A National Tracer Study of Doctoral Graduates in South Africa

Report to the

Department of Science and Innovation

by

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Abbreviations

CAGR	compound annual growth rate
CESM	Classification of Educational Subject Matter (HEMIS)
CeSTII	Centre for Science, Technology and Innovation Indicators
CGS	Council for Geoscience
CHAID	chi-square automatic interaction detection
CHE	Council on Higher Education
CPUT	Cape Peninsula University of Technology
CSIR	Council for Scientific and Industrial Research
CUT	Central University of Technology
CREST	Centre for Research on Evaluation, Science and Technology
DHET	Department of Higher Education and Training
DEL	Department of Employment and Labour
DSI	Department of Science and Innovation
DST	Department of Science and Technology
DUT	Durban University of Technology
HEI	higher education institution
HEMIS	Higher Education Management Information System
HSRC	Human Sciences Research Council
MUT	Mangosuthu University of Technology
nGAP	New Generation of Academics Programme
NMU	Nelson Mandela University
NRF	National Research Foundation
NWU	North-West University
R&D	research and development
RDI	research, development and innovation
RoA	rest of Africa
RoW	rest of the world
RSA/SA	South Africa
RU	Rhodes University
SADC	Southern African Development Community
SAMRC	South African Medical Research Council
SARChI	South African Research Chairs Initiative
SATD	South African Thesis Database
SciSTIP	DSI-NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy
SET	science, engineering and technology
SMU	Sefako Makgatho Health Sciences University
SPSS	Statistical Package for the Social Sciences
SPU	Sol Plaatje University
SSH	Social sciences and Humanities
STEM	science, technology, engineering and mathematics
STI	science, technology and innovation

SU	Stellenbosch University
TUT	Tshwane University of Technology
UCT	University of Cape Town
UFH	University of Fort Hare
UFS	University of the Free State
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UL	University of Limpopo
UMP	University of Mpumalanga
UNISA	University of South Africa
UP	University of Pretoria
UWC	University of the Western Cape
UV	University of Venda
UZ	University of Zululand
VUT	Vaal University of Technology
Wits	University of the Witwatersrand
WRC	Water Research Commission
WSU	Walter Sisulu University

Glossary

Age at graduation	Respondents were asked to indicate their date of birth. Together with respondents' date of graduation, as captured in the South African Thesis Database, respondents' age at graduation was calculated.
Current employment	Respondents were asked a range of questions about their employment position at the time they completed the survey. We refer to this position as current employment or most recent employment position.
Employment status during doctoral studies	One of the key concepts used in this study is the employment status of doctoral graduates during their doctoral studies. We define full-time enrolment as doctoral students who are not employed full time during their doctoral studies. Part-time enrolment refers to graduates who were employed for more than 30 hours during a typical week while enrolled for their doctoral studies.
Gender	Respondents were asked to identify their gender and three categories were recorded: female, male and other. The third group was not included in our gender analyses given the small number of respondents in this group.
Geographic mobility	Geographic mobility refers to the movements between countries and operationalised in this report as the movement between regions (South Africa, the rest of Africa, and the rest of the world).
Intersectoral mobility	Intersectoral mobility refers to the movement of graduates between sectors at different stages in their careers. We define sectors of employment as the following: 1) The higher education sector includes (a) universities, colleges of technology and other institutions providing tertiary education, whatever their source of finance or legal status; and (b) research institutes, experimental stations and clinics under the direct control of or administered by or associated with higher education institutions. 2) The public or government sector includes (a) departments, offices and other bodies that furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community; and (b) non-profit institutions controlled and mainly financed by government, not

	administered by the higher education sector. This sector includes national, provincial and local government. 3) The business enterprise sector includes (a) firms, organisations or institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price; and (b) the private non-profit institutions mainly serving those firms, organisations or institutions. 4) The "other" education sector includes institutions providing pre-primary, primary or secondary education. 5) The private non-profit sector includes (a) non-market, private non-profit institutions serving households (i.e. the general public); and (b) private individuals or households.
Managerial responsibilities	Managerial tasks are defined as controlling or administering an organisation or group of staff.
Mobility	Two themes regarding mobility are explored in this study, namely, (1) intersectoral mobility and (2) geographic mobility.
Nationality	The aim of the study is to trace doctoral graduates from South African universities. In some cases we refer to South African doctorates as referring to all graduates who obtained their qualification from a South African university. In cases where we refer to South African graduates specifically, in other words graduates who have South African citizenship, we make this distinction clear. We asked survey respondents to indicate their citizenship status during two stages in their careers: (1) citizenship status and country while studying for the PhD and (2) citizenship status and country after graduation with a PhD. Respondents' citizenship status during their PhD studies was used as proxy for nationality. In our analysis of the survey results we report on respondents' citizenship status in three categories: (1) South African citizens, (2) citizens of an African country (rest of Africa), and (3) citizens of a country outside of the African continent (rest of the world).
PhD	The unit of analysis of this study is doctoral graduates. This includes graduates who completed their PhD or any other doctoral qualification from a South African university. Throughout the report we refer to the PhD or doctorate as a doctoral qualification.
Postdoc	South African doctoral graduates who accepted a postdoctoral

	fellowship upon completion of their doctoral degree (although the majority are no longer in postdoctoral positions).
Research responsibilities	Research is defined as being engaged in the conception or creation of new knowledge, products, processes, methods and systems.
STEM	Survey respondents were asked to indicate the field in which they completed their doctoral studies. We cross-referenced the reported disciplinary field with the respondent's thesis title as captured in the South African Thesis Database and used the Classification of Educational Subject Matter to classify a respondent's disciplinary field. Respondents' disciplinary fields were grouped into nine scientific domains which in turn were classified as science, technology, engineering and mathematics (STEM) and social sciences and humanities (SSH) fields. STEM fields include (1) agriculture, (2) biological and environmental sciences, (3) engineering and applied technological sciences, (4) health and medical sciences, and (5) physical, chemical and mathematical sciences. SSH fields include (1) economic and management sciences, (2) education, (3) humanities and arts and (4) social sciences.
Technology development, innovation or entrepreneurial activities	These activities include, for instance, the ideation, design, development or implementation of improved or new processes, products or services, or in the creation of businesses such as start-up companies or social enterprises.

Executive Summary

Aims of the study

The general aim of this study was defined as follows: *To trace the mobility, career paths and other attributes of a representative sample of PhD graduates from South African universities across a range of sectors and disciplines.*

The specific research **objectives** were:

1. To investigate the demographic attributes, work experience, career paths and mobility of doctorate holders, including mobility between sectors (public, private and academia), into and out of the country (brain circulation) and into management roles.
2. To identify the dominant perceptions held by doctorate holders and selected employers about career opportunities in the public, private or academic sectors and the factors that led to the doctorate holders choosing careers in these sectors.
3. To benchmark the results of the Water Research Commission (WRC) tracing study of water-related PhDs with those of this study and identify any factors specific to the water sector that need to be taken into account in planning and decision-making for high-end skills in this sector.
4. To assess the progress of PhD graduates through the researcher pipeline (from being next-generation researchers, to being emerging researchers and finally to being established researchers).

Research design and methodology

The single biggest challenge in graduate destination studies is to identify the graduate after he or she has graduated from a university. The study design for this study consisted of three main components:

1. Phase 1 of the study consisted of updating the SA Thesis Database (SATD), which the Centre for Research on Evaluation, Science and Technology (CREST) started developing in 2010 in order to produce a master list of graduate names that would form the target population for the survey.
2. Phase 2 consisted of searching for the contact details of as many of the graduates on the master list as possible, to constitute the sample frame of the survey.
3. Phase 3 involved launching the web-based survey and distributing the questionnaire to the graduates for whom we could find email addresses.

In addition to the activities described in Phases 1 to 3, which were aimed at enabling us to undertake the web-based survey, the team also conduced 113 in-depth qualitative interviews with respondents (mainly drawn from the water sector) in order to gather more nuanced additional narrative data to add to our understanding of the key findings of the survey.

Results and discussion

Representativeness of the findings

By the end of December 2020, a total of 6 452 unique completed surveys had been captured on the Survey Monkey platform. This translates into a response rate of 41,4% (6 452/15 565). This is a comparatively high response rate and probably indicates the interest in this topic (we received many comments to this effect), as well as the very efficient management of the survey process.

