cape with 2.2%, 2.4% and 2.6% of GERD in the 2019/20 period, respectively.

Table 12: R&D expenditure by province (R million and percentages), South Africa, 2014/15 to 2018/19

YEAR	GERD	EASTERN CAPE	FREE STATE	GAUTENG	KWAZULU-NATAL	LIMPOPO	MPUMALANGA	NORTHERN CAPE	NORTH WEST	WESTERN CAPE
	R'000	%	%	%	%	%	%	%	%	%
2015/16	**32 336 679**	6.6	5.5	45.4	10.3	1.9	2.4	2.0	3.7	22.0
2016/17	**35 692 973**	6.2	5.1	46.0	10.2	2.0	2.0	1.5	3.6	23.3
2017/18	**38 724 590**	5.9	5.6	44.7	10.8	2.2	1.8	1.5	3.4	24.1
2018/19	**36 783 968**	6.0	5.4	42.9	11.1	2.2	2.3	2.5	4.6	23.1
2019/20	**34 484 862**	6.1	5.0	41.7	10.5	2.2	2.4	2.6	4.9	24.5

Data source National Survey of Research and Experimental Development, 2015/16 to 2019/20.

2.4.1 R&D expenditure by province and sector of performance

The assessment of provincial R&D by sector of performance (Figure 24) shows that in eight of the nine provinces, the business and higher education sectors remained the largest performers of R&D in 2019/20. Five provinces surpassed the R1 billion mark, including Gauteng (R14.386 billion), Western Cape (R8.453 billion), KwaZulu-Natal (R3.629 billion), Eastern Cape (R2.091 billion) and Free State (R1.711 billion).

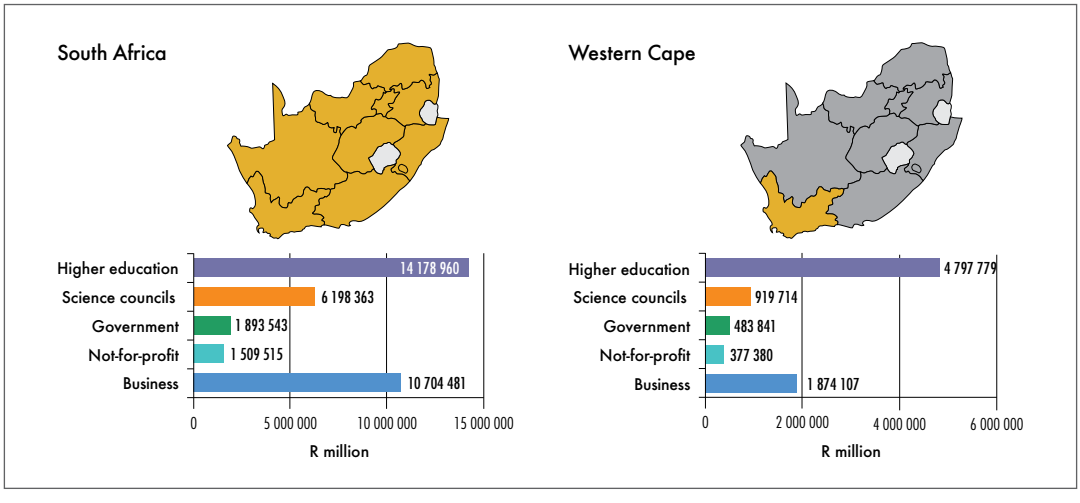
R&D expenditure in the business sector was predominantly concentrated in Gauteng (50.9%), Western Cape (17.5%) and KwaZulu-Natal (11.1%). Similarly, R&D expenditure in the higher education sector was most concentrated in the Western Cape (33.8%), Gauteng (29.5%) and KwaZulu-Natal (10.7%) provinces. R&D expenditure in the higher education sector increased by 8.4% (R374 million) in the Western Cape.

Business funding in 2019/20 decreased by R2.170 billion (28.5%) in Gauteng and by R614 million (24.7%) in the Western Cape, compared to 2018/19.

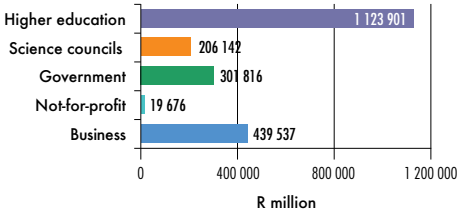
The third largest sector, the science councils, had R&D expenditure concentrated in three provinces and experienced increases in R&D expenditure. Expenditure in science councils increased in the Western Cape by 5.5% (R149 million), Gauteng by 18.7% (R571 million), and Northern Cape (R33 million).

Science councils spend on R&D increased in Gauteng (18.7%), Western Cape (5.5%), and Northern Cape (5.2%).

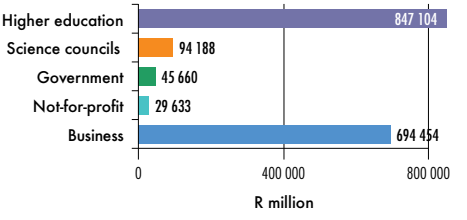
Figure 24: R&D expenditure by province and sector of performance (R million), South Africa, 2019/20



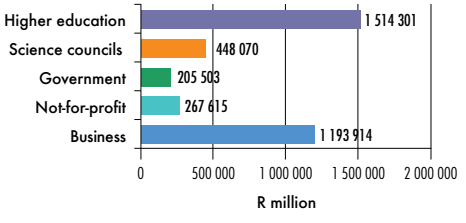
Eastern Cape



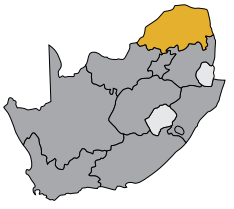
Free State

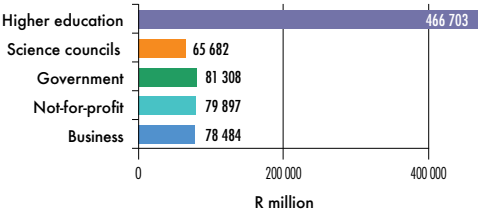


KwaZulu-Natal

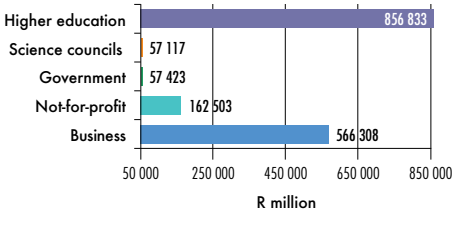


Limpopo

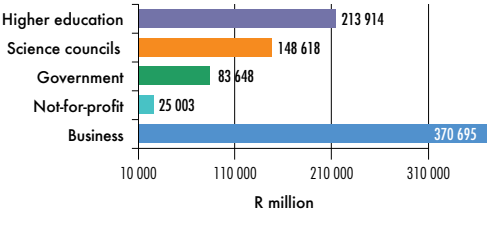


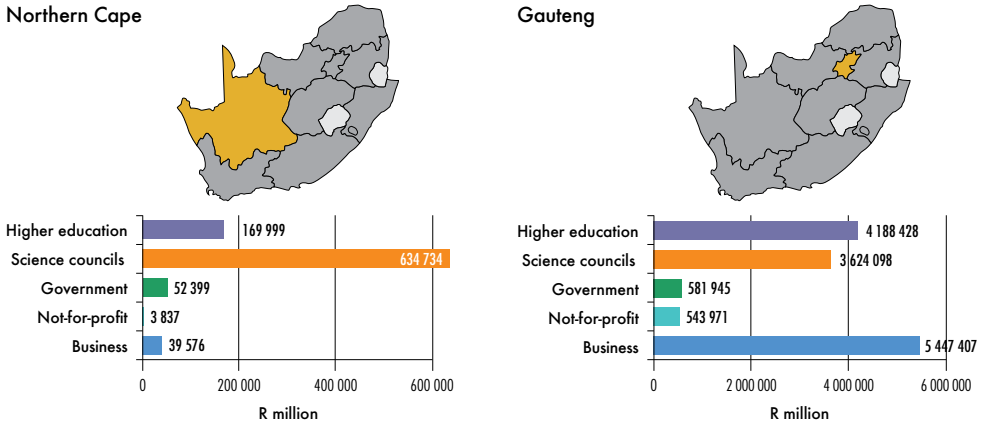


North West



Mpumalanga





Data source National Survey of Research and Experimental Development, 2019/20.

3. HUMAN CAPABILITIES FOR R&D

Section 3:

- **Analyses** R&D personnel **headcount** by occupation, qualification, gender, race, and full-time equivalents.
- Breaks down R&D data for **comparison of trends using five-year data points**.
- **Explores** the South African cohort and **distribution** of **researchers and postgraduate students**.