We report on five demographic variables – gender, nationality, race, age of the respondent and scientific field (science, technology, engineering and mathematics [STEM] and social sciences and humanities [SSH]) – to test the representativeness of our sample against the population data (derived from the Department of Higher Education and Training's Higher Education Management Information System [HEMIS]). The periods/graduation windows referred to in the bullets below are 2000 to 2004, 2005 to 2009, 2010 to 2014, and 2015 to 2018.

- Gender: The comparison shows that female respondents are slightly better represented in our sample than in the national population. However, the differences are very small (ranging from 1 to 4 percentage points).
- Country of birth: The second variable used to test the representativeness of our sample is the country of birth of the graduates as indicated in the HEMIS data. A comparison by four-year window shows no marked differences between the sample and population distributions.
- Race: With reference to the race of respondents, black graduates (including African black, coloured and Indian) were slightly under-represented in our sample when compared to the population data on HEMIS. Analyses relating the race of graduates used a weighting of the relevant items to correct for possible bias.
- Age at graduation: As far as the age at graduation of doctoral graduates is concerned, we saw that the average age of doctoral graduates remained much the same, at about 40/41 years of age, over the period between 2000 and 2018. The comparison with the survey respondents shows very few differences (the biggest difference is for the earliest period (2000 to 2004), where the average age of this group is slightly younger, at 38 years of age).
- STEM and Social Sciences and Humanities (SSH) domains: The results show that, in the first two periods, there were more graduates in the STEM fields than the population shares for STEM (53% compared to 47% during the first period, and 52% compared to 48% in the second period). The relative shares of graduates by STEM and SSH in the samples for the third and fourth periods, however, corresponded closely to the population values. In terms of statistical significance, a significant difference was found for all four periods: 2000-2004 (χ^2 = 18,167, df = 1, $p < 0.05$), 2005-2009 (χ^2 = 8,864, df = 1, $p < 0,05$), 2010-2014 (χ^2 = 6,339, df = 1, $p < 0,05$) and 2015-2018 (χ^2 = 4,109, df = 1, $p < 0,05$). The differences between our sample and the population values are small and we can conclude that our sample is generally representative in terms of STEM/SSH fields.

Based on these assessments and taking into account the large sample size (nearly 20% of the population), the results of this study can be regarded as being representative of the South African population of

doctoral graduates over the past 19 years and that the results presented in this report can be generalised to all South African PhD students who graduated between 2000 and 2018.

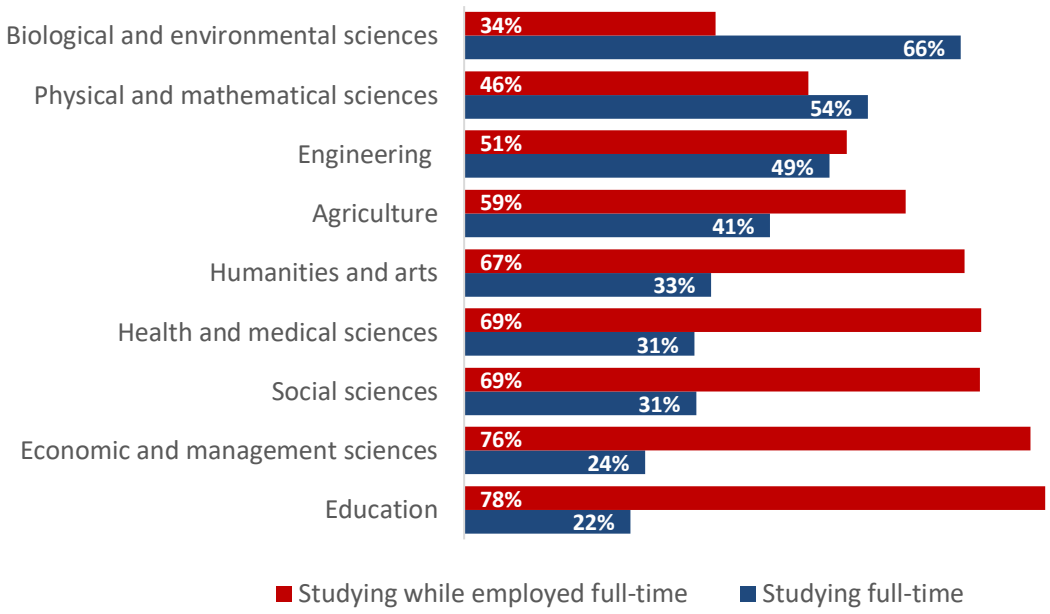
Employment status of graduates during doctoral studies

Headline finding 1

The majority (60%) of doctoral students in South Africa study part time. This means that they are enrolled for their doctoral studies while employed or self-employed. Conversely, only 40% of all doctoral students study full time. Importantly, this proportion of part-time to full-time students (60:40) has remained nearly unchanged over the past two decades, suggesting that this is a structural feature of the South African doctoral system.

Elaboration

Disaggregation of the results shows that the percentages of students studying full time or part time differ by scientific field. Students in the STEM fields are more likely to study full time than students in the SSH. The differences in the employment status of students in the STEM vs SSH fields are, in turn, linked to the age of the students: The youngest subgroup of doctoral students are full-time students in the STEM fields; the oldest group at graduation are part-time doctoral students in Education. Further disaggregation by main science domains reveals wide differences in the proportion of full-time to part-time students (Figure below).



Looking at the country of birth of respondents, we find that respondents from the rest of Africa were more likely to study for their PhDs full time. Nearly 60% (n=871) of graduates from these countries indicated that they were not employed while enrolled for the PhD and hence studied full time. This compares to 31% (n=1 217) of South African nationals and 45% (n=87) of graduates from elsewhere in the world who indicated that they studied full time.

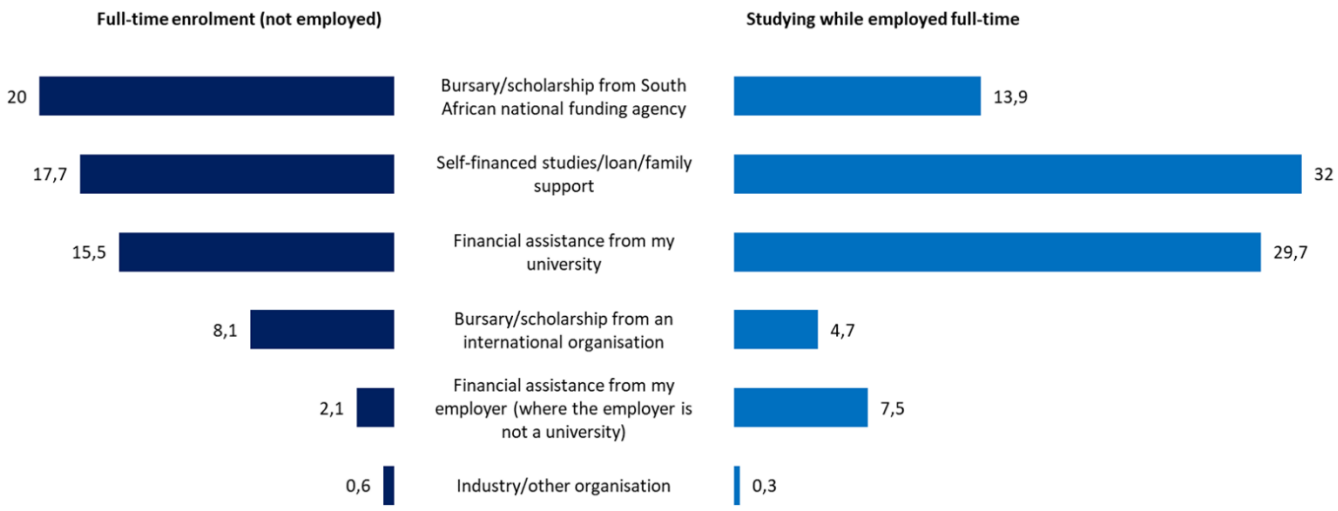
Financing of doctoral studies

Headline finding 2

How do doctoral students finance their studies? The most frequently mentioned source of financing doctoral studies is self-financing (33%), which includes taking out loans and financial support from family members, spouses or partners. The second most cited source of funds is assistance from the respondent's university (30%). These first two results are perhaps unsurprising given that 60% of graduates were employed while doing their doctorates and, of these, many were in the higher education sector. What is surprising is that bursaries or scholarships from South African national funding agencies such as the National Research Foundation (NRF), the South African Medical Research Council (SAMRC) or the Water Research Commission (WRC) were only the third most frequently cited source of financing for studies (22%). Eight percent of respondents (n=794) received financial assistance from an international organisation, compared to 6% (n=593) who received assistance from an employer that was not a university. A small number of respondents received financial support from industry or another (private) organisation/donor.