3.1 R&D personnel

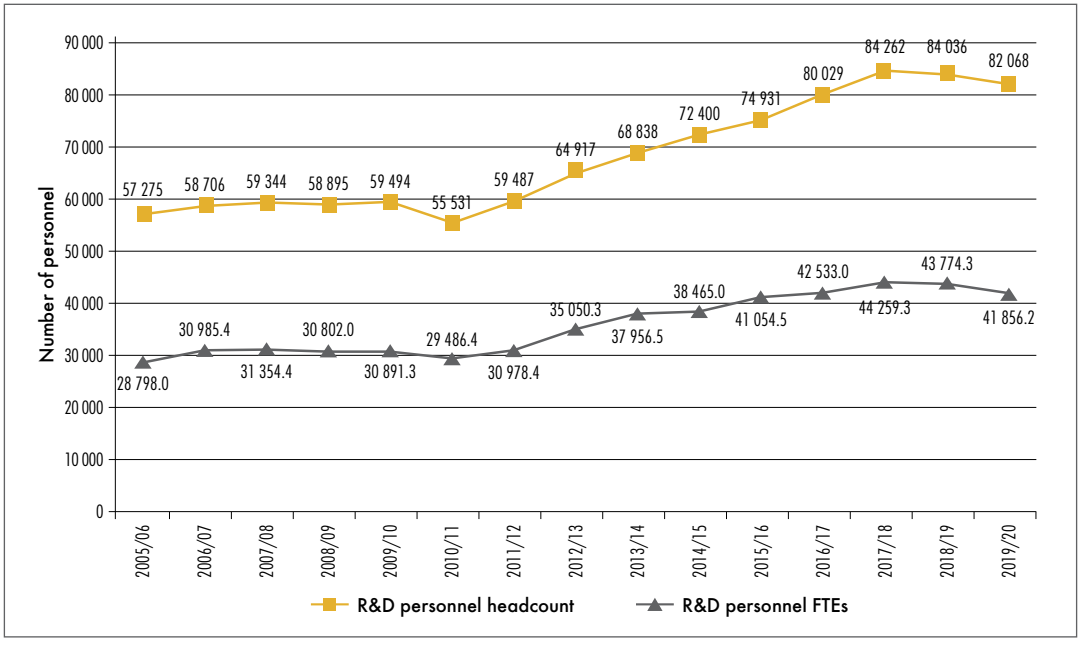
The health and vigour of South Africa's NSI is largely influenced by investment in R&D and the growth of an R&D workforce with skills and expertise to conduct research in key fields. To adequately grow the R&D labour force, it is important to assess the capacity of the system as well as the progress of transformation goals in relation to race and gender, to redress aspects of South Africa's history.

Year-on-year, the change in R&D personnel, measured by headcount and full-time equivalents, recorded a decline of 2.3% and 4.4% respectively in 2019/20.

Historic data trends reveal a general upward trend in South Africa's R&D personnel headcount and full-time equivalents (FTEs) with gradual growth trends noted between 2005/06 and 2010/11.

In 2018/19 and 2019/20 the R&D personnel headcount and number of FTEs tapered off, declining by a margin of 2.3% year-on-year from 84 036 to 82 068 between 2018/19 and 2019/20 (Figure 25). Survey periods prior to 2018/19 reported growth rates of 5.3% and 6.8% respectively between 2015/16 to 2016/17 and 2016/17 to 2017/18. Further analysis in this section illustrates that postgraduate student headcount in the higher education sector contributes significantly to R&D personnel.

Figure 25: R&D personnel (headcount and FTEs), South Africa, 2005/06 to 2019/20



Data note	Following OECD (2015) 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 for a period exceeding six months. In addition, emeritus professors, honorary fellows and research fellows are now explicitly included in the estimates of R&D personnel.
Data source	National Survey of Research and Experimental Development, 2005/06 to 2019/20.

3.1.1 R&D personnel headcount by institutional sector of performance

More than two-thirds of R&D personnel were in the higher education sector (73.3%), showing consistent growth in headcount year-on-year. A total headcount of 60 168 was reported in the higher education sector in 2019/20 (Figure 26). A significant growth rate of 25.3% for R&D personnel within the sector was obtained between 2015/16 and 2019/20. This accelerated growth was due mainly to post-graduate students within the higher education sector, particularly at the researcher level.

The business sector has experienced a continuous decline in headcount, shrinking from 17 554 to 16 876 between 2017/18 and 2018/19 and showing a further decline to 12 748 in 2019/20.

In science councils the headcount exhibited a similar downward trend, reporting reductions each year from 2015/16 until 2019/20. In 2019/20 the total R&D personnel of 4 070, was lower than the 5 162 personnel in science councils in 2015/16.

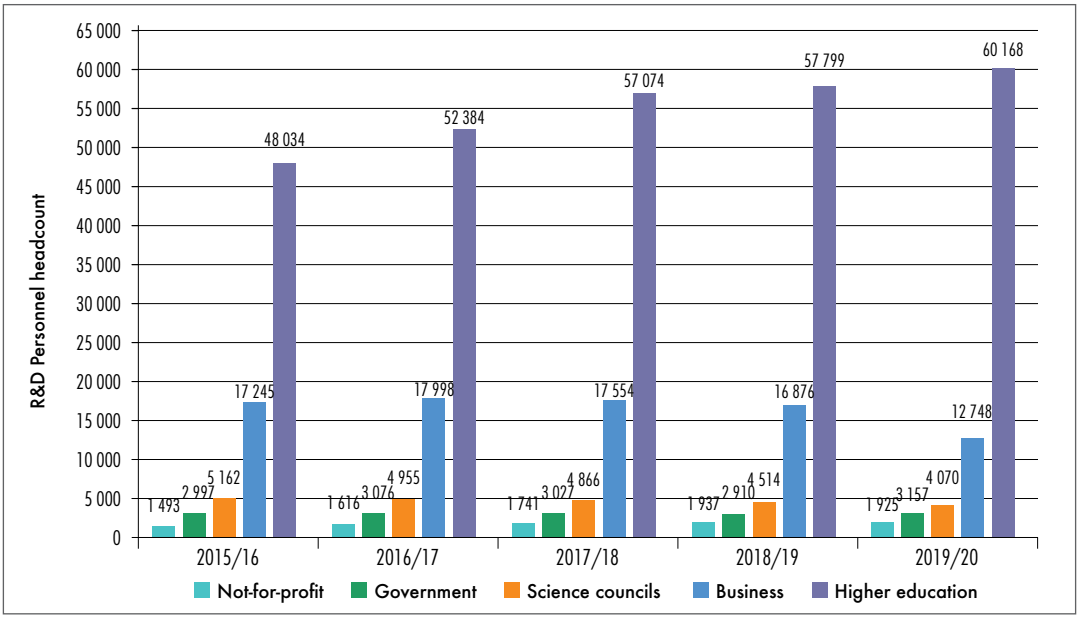
The business sector has lost 4 806 headcounts since 2017/18, and points to a growing concern in the business sector.

In contrast, the government sector displayed an increase in R&D personnel, despite recording declines in R&D personnel in previous survey periods. The NPO sector reported a marginal decrease in headcount of 0.6% between 2018/19 and 2019/20.

Despite a policy focus that aims to grow and improve South Africa's R&D workforce, some of the data trends show significant losses and stagnation in human resources. In 2019/20, the headcounts of R&D personnel in the business, government and science council sectors were nearly the same and, in some instances, lower than the headcounts recorded in 2015/16 (Figure 26). This area needs to be stimulated and incentivised to grow and reclaim previous levels of capacity.

Between 2015/16 and 2019/20 declines in researchers, technicians and other personnel supporting R&D categories was observed at times. Although not definitive, declining headcounts can be linked to slow growth in the South African economy, as well as the culmination of research projects and contracts and vacant positions not being filled due to budget constraints. Some entities also went through major restructuring events contributing to the reduction in R&D personnel.

Figure 26: R&D personnel by sector (headcount), South Africa, 2015/16 to 2019/20



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

3.1.2 R&D full-time equivalent personnel by institutional sector of performance

Associated with the decline in headcounts, R&D FTE personnel decreased overall by a further 4.4% between 2018/19 and 2019/20. This was the second decline in total R&D FTE personnel in the past

five years. In previous years, FTEs increased by 4.1% between 2016/17 and 2017/18 and by 6.7% between 2014/15 and 2015/16. The R&D FTE personnel per thousand in total employment indicator increased again by 0.1% reaching 2.8% in 2019/20. The total R&D FTE personnel per thousand in total employment indicator remained static in the preceding cycles, reaching 2.6% in 2015/16 and 2016/17 and remaining at 2.7% in the years 2017/18 and 2018/19.