Elaboration

Financing of doctoral studies is expected to correlate with whether the graduate studied full time or part time. As one would expect, graduates who were not employed during their PhD studies were more likely to cite financial assistance from a South African national funding agency (20%) than the 13,9% of respondents who were employed on a full-time basis. Graduates who were employed full time during their doctoral studies were more likely to be self-financed (32%) or receiving financial assistance from their universities (29,7%). The latter group refers to the large proportion of academic staff at South African universities who pursue doctoral qualifications and receive a staff rebate or tuition support.



Further elaboration revealed little change in the percentage of full-time enrolled respondents who received bursaries or scholarships from national funding agencies over time. However, the field of study makes a difference. We found that 63% of full-time graduates enrolled in the STEM sciences received funding from a national funding agency, compared to 33% in SSH.

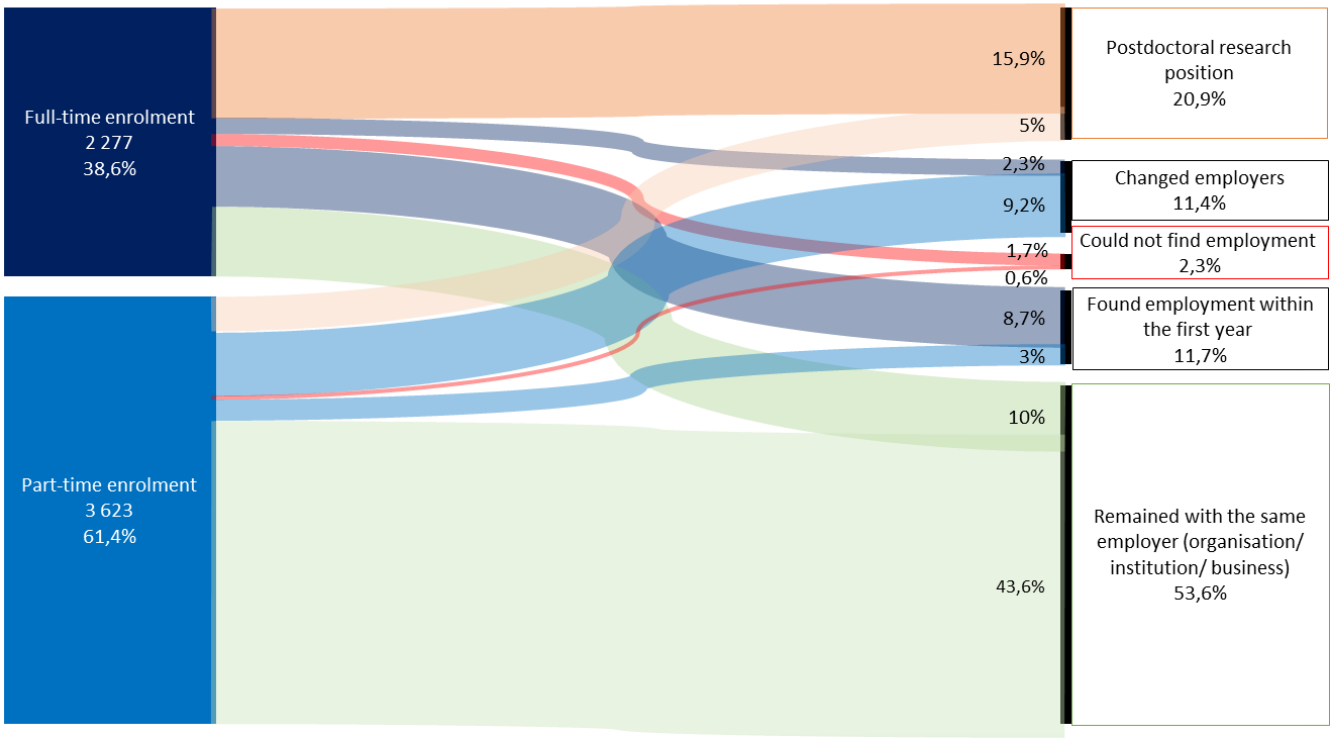
Finding employment after graduating

Headline finding 3

Most South African doctoral graduates over the past 19 years have remained with the same employer since obtaining their doctorates. This is not surprising either, given that about 60% of all doctoral students in the country were already employed when they enrolled for doctoral studies. It is worth noting that a substantial number of students (20%) indicated that they accepted a postdoctoral fellowship on completion of their studies. An equally important finding of our study is that **only 2-3% indicated that they could not find employment after completing their doctoral degree**.

Elaboration

Further elaboration on the different flows or pathways of full-time and part-time students after graduation and where they found employment is provided in the Sankey diagram below. The two blocks in the left column of the diagram (dark and light blue blocks) show the distribution of our sample by enrolment status **during their doctoral studies** – 39% of respondents studied full time compared to 61% who were employed full time while studying. The coloured flow bands show the proportional share of either full-time or part-time graduates who (1) accepted a postdoctoral fellowship, (2) changed employers, (3) could not find employment, (4) found employment in the first year, and (5) remained with the same employer/organisation/institution. The employment status of respondents **in the year following the completion of their doctoral studies** is illustrated in the blocks on the right side of the diagram. For example, the broad orange band indicates that 15,9% of the total sample studied full time and accepted a postdoctoral fellowship within the first year after completing their studies. In addition, a further 5% of the total sample who were employed while studying managed to obtain a postdoctoral fellowship after graduation. This means that 21% of our graduates over the past 19 years managed to secure postdoctoral fellowships after graduation. As the figure shows, however, the single biggest group of graduates (53,6%) found employment in academia, where most of them had already been employed while pursuing their doctoral studies.



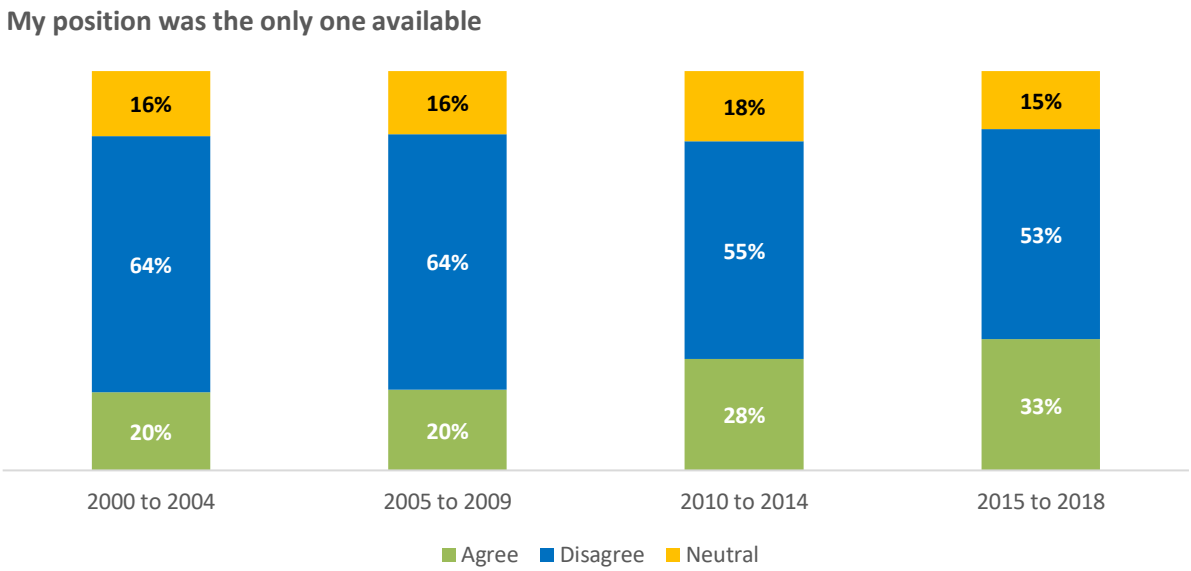
Alignment of current employment and field of doctoral expertise

Headline finding 4

The results discussed thus far have shown that the majority of South African doctoral graduates are employable, with a very small percentage (2 to 3%) not finding employment immediately following the completion of their doctoral studies. Being able to quantify the exact percentage of doctoral graduates who are not immediately employable is a major contribution of this study to our understanding of the state and dynamics in the labour market of doctoral graduates in the country. However, it is also necessary to address some of the more qualitative aspects related to employability and employment. The majority (70%) of graduates indicated that they found employment directly related to their fields of expertise or training. **However, nearly one in five (18%) of respondents (n=901) indicated that they could not find employment related to their field of expertise.** Further disaggregation of the data shows that graduates who received their doctoral degrees in the past five years were more likely (22%) than those who received their degrees more than 15 years ago (13%) to indicate that their current job or position was **not** related to the field of expertise of their doctorate. These results challenge policy makers as, although SA doctoral graduates are successful in finding employment, they are increasingly indicating that the employment is not what they expected or wanted.

Elaboration

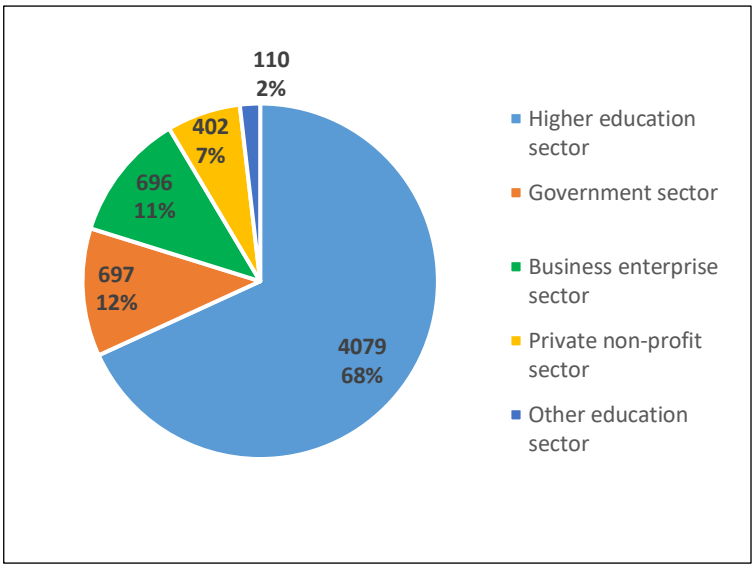
Disaggregation by science field shows that graduates in SSH reported more challenges in finding suitable employment than graduates in the STEM fields. These findings are supported by the responses to a follow-up question. When asked about their most recent/current employment position, on average slightly more than a quarter of respondents indicated that their current employment position was the only option available. **However, when we disaggregate these responses by graduation window, we see that one third of recent graduates indicated that their employment was the only option available (compared to 20% of graduates who completed their studies 10 to 19 years ago).**



Intersectoral mobility of doctoral graduates

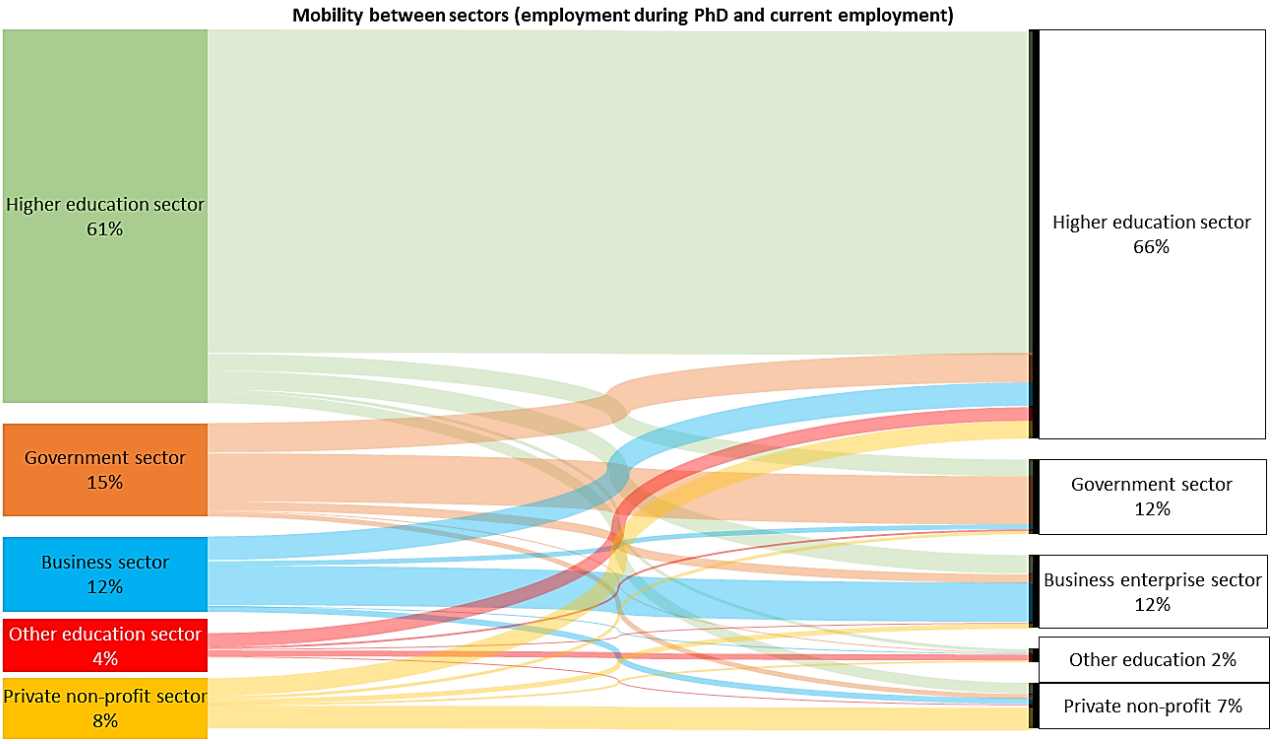
Headline finding 5

Graduates were asked to indicate their sector of employment during their doctoral studies as well as their current (or most recent) sector of employment. This allowed us to establish the extent of the mobility of doctoral graduates between sectors over the past 19 years. A major finding is that **nearly two thirds of respondents were employed in the higher education sector at the time of the survey and have remained in the sector**.



Elaboration

Those who were already employed in academia (light green band in figure below) during their doctoral studies have remained in the sector. Small percentages have moved to the public, business and other sectors. However, these "losses" have been offset by gains both from the public sector (which includes the science councils) and business. The end result is a net gain for the higher education sector (66% currently employed in the sector compared to 61% of graduates in the sector during their studies). The government sector (orange band) has witnessed an overall net loss, mostly through the migration of staff to universities. At the time of their studies, 15% of all graduates were employed in this sector. When we conducted this study at the end of 2021, the percentage had decreased to 12%. There were no other significant changes in terms of the big picture. In the final analysis, the Sankey diagram shows a very "stable" system with minimal intersectoral mobility.



Postdoctoral fellowship career trajectory

Headline finding 6

A fifth of our survey respondents indicated that they accepted a postdoctoral fellowship upon completion of their studies. Over the two decades, the number and proportion of PhD graduates doing postdoctoral fellowships has grown significantly. During this period, the biological and environmental sciences, and the STEM fields in general, were best represented in postdoctoral positions, while they are least likely to be found in the SSH fields, especially in the field of education. However, since 2011, our study showed a steep increase in the number of postdoctoral fellows in economics and management compared the STEM fields. This trend may be an indication that certain STEM fields do not have the capacity to absorb more postdoctoral fellows.

Elaboration

Although slightly more than half of the postdocs were male, both **genders** were equally likely to accept a postdoctoral fellowship after their PhD, irrespective of the field (STEM or SSH) in which they had graduated. However, when the responses are disaggregated by science domain, we found proportionally fewer female postdocs in the engineering and applied technological sciences or the physical, chemical and mathematical sciences than in the health and medical sciences, the biological and environmental sciences and the social sciences. It seems that the disparities in the representation of the genders that we witnessed in the academic pipeline (from undergraduate to doctoral students) continue to be mirrored at the level of postdoctoral fellowships.