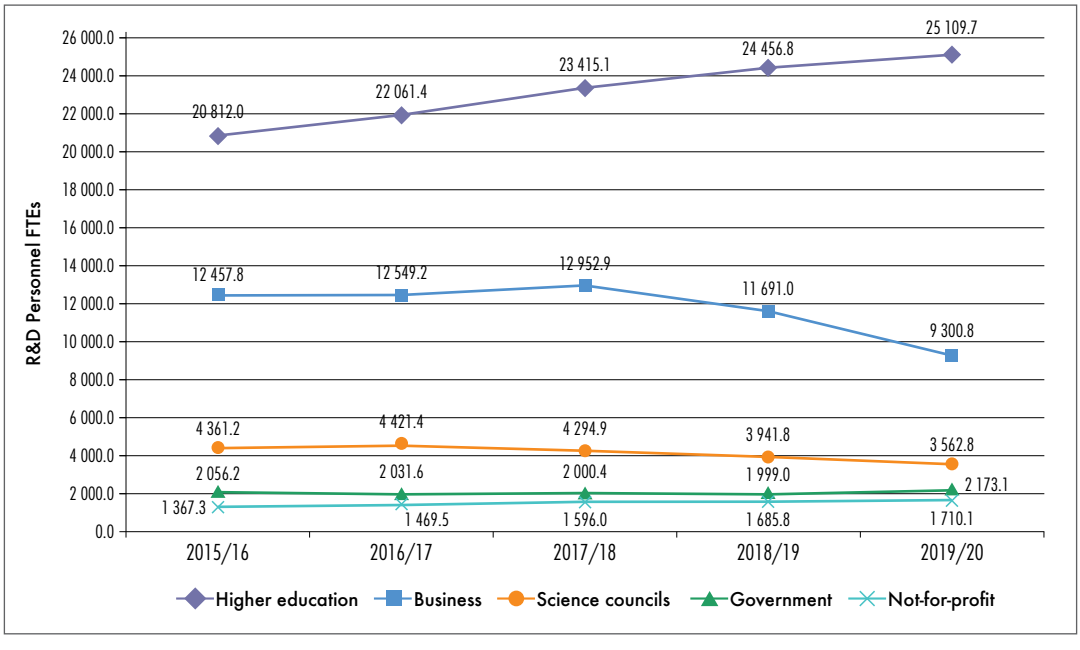
The government, higher education and not-for-profit sectors all showed a year-on-year increase in FTEs in 2019/20, recording 8.7%, 2.7% and 1.4% respectively.

The business sector showed the most noticeable decline in FTEs between 2017/18 and 2019/20, with a 28.2% decline in this period (Figure 27). Science council R&D FTE personnel contracted by 9.6% between 2018/19 and 2019/20.

The R&D FTE personnel per thousand in total employment indicator increased by 0.1%, reaching 2.8% in 2019/20. In 2017/18 and 2018/19 the indicator remained at 2.7%.

While continued improvements in headcount and R&D FTE personnel are welcomed, survey data reveals a contraction of time devoted to research activities. This could be a response to the current economic climate. Further observation of this data trend will provide more insight into how entities prioritise their time and efforts.

Figure 27: R&D FTE personnel by sector, South Africa, 2015/16 to 2019/20



Data note	Following OECD (2015) practice, doctoral students and post-doctoral fellows are counted as researchers.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

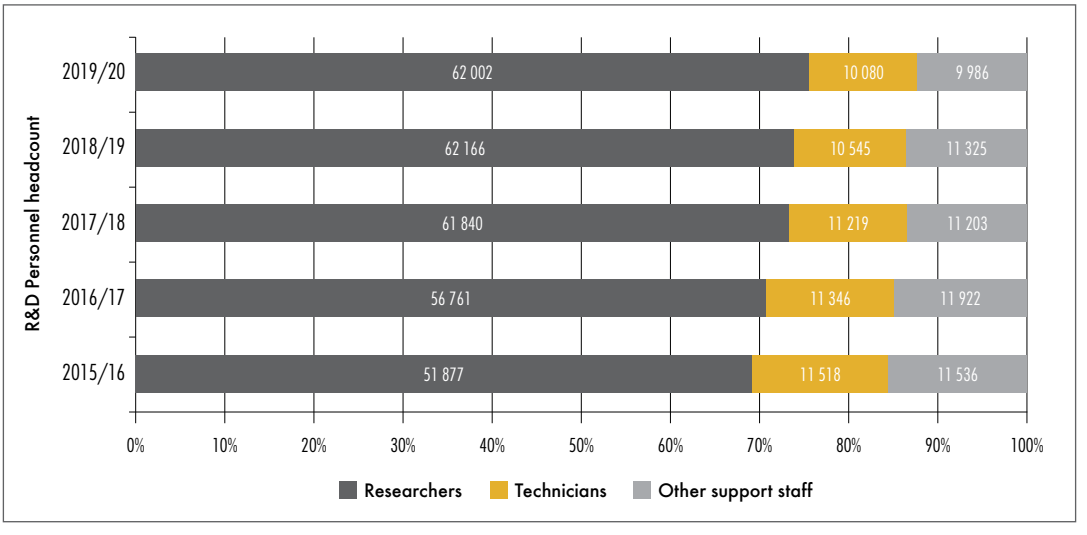
3.1.3 R&D personnel by occupation

The profile of the R&D workforce remained similar to that observed in previous survey cycles. The 2019/20 survey revealed that the R&D personnel contingent was made up of 75.5% researchers, 12.3% technicians and 12.2% other R&D support staff (Figure 28). This profile ratio has remained relatively consistent over time, showing a marginally increased proportion of researchers and a proportional decline in technicians and other support staff percentages.

The overall headcount of researchers increased within the last five years. It grew from 51 877 to 62 166 between 2015/16 and 2018/19 and remained largely the same with a decreased total of 62 002 reported in 2019/20.

The technician headcount continued to decline from 10 545 in 2018/19 to 10 080 in 2019/20 with the headcount of other support staff also declining from 11 325 to 9 986 over the same period. Both the technician and other support staff categories reported values lower than those reported in 2015/16.

Figure 28: R&D personnel by occupation (headcount), South Africa, 2015/16 to 2019/20



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

Globally, the shift to a more technologically intensive society requires skilled, technology-oriented personnel. The success of the NSI relies on a well capacitated and functioning R&D workforce. As researchers drive the conception and creation of new knowledge, this group is discussed in more detail in the following section.

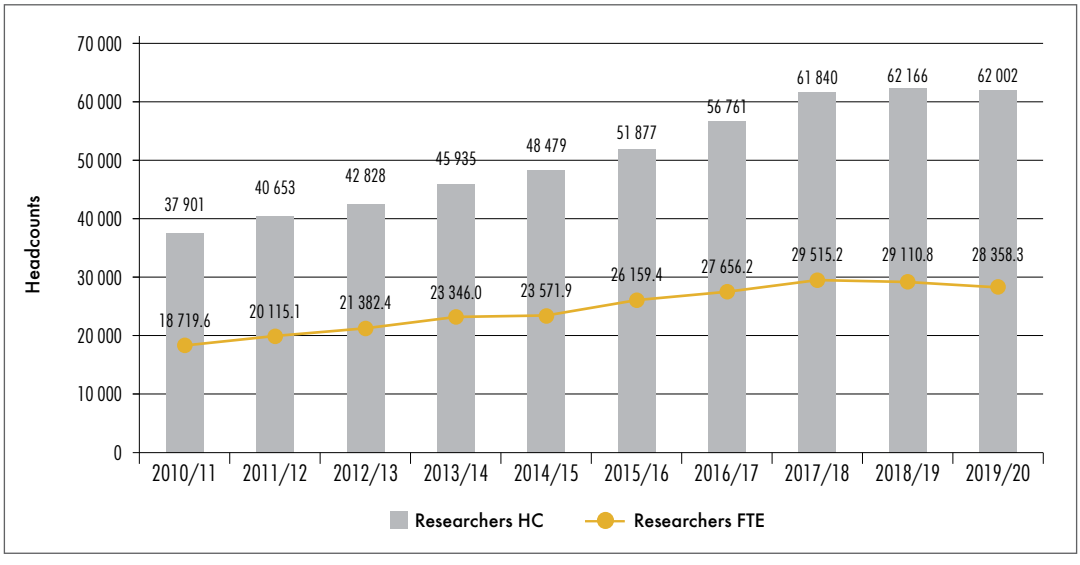
3.2 Researchers

Most R&D activities are carried out by researchers, and the continuous evaluation of the performance of this cohort is key. The period 2011/12 to 2018/19 reflected steady growth in the researcher headcount and FTEs (Figure 29). The total researcher headcount was 62 022 in 2019/20, with 28 358.3 FTEs reported for the same period. Both categories showed declines; the researcher headcount by 0.3% and FTEs by 2.6%.

Of the country's researcher cohort, 46.2% were women in 2019/20, with approximately 30.9% holding, or enrolled for a PhD.