Since there were more postdoctoral fellows in the STEM fields, who would have been more likely to have studied full-time, it is not surprising that we found that postdocs obtained their PhD at a **younger age** than the rest of our respondents.

While the majority of our sample spent an average of three years in a fellowship position, one in three could be described as a "serial postdoc", who accepted one or more postdoctoral positions after their

first fellowship. Our data – both quantitative and qualitative – indicate that the majority do so not out of choice, but rather because of the lack of employment opportunities, especially in the academic sector, where they hope to find permanent positions. Importantly, these serial postdocs are even younger when they graduate with their PhD than their counterparts with a single postdoctoral fellowship.

These results, together with the slow growth of postdoctoral fellowships in some fields, are important from a policy perspective. Although our results show that such fellowships carry benefits, other results lead us to conclude that the South African science system is reaching the limit of its capacity to absorb increasingly younger graduates, whose lack of full-time employment options leads them to apply, often repeatedly, for a finite number of postdoctoral fellowship positions. The biological and environmental sciences are of particular concern, as they have the slowest growth rate in postdoctoral fellowships, and the highest likelihood of hosting serial postdocs.

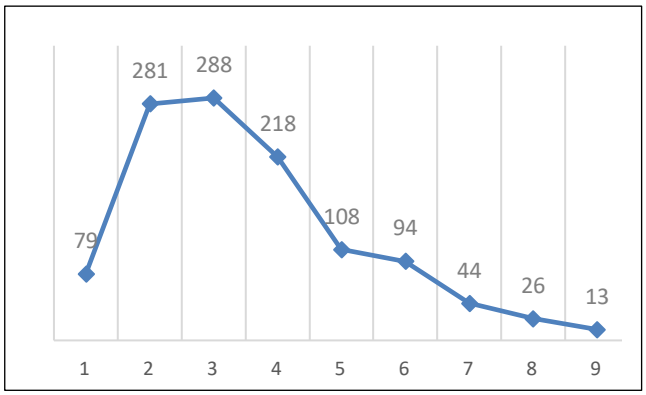
The reasons for taking a postdoctoral position are mainly to gain additional training in the field of one's PhD and to carry out research independently, but the ultimate goal is to eventually secure a permanent position, especially in academia. Our qualitative data show how these and other expected benefits of the postdoctoral fellowship were mostly realised in the cases we interviewed, while the quantitative data show that the majority of postdoctoral fellows, and especially serial postdocs, have indeed found employment in the higher education sector. The qualitative data do, however, alert us to many negative features of postdoctoral fellowships, and the lack of full-time employment opportunities that are likely to have fuelled the dramatic increase in postdoctoral positions since 2011.

The "serial" postdoctoral fellow

Headline finding 7

While the majority of postdocs spent an average of three years in a fellowship position, one in three may be termed "serial postdocs", who accept one or more postdoctoral positions after their first fellowship. **Our data indicate that the majority of serial postdocs do not continue in these positions out of choice, but rather because of a lack of employment opportunities, especially in the academic sector, which is their preferred sector of employment.**

The figure on the right shows that just over half of postdocs (55%) typically spend between one and three years in a fellowship. However, a significant proportion spend four (19%), five (9%), six (8%) or more in such positions.



Elaboration

Most postdoctoral fellows accept fellowships to gain additional training in the field, to carry out research independently or to work on a specific project. But more than a quarter of our sample (28%) also indicated that they accepted a postdoctoral position because other employment options were not available. However, these responses apply to all postdoctoral fellows. When we analysed the same responses for the subgroup of serial postdocs (those who held such positions for more than three years), more than two in five (41%) of this group indicated that could not find any other form of employment.

The indication that the main driver for multiple postdoctoral fellowships is the lack of other employment opportunities is further supported by the qualitative data. As an interviewee explained, the reason for "sticking with long-term postdoctoral positions in the academic environment is the potential for growth, and for getting a [permanent] position. But 90% [of the time, this] doesn't seem to be the case, because the university doesn't want to hire". Another interviewee agreed that, currently, the "common opportunity that we get is the postdoc. So, it's postdoc after postdoc. There's no permanent job at the moment".

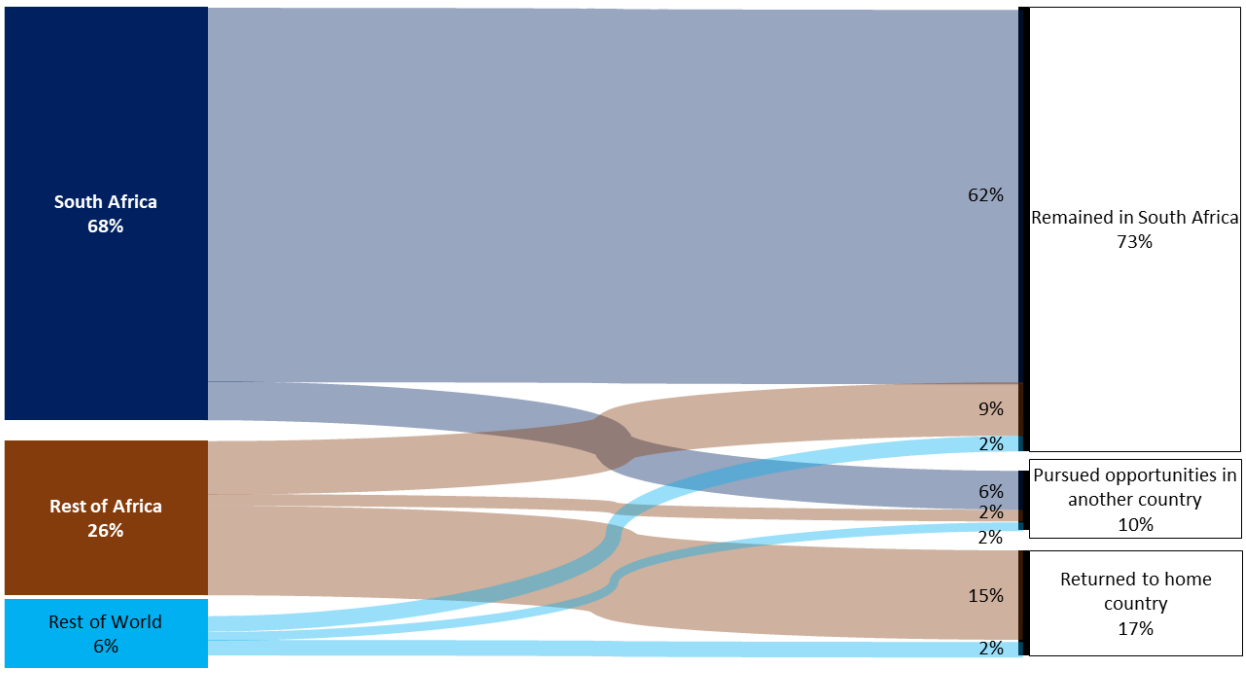
The geographical mobility of SA doctoral graduates

Headline finding 8

South Africa has benefited significantly from the inward flow of doctoral students to the country. One of the main objectives of our study was to determine the mobility of doctoral graduates into and out of South Africa.