Stagnating growth in researcher FTEs and the additional burden of the impact of COVID-19 on society, raises concerns about the pace of growth in the R&D workforce and whether it is sufficient to ensure that the country meets its GERD/GDP targets in the timeframe specified.

Figure 29: Researchers (headcount and FTEs), South Africa, 2010/11 to 2019/20



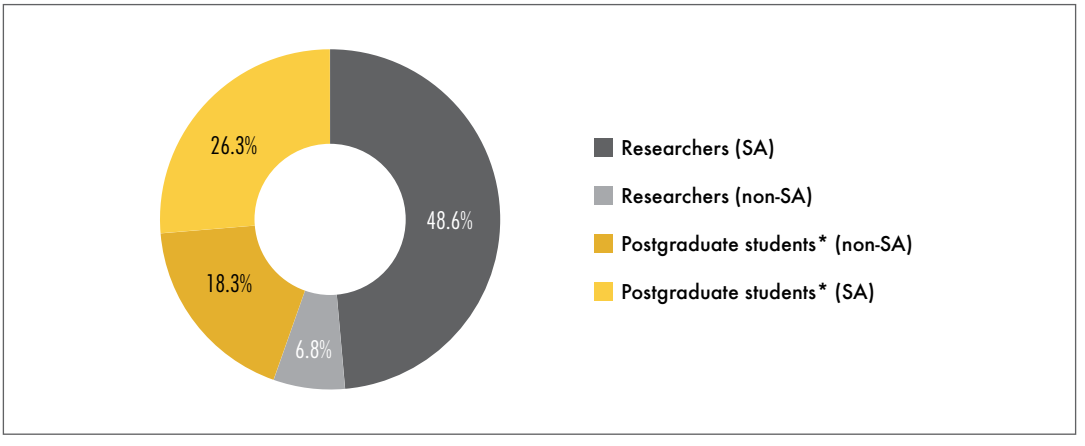
Data note	Following OECD (2015) practice, doctoral students and post-doctoral fellows are counted as researchers.
Data source	National Survey of Research and Experimental Development, 2010/11 to 2019/20.

3.2.1 Distribution of researchers by headcount

From 2016/17 the R&D Survey has allowed for the disaggregation of R&D personnel as South African and foreign nationals and by staff and postgraduate students*. Reviewing the R&D personnel data through this lens may provide insight on how well capacitated the system really is. A strong system will be achieved by producing internal research capacity and attracting skilled and experienced talent from abroad.

The 2019/20 R&D Survey reports that South African researchers (excluding students) comprise 48.6% of total researchers, with a smaller representation of non-South African researchers at 6.8% (Figure 30). Postgraduate students made up the balance of 44.6% in 2019/20. Of these, South African post-graduates constituted 26.3%, and non-South African postgraduates 18.3% of the cohort.

Figure 30: Distribution of researchers (headcount, percentage), South Africa, 2019/20

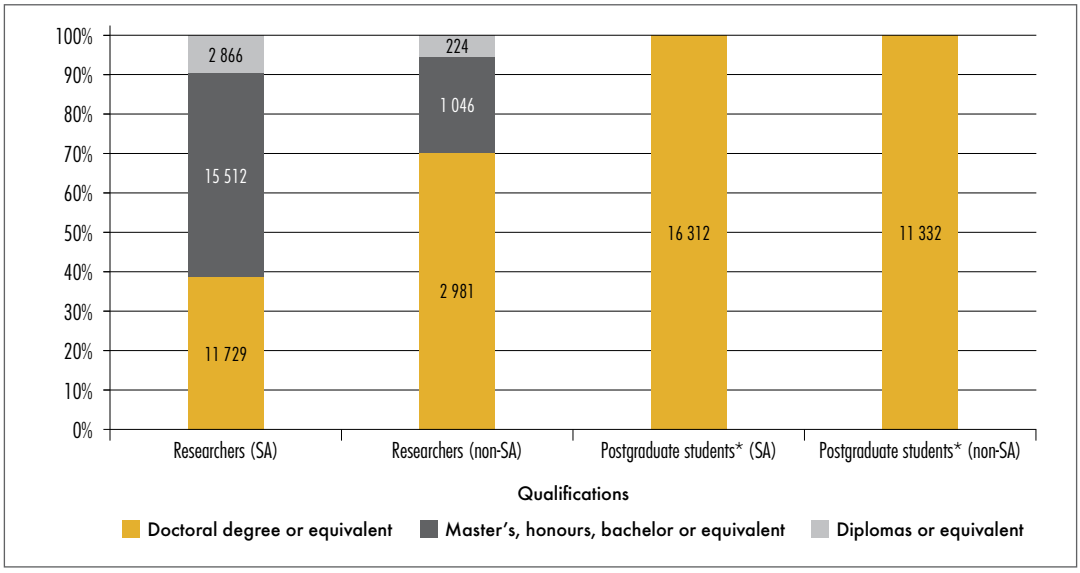


Data note	*Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2019/20.

A closer look at the qualification of researchers shows that just over one-third (39.0%) of South African researchers hold a doctoral qualification, 51.5% have a master's, honours or equivalent qualification and a very small proportion (9.5%) hold a diploma or equivalent qualification (Figure 31).

Even though the representation of non-South African researchers is much smaller by headcount, 70.1% have a doctoral degree. The high proportion of doctoral qualifications in this grouping is evidence of South Africa's ability to attract highly qualified staff to the country. Of the 27 644 postgraduate students, 61.0% are South African and hold a doctoral degree or are enrolled for one. A detailed analysis of postgraduate students by nationality is included in Figure 37.

Figure 31: Researcher (headcount) by qualification, South Africa, 2019/20

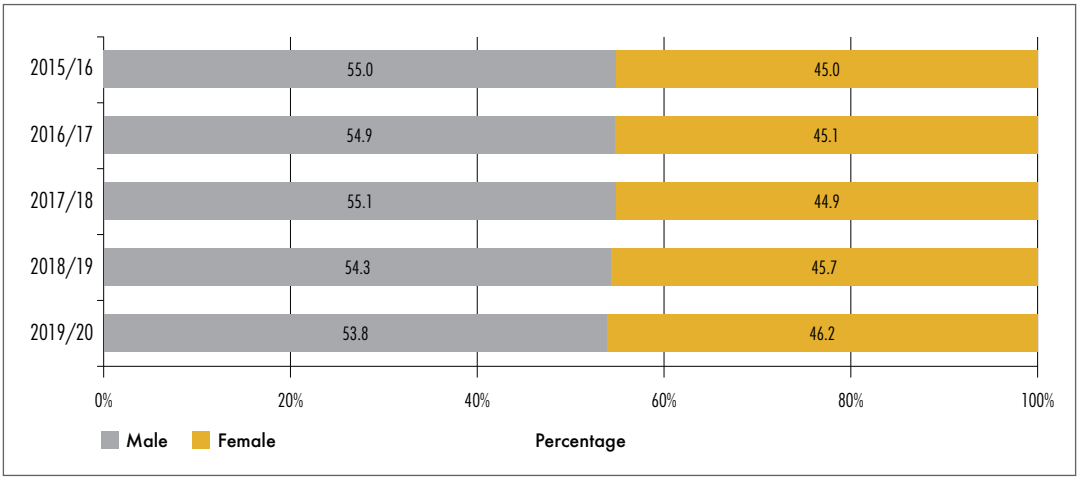


Data note	R&D personnel include postgraduate students* (post-doctoral fellows and doctoral students) under the 'researcher' category. In terms of the disaggregation, the 'researcher' category includes South African and foreign national researchers, and South African and foreign national postgraduate students (post-doctoral fellows and doctoral students).
Data source	National Survey of Research and Experimental Development, 2019/20.

3.2.2 Researcher headcount by gender

In 2019/20, women researchers accounted for 46.2% of all researchers. Slow but steady growth of female researchers is evident over the last five years, from 45.0% in 2015/16 to 45.7% in 2018/19 (Figure 32). Of the total researchers approximately 30.9% are women holding a PhD, including students enrolled for a PhD.

Figure 32: Researchers by gender (percentage), South Africa, 2015/16 to 2019/20



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

3.2.3 Researcher headcount by institutional sector of performance

The largest concentration of researchers is found within the higher education, business and science council sectors. Researcher headcount by sector between 2015/16 and 2018/19 reveals minimal changes in researcher numbers over time. The slow growth observed was influenced by several factors, such as internal restructuring leading to a reduction in the number of researchers, vacant posts and reduced financial income.

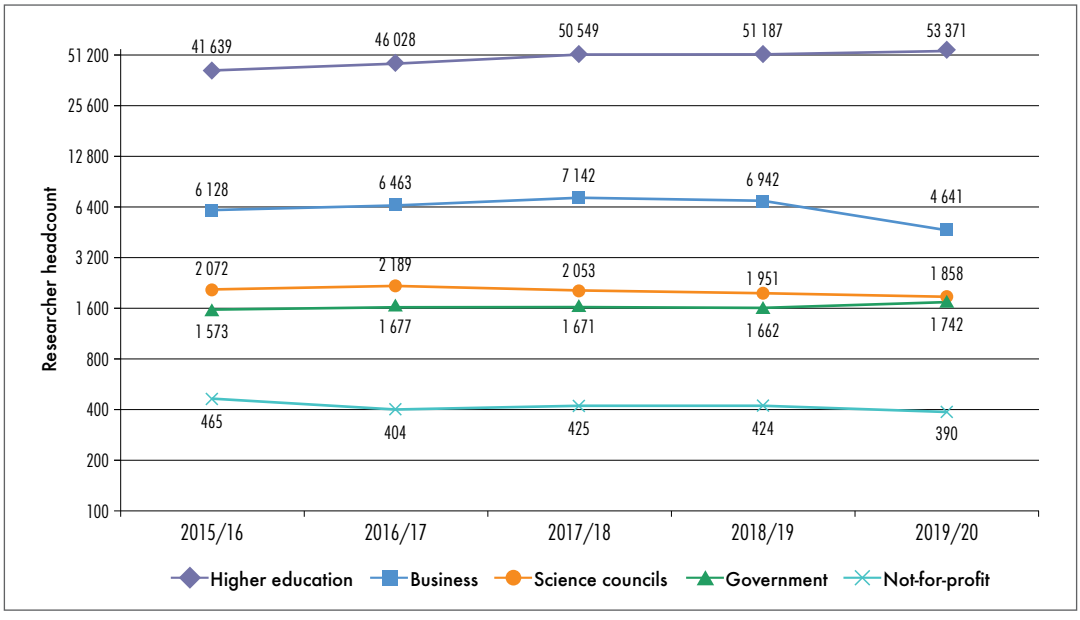
Higher education remained the sector with the greatest concentration of researchers and contributed the most to the increase in researcher numbers. Researchers in the sector increased by a small margin of 4.3% from 51 187 recorded in 2018/19 to 53 371 in 2019/20 (Figure 33). In 2019/20 the data revealed that of the 53 371 researchers in the sector, 25 727 (48.2%) were staff and 27 644 (51.8%) were postdoctoral fellows and doctoral students.

Researcher headcounts shows stagnation and decline in certain sectors. The science council and business sectors reflected declines in human resources.

Researchers in the government sector also increased by 4.8% between 2018/19 and 2019/20.

Sectors recording decreases in the headcount of researchers were the business, not-for-profit and science council sectors, with year-on-year declines of 33.1%, 8.0% and 4.8% respectively between 2018/19 and 2019/20. The science council and business sectors reflected declines in both financial and human resources consecutively, but the most significant decline was observed in the business sector with a decline of 33.1% in researcher headcount over the same period.

Figure 33: Researchers by sector (headcount), South Africa, 2015/16 to 2019/20



Data note	Higher education R&D personnel include post-doctoral fellows and doctoral students under the 'researcher' category.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

3.2.4 Researcher full-time equivalents by sector of performance

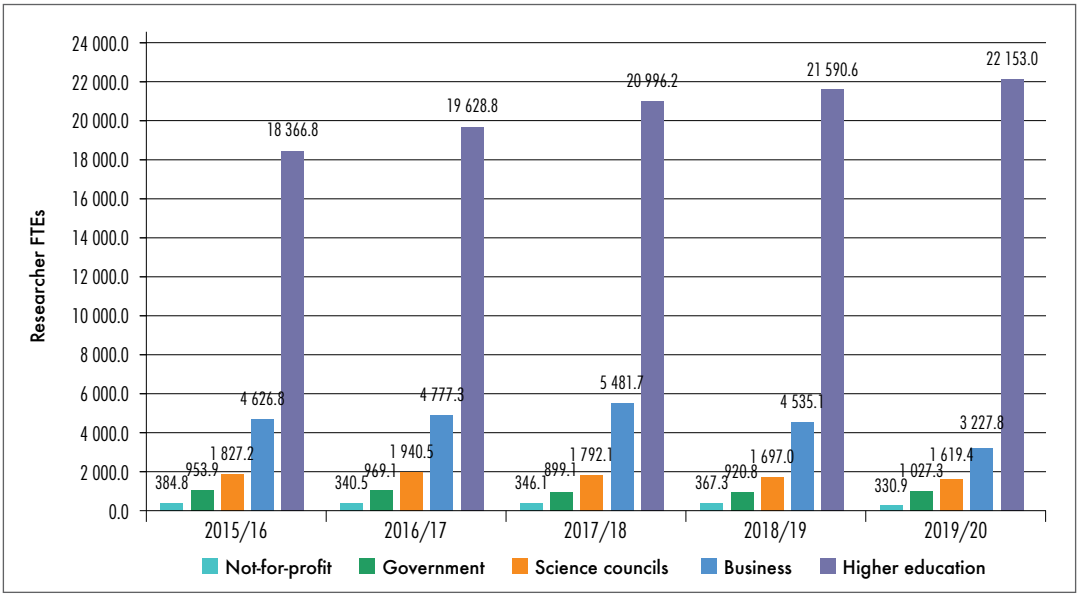
Like the trends observed in previous survey periods, researcher FTEs in the higher education sector continued an upward trajectory by a margin of 2.6%, increasing from 21 590.6 in 2018/19 to 22 153.3 in 2019/20 (Figure 34). This is associated with increased postgraduate student numbers as well as the additional personnel categories included from 2016/17 onwards. More than 70% of researcher FTEs are postgraduate students.

Researcher FTEs in the business, not-for-profit and science council sectors all showed declines, ranging from 28.8% to 9.9% and 4.6% respectively, an indication of entities reducing the time spent on R&D as they try and cope with disruptions occurring in their sectors.

The government sector reported increases in both headcount and FTEs, with researcher FTEs increasing by 11.9% from 920.8 in 2018/19 to 1 027.3 in 2019/20.

Despite the noted increases, and more substantial decreases, of researcher FTEs observed in this specific survey period, overall, the FTEs at national level showed a smaller decline, of only 2.6%, between 2018/19 and 2019/20.

Figure 34: Researcher (FTEs) by sector, South Africa, 2015/16 to 2019/20



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.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

3.2.5 Researchers by population group

The proportions of the various population groups differ somewhat from previous survey data.

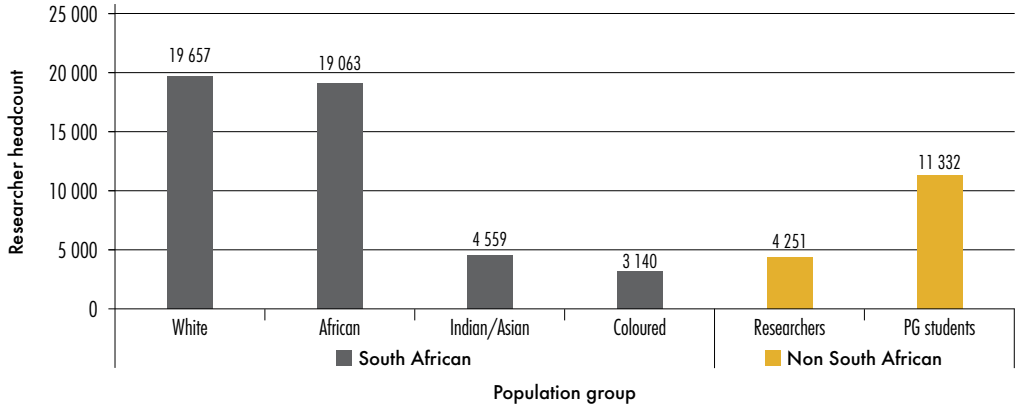
Nominal changes in population group representation may be accounted for by the inclusion of a non-South African classification in the 2016/17 survey cycle. This was a methodological adjustment, based on the recommendations of the revised Frascati Manual. This new category of non-South African researchers constituted 6.8% of the R&D researchers, a decrease from the 7.5% reported in 2018/19.

Black researchers (African, coloured and Indian/Asian) constituted 43.2% of the total R&D researchers in 2019/20, while 25.1% were citizens of foreign countries. Within this grouping of total researchers, 19 063 are African and 18.6% hold a PhD.

A total of 15 583 (25.1%) of the researchers active in South African R&D are non-South Africans, including 11 332 (18.3%) foreign post-doctoral fellows and doctoral students (Figure 35).

Over one-third of researchers were from the white population group, 31.7% in 2019/20. The collective representation of other population groups (African, coloured and Indian/Asian) constituted 43.2% of the total R&D workforce in 2019/20, a slight proportional increase from the 42.4% recorded in 2018/19. Within this grouping of total researchers, 19 063 are African, of which 18.6% hold a PhD.