Elaboration

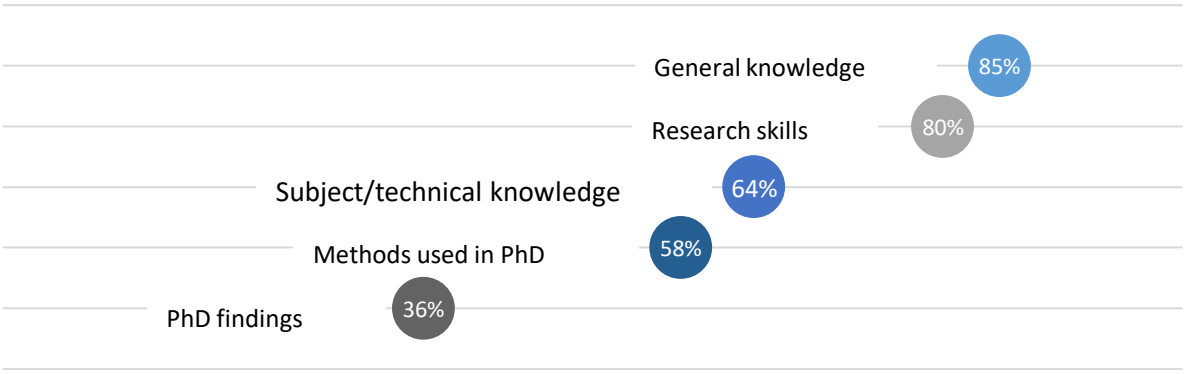
Survey respondents were asked about their geographic mobility during two stages of their careers. Firstly, respondents were asked to describe their original plans upon completion of the PhD and then to indicate what had actually happened in the first year following completion of their studies. Secondly, respondents were asked to indicate in which country they had been most recently employed. Combining the number of SA nationals who remained in the country after graduating with the numbers of students from the rest of Africa and the rest of the world, South Africa's net gain in terms of non-South Africans finding employment in the country increased by nearly 5 percentage points over the past 19 years. Of the 3 770 graduates in our sample who were born in South Africa, 372 or 9,2% left the country after graduation. At the same time, of the 1 812 graduates from outside the country in our sample, 633 (or 35%) remained in the country. **This translates into a net brain gain of 261 graduates or 4,6% of our sample. If we average this out over the past 19 years, it means that South Africa has a net gain of 1 400 doctoral graduates from other countries who remained in the country (after subtracting those SA nationals who left the country).**



Utility of PhD in current employment

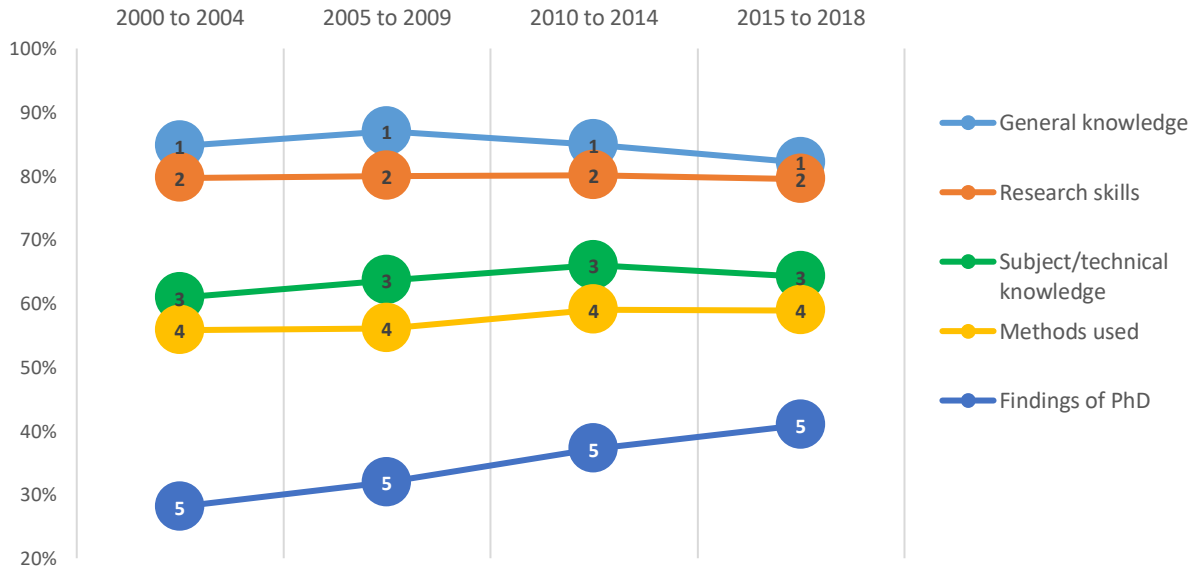
Headline finding 9

South African graduates rated the general knowledge and research skills acquired though their PhD studies to have been of most benefit in their current employment. The survey asked respondents to consider the extent to which they used their PhDs in their **current** employment. In particular, they were asked to rank the application and utilisation of five different aspects of their doctoral studies. The results (see figure below) show that general knowledge and research skills were considered more useful in their current job than field-specific knowledge, methodological skills or the specific research findings of their dissertations.



Elaboration

The general findings described above were also found to hold over time. A comparison of the ratings of the five categories of utility by graduation window shows that the ranking of these benefits remains the same irrespective of when the respondents graduated. Interestingly, the high rankings for the first four categories remain at similar levels over the period 2000-2018. The fact that the value of the findings of their PhDs were rated more useful by recent graduates also makes sense, as the usefulness of the specific findings of a doctorate diminishes over time. This is clearly not the case for the other benefits of doing a doctorate.



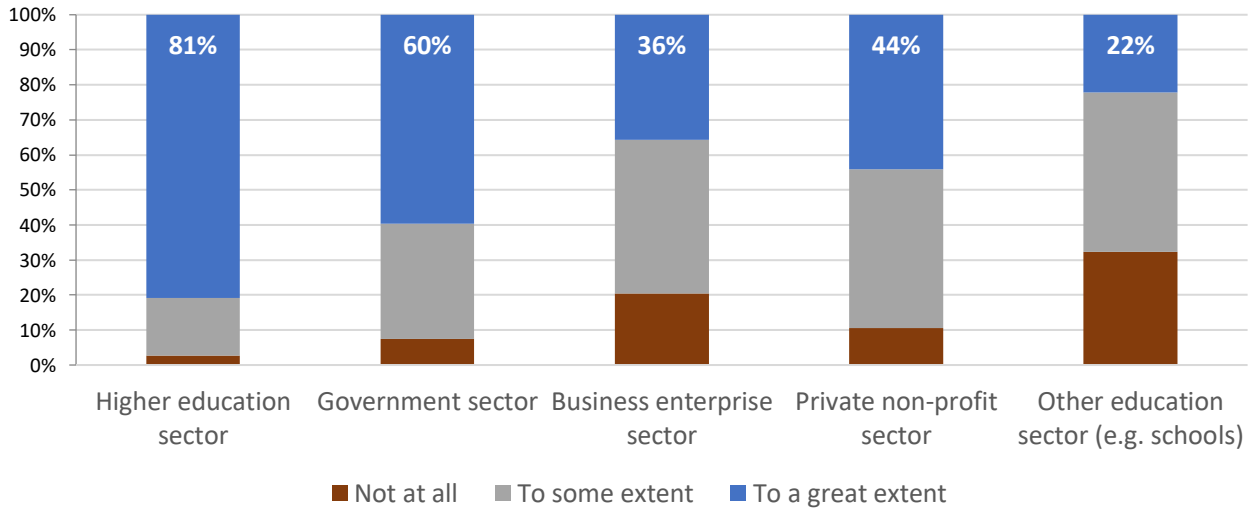
Value of doctoral degree in employment

Headline finding 10

More than two thirds (70,5%, n=3 875) of respondents indicated that a *doctoral degree was a requirement* for employment in their current position. Not surprisingly, the majority of graduates currently employed in the higher education sector (83%) indicated that a PhD was a requirement for their work, compared to only 53% in the government sector. Fewer respondents in the private non-profit sector (39%) and business sector (33%) deemed the doctorate a requirement for their current employment.

Elaboration

These findings are substantiated by responses to a related question in the study, i.e. whether their current employment included research. The majority (70%) across all sectors indicated that it was. Disaggregation by sector (see figure below) reveals, not surprisingly, substantial differences in the reported utility of research.



An interesting finding is that disaggregation by scientific domain did not reveal statistically significant differences on this issue.

The return on investment of doctorates

Headline finding 11

Between 80 and 92% of doctoral graduates indicated that they were satisfied with their decision to pursue a PhD, with the field chosen for their doctorate, and with the return on their investment, and that their expectations of obtaining a doctorate had been met.

The interviews revealed that individuals decided to do PhD degrees for a variety of reasons, mostly related to career advancement. Doing a PhD was viewed either as the means to enter a particular career, a ladder for upward mobility, and/or a bridge from one career and/or sector to another. Respondents reported that their doctoral degrees had improved their existing stock of knowledge, skills and networks which, in turn, markedly broadened their career prospects or gave them a competitive edge in the labour market. Some interviewees pointed to what might be termed the "symbolic" value of a PhD insofar as it signals to prospective employers and others an expected level of competence or skills set. They also highlighted that having a PhD – and often the title that comes with it – brought with it a certain cachet. All in all, the positive perceptions of others towards the PhD could be leveraged to the advantage of doctorate holders.