Figure 35: Researchers by population group (percentage), South Africa, 2019/20



Definition	Higher education researchers include post-doctoral fellows and doctoral students under the 'researcher' category. Student data differentiates between South African and non-South African nationals. The population is classified according to the following race groups: African, coloured, Indian/Asian and white.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

3.3 Postgraduate students

3.3.1 Post-doctoral fellow and postgraduate student headcount and full-time equivalents

The overall number of post-doctoral fellows and postgraduate students (doctoral and master's students) engaged in R&D grew from 86 395 in 2018/19 to 87 146 in 2019/20 (Figure 36). The 2019/20 survey reported 2 867 post-doctoral fellows, 24 777 doctoral students, 29 578 master's (full research) and 29 924 master's (coursework plus thesis with research component).

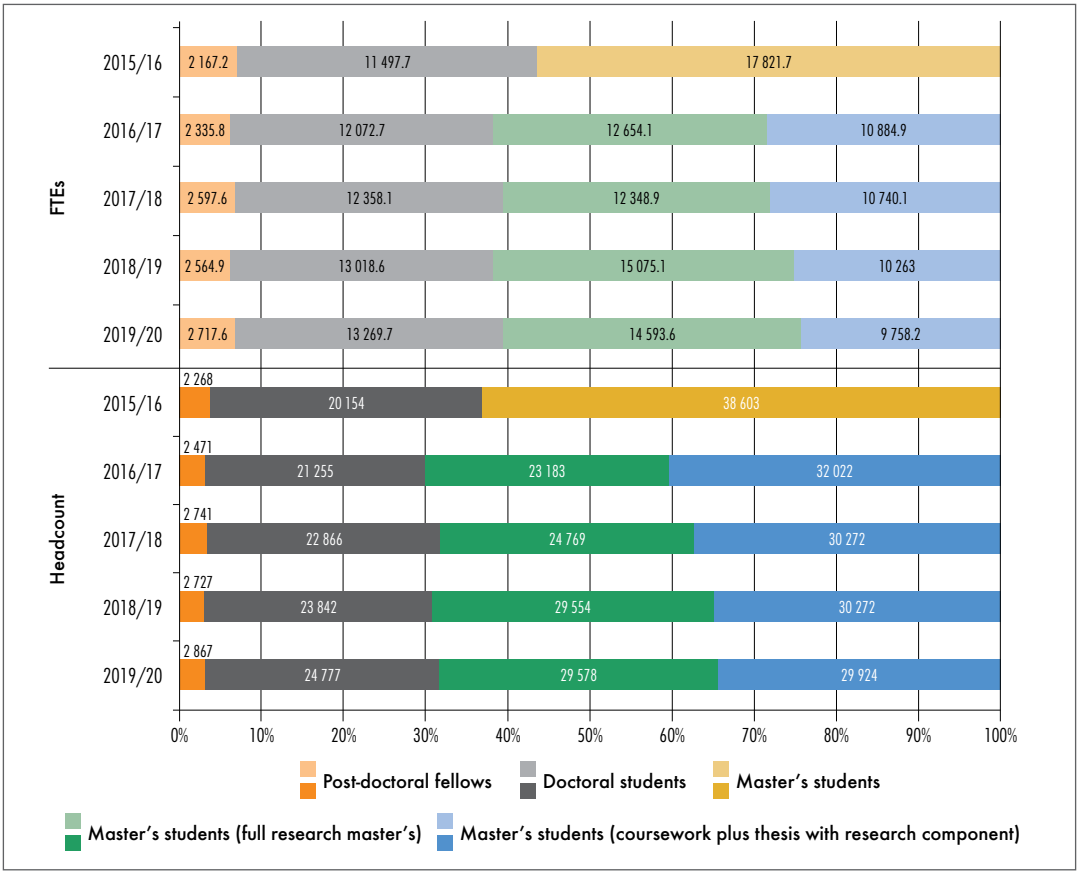
Post-doctoral fellows and doctoral student numbers combined grew by a smaller margin of 4.0% from 2018/19 to 2019/20 which was close to the growth rate of 3.8% observed from 2017/18 to

2018/19. The headcount of doctoral students increased by 3.9% from 23 842 in 2018/19, reaching 24 777 in 2019/20.

Historically post-doctoral fellows have increased by substantial margins with a 10.9% increase recorded from 2016/17 to 2017/18. However, the 2018/19 data showed no growth in the number of post-doctoral fellows and reported a 0.5% decline with the headcount decreasing from 2 741 in 2017/18 to 2 727 in 2018/19. The 2019/20 survey data recorded a 5.1% increase in post-doctoral fellows.

The growth in postgraduate numbers continues to slow down.

Figure 36: Higher education post-doctoral fellows and postgraduate students (headcount and FTEs), South Africa, 2015/16 to 2019/20



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. The 2016/17 R&D Survey included the delineation of the master's students into master's (full thesis) and master's (coursework plus thesis). 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" are included and on average they spend approximately half of their time performing actual research.
Data source	National Survey of Research and Experimental Development, 2015/16 to 2019/20.

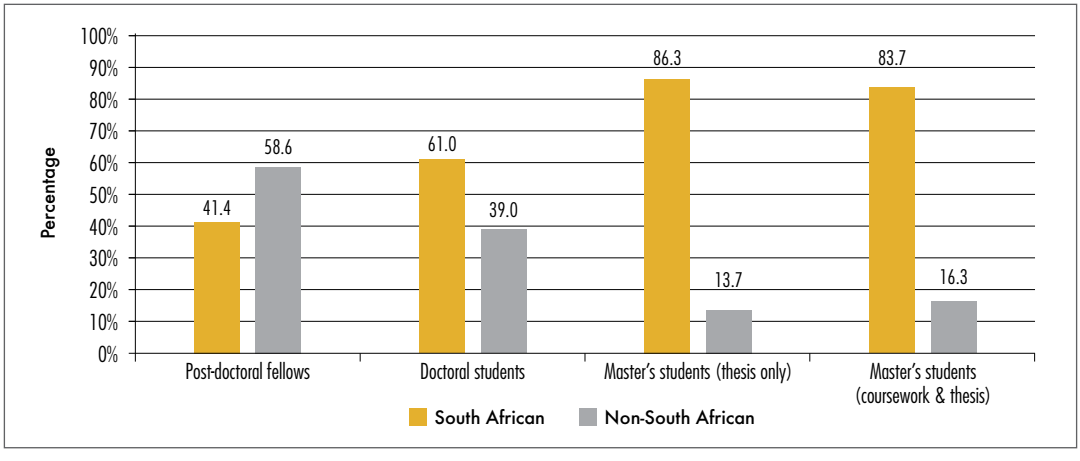
3.3.2 Profile of South African and non-South African postgraduate students

Of the 87 146 postgraduate students in 2019/20, 76.7% were South African and 23.3% non-South African nationals. Post-doctoral fellows and doctoral students are included as researchers and accounted for 27 644 of the researchers at higher education institutions in the 2019/20 R&D Survey. Analyses of the group of post-doctoral fellows and doctoral students revealed that 16 312 (59.0%) were South African nationals and the remaining 11 332 (41.0%) were foreign nationals.

The proportion of South African to foreign nationals observed among doctoral students for 2019/20 was 61.0% and 39.0% respectively (Figure 37). An inverted trend was observed for postdoctoral fellows, with a split of 41.4% South African nationals to 58.6% foreign nationals. Most master's students were South African nationals in 2019/20, representing 86.3% of the master's by thesis students and 83.7% of the master's by coursework and thesis students.

The COVID-19 pandemic had no effect on the researcher headcount in the 2019/20 financial year in South Africa, however the restriction of movement had a major impact on foreign nationals at local higher education institutions and may become evident in future trend data for South Africa's R&D workforce.

Figure 37: Higher education postgraduates by qualification (headcount), South Africa, 2019/20

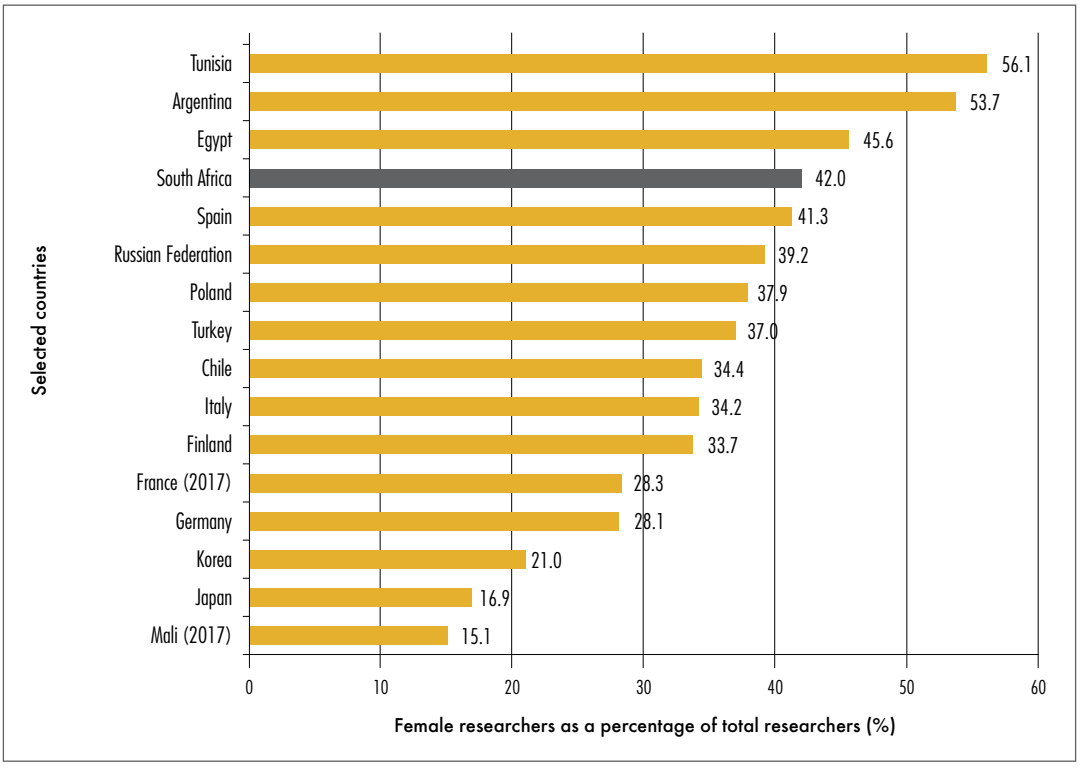


Data note	The 2019/20 survey distinguished between South African and non-South African post-doctoral fellows, doctoral and master's students. Non-South African personnel are classified as not from South Africa but undertaking research in South Africa for a period exceeding six months. They can be temporary or permanent residents as described by the System of National Accounts (SNA).
Data source	National Survey of Research and Experimental Development, 2019/20.

3.3.3 Female researchers as a percentage of total researchers

In South Africa, a higher proportion of researchers are female compared with countries with a comparatively larger R&D expenditure, such as Germany and France (Figure 38). The figure suggests that a high proportion of female researchers appears to be a feature of developing economies. The proportion of female researchers in South Africa was 42.0% of total researchers in 2019/20, which is slightly lower than the 45.7% recorded in 2018/19. South Africa has improved on this indicator gradually over the past nine years, with a decrease in 2019/20. The comparative data in Figure 38 suggests that, when compared with developed countries, female researchers form a higher proportion of total researchers in developing countries.

Figure 38: Female researchers as a percentage of total researchers (headcount) in selected countries, 2019/20 or latest available year

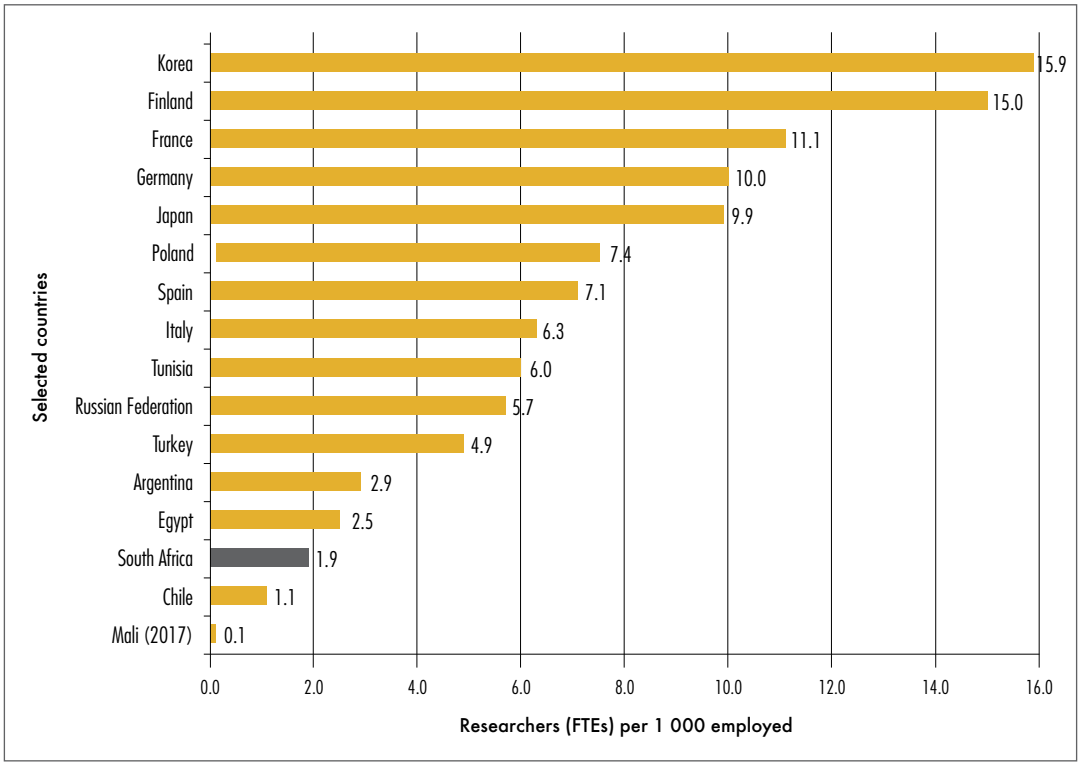


Data sources: South Africa: National Survey of Research and Experimental Development, 2019/20.
Argentina, Chile, Finland, France, Germany, Italy, Korea, Japan, Poland, Russian Federation, Spain, Turkey: OECD (OECD 2021).
Egypt, Mali, Tunisia: UIS (UNESCO 2021).

3.3.4 Researcher full-time equivalents per thousand in total employment

South African researcher FTEs per thousand in total employment remained unchanged in the past two years (1.8 in 2017/18 and 2018/19). In 2019/20, South Africa's researcher per thousand employed was 1.9, an increase of just ten basis points. It places South Africa between Egypt (2.5) and Chile (1.1) (Figure 39). In Russia, the number of researchers per thousand employed (5.7) was much higher than South Africa. By contrast, high-income countries like Korea reported 15.9 and Finland 15.0 researchers per thousand employed in 2019, which was slightly higher than 2018.

Figure 39: Researcher FTEs per 1 000 in total employment in selected countries, 2019/20



Data sources South Africa: National Survey of Research and Experimental Development, 2019/20.
Argentina, Chile, Finland, France, Germany, Italy, Korea, Japan, Poland, Russian Federation, Spain, Turkey: OECD (OECD 2021).
Egypt, Mali, Tunisia: UIS (UNESCO 2021).

4. CONCLUDING REMARKS

In 2019, South Africa's GDP decreased by 1.4 percentage points to 0.1% (after considering revisions due to the benchmarking and rebasing of the GDP series to 2015). The number of unemployed South Africans, a major ongoing challenge, increased by a further 1.4 million in 2019.

In the period under review, many comparator countries, mostly developing economies, also displayed signs of slowing growth, stagnation and even decline in R&D intensity. Gross expenditure on domestic R&D in South Africa declined for the second time since 2010/11 and GERD/GDP fell from 0.69% to 0.62%, close to its lowest level over the last decade, of 0.72%. This decline reflects the economic stagnation and lack of growth that intensified during the 2019/20 reference period, bringing with it increased levels of unemployment and poverty. Now, more than ever, South Africa needs to attain the R&D intensity targets that it has set to promote inclusive and sustainable development.

This chapter highlights key areas for R&D growth. Section 4.1 focuses on the need to support the growth of business sector R&D, particularly considering the impact of the global COVID-19 pandemic. Section 4.2 considers health and green R&D as priority areas, while section 4.3 considers R&D personnel and the impact of postgraduate students on the workforce. Finally, section 4.4 considers foreign funding and ways to grow GERD.

4.1 The future for the business sector

The COVID-19 pandemic and resulting lockdown in March 2020 negatively impacted the South African economy. Many businesses ceased operating due to the national state of disaster regulations promulgated to reduce infections and hospitalisation. As a result of the lockdown, many businesses did not recover and eventually closed. The next R&D Survey (2020/21) will better reflect the impact of these conditions on businesses and R&D expenditure.

However, Statistics South Africa's rapid response survey, conducted in May 2020, revealed that firms of all sizes across all sectors reduced their R&D expenditure by an average of 40% – a clear indication of the significant impact of COVID-19 (Stats SA, 2020).