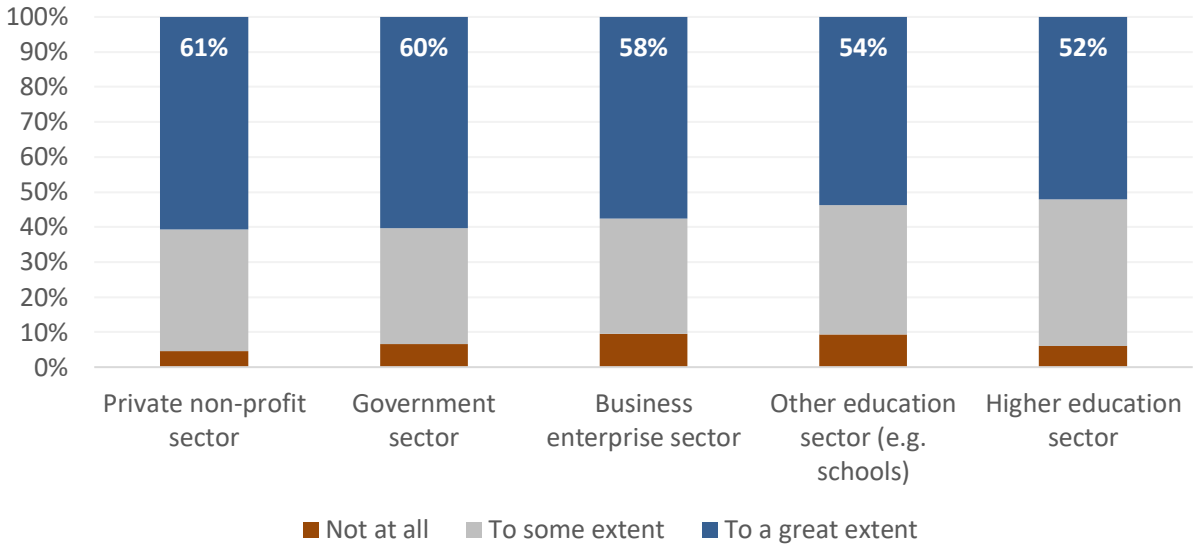
Managerial responsibilities in current employment

Headline finding 12

Just over half (54%) of respondents indicated that managerial responsibilities made up a large part their current employment responsibilities. The acquisition of managerial skills is not necessarily an expected outcome of doctoral studies, and – on the face of it – it is somewhat surprising that so many respondents indicated that they had managerial responsibilities. The fact that this finding was found to apply across all sectors needs to be interpreted, together with other results from our study, particularly the large percentage of doctoral graduates who indicated that research skills and field-specific knowledge were either a requirement of or of great value in their current job. These facts suggests that most graduates find themselves in positions (in academia, science councils, government and business) where they have to combine knowledge and research-related skills (directly obtained from doing a PhD) with managerial responsibilities. Being involved in management (and even administrative tasks) now seems to be an essential component of work, even for knowledge workers.

Elaboration

The lowest proportion of doctorate holders with managerial responsibilities was in the higher education sector (52%, n=2 103), and the highest in the non-profit (61%, n=242) and government sectors (60%, n=420).



Recommendations

First cross-sectoral study to act as benchmark for future studies

Recommendation 1

This study is the most comprehensive tracer study of PhD students who graduated from South African universities in the recent past. The findings presented in this report provide, for the first time, accurate, precise and generalisable information on a wide variety of issues – the employability of SA doctoral graduates, the financing of doctoral studies, the differences in the career trajectories of full-time and part-time students, the challenges facing postdoctoral fellows, the absorptive capacity of different employment sectors and the geographic mobility of doctoral graduates. The report also gives new insights into the perceived value and utility of pursuing doctoral studies. It is fair to say that this study would be a valuable **baseline** for any future studies of this nature. Our first recommendation is that doctoral tracer studies (or some form of tracking doctoral graduates) become a regular feature of higher education and labour studies in the country.

Studies needed on the financing of doctoral studies

Recommendation 2

The study has revealed that there are significant differences between students studying full time and those studying part time, in respect of different disciplines, races and ages. The fact that the single biggest source of financing was identified as self-financing by the student is a clear indication that government funding of doctoral studies is inadequate and has become one of the main reasons why many doctoral students have no choice but to study part time. Our second recommendation is therefore that further research into the **financing of doctoral studies** be undertaken. Such research should aim to gain a better

understanding of how doctoral students are financed and supported by their universities, their employers, and national and international funding agencies, as well as how these different funding modalities affect PhD studies and graduates' subsequent career trajectories.

Need for research on the changing nature of work and expectations of doctoral graduates

Recommendation 3

Our study found that most South African doctoral graduates are employable (with only 2-3% unable to find employment). However, further disaggregation of qualitative data also showed that 20% of graduates (especially those who graduated in recent years) were unable to find employment related to their technical skills or fields of expertise. This raises questions about the nature of the "standard" doctoral degree and the knowledge and skills students acquire, and specifically whether these skills align well with changes in the labour market. Our third recommendation is that more should be done to describe and explain how changes in the nature of work are impacting on expectations related to the kind and range of skills doctoral graduates should have.

Recommendations for policy review based on evidence

Recommendation 4

This study has confirmed the results of a number of previous studies conducted by CREST (SciSTIP), which indicated (a) that doctoral students in South Africa commence their studies at an average age of 34; (b) that there are large differences between fields (in SSH the average age at which students commence PhD studies is 36); and (c) that the majority of doctoral students in the country (60%) study while they are employed (Mouton et al., 2015, Van Lill, 2019). The current reality is that South Africa has too few doctoral students who are (1) studying full time; (2) properly funded and (3) able to commence and complete their doctoral studies earlier than the average of 40/41 years. From a policy point of view, these results call into question some of the rules of the most recent NRF funding policy, which focuses exclusively on students who study full time (the minority in the system) and who are not older than 32 at the start of their PhD studies (again the minority of students across all disciplines), and which ignore (for all practical purposes) the huge contribution that non-South African students (more than 30% of all doctoral students are from the rest of Africa) have made to our higher education and science system. We therefore strongly recommend that the NRF revisits and revises their current policy to take the above into account.

Call for dialogue on the position and status of the postdoctoral fellow

Recommendation 5

Our study has confirmed that many doctoral students pursue a postdoctoral fellowship not because they want to, but because they have no alternative. This is particularly true for students who aspire to a career in academia, where the lack of growth means that there are very few positions available for young entrants. As a result of this, they accept successive fellowships simply because no permanent position is available. Many of our postdoctoral fellows indicated that they believe that their precarious position and the effect of this on their self-identity and future expectations was not properly appreciated. We therefore recommend that the relevant role players (Universities South Africa [USAf], the DSI, the Council on Higher Education [CHE] and funding agencies) convene an expert group to investigate in more detail how the position and

status of postdoctoral fellows can be strengthened and what measures are required to ensure that the value and talent of this group is not lost to academia and the science system in general.

Need to investigate the absorptive capacity of doctoral graduates in the knowledge sector

Recommendation 6

Our study has provided, for the first time, precise and comprehensive data on the intersectoral and geographic mobility of doctoral graduates. The evidence suggests that the capacity of the system to absorb increasing numbers of these graduates is already strained. There are signs that, although we may continue to produce larger numbers of doctoral graduates every year, the lack of growth in new posts in academia and other knowledge-intensive sectors may soon translate into lower employability rates for doctoral graduates in the country. This phenomenon is particular evident in the STEM fields, where increasing numbers of graduates in the biological and environmental sciences end up in one postdoctoral position after another. Our final recommendation, therefore, is that a specific initiative is launched to investigate the absorptive capacity of the knowledge sector in the economy further to ensure that there is an optimal alignment between the supply and demand of highly-skilled graduates. Predictive modelling of the current mobility trends could be one of the methods used.

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Chapter 1: Introduction and background

1.1. Terms of reference

In September 2019, the DSI-NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP) submitted a proposal to undertake a study (cross-sectoral PhD tracer study) in response to a call for tenders by the Water Research Commission (WRC). In a letter dated 21 January 2020, we were informed that our proposal had been successful and we were commissioned to undertake this study.