In addition, the COVID-19 study on business R&D further found that research and development firms were affected by the pandemic even more deleteriously than non-R&D firms, with significant numbers of researchers made redundant. Most R&D firms laid off up to 20% of their research staff. In light of decreasing spending by businesses on R&D while government spending increased (discussed earlier in this report), there is a danger that R&D intensity could continue to decrease or become even more dependent on government funding and subsidization.

Statistics South Africa's rapid response survey found that more than 50% of firms in the mining and quarrying, construction, electricity, gas, and water supply sectors decreased their R&D expenditures.

Besides a general reduction in investment in R&D, some mining companies were sold in this period, resulting in the sale of assets or closure of certain operations including mine shafts.

The business sector received increased funding from external entities. Foreign funding to the business sector increased from around R400 million to R1.168 billion (section 2.2.4) while government funding to the business sector tripled from R215 million to R649 million, and funding from other national sources increased from R45 million to R346 million (section 2.2.3). This increased reliance on external sources of funding, particularly if it continues in coming years raises questions about the long-term sustainability of the business sector's R&D activities.

Mustapha and Kasongo (2021) suggest that to mitigate the negative impact of COVID-19 on cash flow, revenue, and employment, the Department of Science and Innovation should provide funding support to R&D firms in critical sectors. In addition, the DSI should develop a strategy for South Africa to retain research staff. Furthermore, it is crucial to accelerate the development of digital skills for workers and enterprises, including investment in new and safer ways of working.

4.2 Priority research areas: green R&D and health R&D

4.2.1 Green R&D

Green R&D seeks to create products and services that reduce negative environmental impacts and optimise the use of resources for sustainability. In the areas of agriculture, biogas, water treatment, power generation, and bio-composites, there are many opportunities for job creation. The results of the 2019/20 R&D Survey show that expenditure in green R&D has increased year-on-year and remains dominant in the agricultural and earth sciences fields.

Alternative ways to reduce carbon footprints is another area of focus worldwide, including the use of alternate resources to achieve this. South Africa has the added pressure of an electricity infrastructure that has continued to degrade over the past decade. Most scientists agree that fossil fuels will be significantly decreased or expended in approximately 50 years for oil and gas (Shafiee & Topal, 2009). However, when considering the areas of the economy that will benefit from green R&D, there is very little research devoted to energy resources (1.1% of GERD) and energy supply (6.8% of GERD). There have been significant contributions made by government and the business sector to address this issue. One of these is the recently approved South African Hydrogen Society Roadmap 2021 to a greener economy. This programme is however in its infancy, and South Africa should continue to direct much more R&D into this priority area.

4.2.2 Health R&D

Health R&D is defined as R&D that is relevant to human health. The COVID-19 pandemic highlights the need to invest in health knowledge. Financing for health R&D has grown overall over the past five years. Expenditure on health R&D has been increasing since 2015/16, with 24.9% (R8.583 billion) of GERD going to health R&D in 2019/20. The public sector (government, higher education and science councils) is the largest investor in health R&D in South Africa, a trend that has continued over the past five years. Research in the medical and health sciences accounted for most of the health R&D spending (86.3%). A total of R4.684 billion was spent on communicable diseases (TB, HIV/AIDS, and malaria), a decrease of R422 million compared with the previous year.

4.2.3 State-owned Enterprises

R&D expenditure by SOEs are in key areas of industrialisation. There has been some growth in the contribution of SOEs to R&D expenditure over the last two years reaching 19,2% of BERD in 2019/20. However, this level is still some way off from the 27.9% reached in 2008/09, which indicates great propensity for growth in this crucial component of the business sector.

4.3 R&D personnel: the impact of postgraduate students

R&D personnel contribute to the production, dissemination, and application of knowledge. To foster high-level skills in South Africa, graduates need access to targeted curricula and cross-disciplinary learning, as well as a system that promotes knowledge diffusion and the flow of foreign talent. Growing the national system of innovation in South Africa also entails growing new entrants to R&D workforce, equipped with the skills and expertise for research in key fields. Furthermore, assessing the progress of transformation goals to promote diversity in the R&D workforce is important.

Previously, there has been a general upward trajectory in South Africa's R&D personnel headcount and full-time equivalents (FTEs), with gradual growth trends noted between 2004/05 and 2010/11, and more robust year-on-year growth between 2010/11 and 2017/18. Particularly robust growth rates of 5.3% and 6.8% were reported between 2015/16-2016/17 and 2016/17-2017/18. However, there was a 2.3% decrease in the R&D personnel headcount between 2018/19 and 2019/20, declining from 84 036 to 82 068. In 2019/20, there was a decline in the number of researchers in the science council and business sectors and only modest increases in the higher education (excluding postgraduate students), government and not-for-profit sectors.

In contrast, there was an increase in the number of postgraduate students in the R&D workforce in South Africa. In 2019/20, the postgraduate student headcount in the higher education sector, which contributes greatly to the total R&D personnel in the country, continued to show consistent year-on-year growth.

Overall, 87 146 postdoctoral fellows and postgraduate students (doctoral and master's students) engaged in R&D, up from the 86 395 reported in 2018/19. Post-doctoral and doctoral students combined grew at a similar rate from 2017/18 to 2019/20 – a trend seemingly unaffected by declining national GERD. However, it is evident that students are not being absorbed into the R&D personnel landscape, as shown by the decline in headcounts.

South Africa's stagnant number of researchers per 1000 people, combined with a soaring unemployment rate, raises the question of what happens to South African postgraduates once they leave the higher education system. Considering the stagnant growth of researcher FTEs and the additional burden of COVID-19 on society, there is concern about whether the country will meet its GERD/GDP targets within the specified timeframes, given the low growth in researcher FTEs.

Initiatives such as the DSI and Council for Scientific and Industrial Research (CSIR) Comprehensive Bursary Programme target honours students and improve the retention of postgraduate students (DST 2017/18), while the National Research Foundation provides funding, human resource development, and research facilities. The findings in this report raise questions around whether these initiatives are working to help retain postgraduates and if they should be adjusted to address the R&D personnel gap. Recommendations stemming from these findings include expanding the number of these initiatives in the higher education sector, targeting specific research fields based on national priority areas, and focusing on post-doctoral level students to retain strong researchers who might otherwise leave the country. Furthermore, incentives for conducting R&D sufficient for businesses to retain a cohort of researchers should be explored.

4.4 Increasing foreign funding

Since the advent of COVID-19, many countries invested money into fighting the pandemic, which was not previously considered in their financial planning. It is therefore imperative to find alternative ways to attract funding into R&D. One such way is to attract more foreign funding.

Foreign investment in R&D in 2019/20 reached R4.662 billion, an increase of R664 million over the previous year. A decade ago, the business sector was the largest recipient of foreign R&D funding, but currently, the higher education sector receives the bulk of funding at R1.979 billion (42.5%) (see Figure 6). In 2019/20 there was a significant increase in the share of foreign funding to the business sector which increased by 15.1% and amounted to R1.169 billion. If this trend continues, it could show a positive trend in foreign investment into the business sector.

The largest proportion of foreign funding by country originates from the USA/Canada (78.5%), followed by Europe (18.6%) and Africa (outside SA) (1.4%). Funding from the USA/Canada is directed largely to the government (41.8%), foundations (20.3%) and private non-profit-organisations (9.5%). Funding from Europe is directed more evenly across the different economic sectors, whereas the business sector received the most funds from Africa.

The 2019 White Paper on Science, Technology and Innovation outlined new policy goals. These include increasing levels of funding, developing funding priorities, institutionalising a framework to guide STI investment, and improving funding efficiencies.

A concerted effort should also be made to increase foreign funding into R&D. This can be done by streamlining practical mechanisms to encourage opportunities for foreign venture capital and private equity companies, promote foreign direct investment in R&D, and offer additional support to government agencies and role players such as the Trade and Investment South Africa (TISA) agency that promotes investment.

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METHODOLOGICAL NOTE

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

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

The scope of the survey includes all units performing R&D, either continuously or occasionally. The survey collects data in accordance with the guidelines recommended by the OECD in the Frascati Manual (OECD 2002, 2015, 2020). This helps to maintain coherence and international comparability. The System of National Accounts (EC, IMF, OECD, UN and the World Bank, 2009) and the national system of innovation differ on the identification of target units and definitions.

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

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

R&D performers in sectors were taken to be any units with R&D expenditure or likely to have had R&D expenditure, in 2019/20. The R&D data were collected by means of questionnaires that were sent to the units in each sector by electronic mail. Quality indicators of survey coverage, fieldwork, data processing and analysis were assessed in the metadata report of the survey.

Readers must note that time series analysis of the data using the 2019/20 R&D Survey's estimates should be read with caution, taking into consideration the relatively low response rate due to the advent of COVID-19.

A detailed methodology and metadata are provided in the Statistical Report.

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