The general aim of the proposed study was formulated as follows: *To trace the mobility, career paths and other attributes of a representative sample of PhD graduates from South African universities across a range of sectors and disciplines.*

Five specific study **objectives** were identified:

1. Investigate the demographic attributes, work experience, career paths and mobility of doctorate holders, including mobility between sectors (public, private and academia), into and out of the country (brain circulation), and into management roles.
2. Working in tandem with other relevant initiatives, including the WRC Water Research, Development and Innovation (RDI) Roadmap skills mapping study (currently under way), provide an indication of supply vs demand for doctorate holders.
3. Identify the dominant perceptions held by doctorate holders and selected employers of career opportunities in the public, private and academic sectors, and the factors that led doctorate holders to choose careers in these sectors.
4. Benchmark the results of the WRC tracing study of water-related PhDs (currently under way) with those of this study and identify any factors specific to the water sector that need to be taken into account in planning and decision-making for high-end skills in this sector.
5. Assess the progress of PhD graduates through the researcher pipeline (from next-generation researchers, to emerging researchers and finally established researchers).

The terms of reference included a section on the **rationale** for the study. The following observations made in this section are important:

1. Doctoral education and training in any country is a lengthy and costly process. This makes it imperative that policy makers (including funding agencies) are informed about the return on this (public) investment. A related point is made about the need to have evidence of the socio-economic impact of doctoral training.
2. A second set of observations pertain to the disjuncture between the steep increase in the numbers of doctoral graduates in the country (especially over the past 10-12 years) and the capacity in the labour market to absorb the increasing number of graduates.
3. Thirdly, the proposed study should also be able to establish whether the findings from a pilot

tracer of graduates in the water sector[1] are in fact representative of trends across all scientific disciplines. The results of the study would also inform the establishment of a digital platform for tracking NRF-funded students.

4. Finally, to ensure compatibility with the current study, the proposed study should "sample" doctorates in the period 2013-2018.

The specific expectations from the study were formulated as follows:

1. To inform national policy related to the academic pipeline from emerging scholars to established scientists.
2. To inform the proposed work on the digital tracking platform to be established at the NRF.
3. To gain a deeper understanding of the factors that inform the decision-making of doctoral graduates during their studies (about future employment) as well as after graduation (in their career choices).
4. To validate the representativeness of the findings of the WRC pilot study.

1.2. Background and rationale

In our original proposal we indicated that the rationale for the proposed study could be found in three inter-related dynamics in the South African science and innovation system:

- Trends in doctoral enrolments and graduations between 2000 and 2018[2].
- The lack of accurate and up to date knowledge and understanding of the career trajectories of doctoral graduates.
- The current demands for inputs into policy and strategy initiatives in the national system of innovation.

1.2.1. Trends in doctoral enrolments and graduations over the past 19 years

The imperative to grow the academic pipeline and specifically to increase the production of doctoral graduates in South Africa (both in general and in the science, engineering and technology fields) was identified as a policy priority in the White Paper on Science and Technology in 1996 (DST, 1996) as well as in subsequent strategies such as the National Research and Development Strategy [DST, 2002]) and plans the Ten-Year Innovation Plan [DST, 2008]). In the National Development Plan, the target of producing 5 000 doctoral graduates a year was set for 2030.

[1] In 2019, the WRC commissioned a pilot tracer study of doctoral graduates who completed their doctoral studies in Water and Sanitation at South African universities.
See Pouris, A. & Thopil, G. 2019. Trace study of Water PhDs in South Africa. A report to the Water Research Commission.

[2] The original terms of reference referred to a shorter time frame (2013 to 2018). However, SciSTIP indicated that it would be more useful to have a perspective on the trends in mobility of SA doctoral graduates over a longer period. This request was accepted and the time frame was extended to coincide with the records in the SA Thesis Database housed at CREST.

A recent comprehensive assessment of the state of the research enterprise in South Africa (Mouton et al., 2019) shows that this target is likely to be met. The report indicated that a total of 28 686 doctoral students graduated from South African universities between 2000 and 2017, and emphasised that, of the 28 686 who graduated by 2017, about two thirds were South African nationals and slightly more than one quarter (26%) were from the rest of Africa (RoA). The report also showed that the real growth in doctoral graduation output was produced by students from the rest of Africa who enrolled at South African universities. The rate of increase for RoA students has been nearly three times faster than the rate of increase for South African students. Hence, by 2017, doctoral graduates from the rest of Africa already constituted 37% of all graduates compared to South African nationals, who constituted 57% of all graduates. The inbound mobility of doctoral students from the rest of Africa is the main reason for the steep increase in the number of graduations over the past 10 years.

The statistics attest to the fact that South Africa has once again become a destination for migrant students from Africa, on a far larger scale than before apartheid (Cloete, Sheppard and Bailey, 2015). This increase is in part driven by the Southern African Development Community (SADC) Protocol on Education and Training, which removes barriers to the free movement of researchers and students of higher education across the region (Kahn, 2015). The protocol requires member states to allocate up to 5% of their university places for SADC students and to charge them domestic fees.

The report concluded that, although we have comprehensive and accurate statistics about trends in doctoral enrolments and graduations in the country, we lack a qualitative understanding of these trends, and specifically where the growing number of doctoral graduates go after graduation (Mouton et al., 2019). In the present study we therefore aim to address some of the gaps in our knowledge of trends in doctoral production in South Africa.

1.2.2. The lack of accurate and up-to-date data and knowledge of the career trajectories of doctoral graduates

Following on from the points made in the section above, we emphasised in our proposal to the WRC that we still lack recent data and knowledge about the career trajectories of doctoral graduates in the country. Under this heading we would include to two specific clusters of studies (which are complementary, but different in approach and methodology).

1.2.2.1. Academic pipeline studies: From emerging to established scholars and scientists

The "academic pipeline" can be understood in both a narrow and a broad sense. In the narrow sense, the focus would typically be on the actors (students, postdoctoral fellows, early career academics and established scholars) and their decision-making as they move through the pipeline. This focus is addressed in the literature on academic career trajectories, one example of which is found in literature that looks specifically at student retention and attrition. One model – the chain of response model (Cross, 1981) – explores the barriers to students' participation by classifying barriers as situational, institutional or dispositional (Carroll, Ng, & Birch, 2009). Situational factors are a student's particular life circumstances at the time of their studies. Five key situational factors are included in this model: (1) employment pressures, (2) financial pressures, (3) family commitments, (4) the independent study context, (5) and the

health of the student. Institutional factors include "procedures, policies and structures of the educational institution that exclude or discourage participation in educational activities" (Carroll, Ng & Birch, 2009). Institutional barriers are often experienced by students when they perceive university programmes as inaccessible, particularly to adult (working) students. Dispositional factors, on the other hand, are internal reasons (personal or attitudinal) that influence academic participation, including the beliefs, values, attitudes and perceptions of an individual or collective. Key factors here are student satisfaction and the motivations or intentions of the student. Many studies have found that situational barriers are more often cited as obstacles to learning than institutional or dispositional barriers (Van Lill, 2019). A study by Greenback (2007) identifies the following factors to influence the continuation of studies, particularly from undergraduate level to postgraduate level: (1) teaching styles, (2) student support, (3) attitude of lecturers, (4) academic orientation, and (5) preparation.

A broader perspective on the academic pipeline would factor in enabling and constraining conditions in the "ecosystem" that affect such decision-making and its outcomes. Such a perspective would typically look at institutional dynamics and trends within the higher education sector (institutional governance, capacity and performance), labour market factors (conditions for the employability of graduates), national policy frameworks (immigration policies) and geopolitical considerations related to internationalisation and globalisation in science and higher education. In the South African context, any number of these factors individually or jointly impact on the academic pipeline, including the following:

1. Low investment by business in research and development (R&D), which affects the potential labour market for postgraduate students.
2. Large differences in the employability of graduates depending on scientific discipline and field.
3. Immigration policies that prevent non-South African nationals from getting tenured positions at South African universities.
4. The continued growth in postgraduate student enrolments from other African countries due to geopolitical shifts that impact on the mobility of university students worldwide.
5. Institutional policies and capabilities to "manage" progression through the academic pipeline, e.g. the huge difference in the availability of high-quality supervisory and mentoring capacity and support for emerging scholars and early career academics across the 26 South African public universities.

1.2.2.2. Destination or tracer studies

The lack of information and knowledge identified in the previous section speaks to the need to conduct regular destination or tracer studies of university graduates. In 2015, CREST completed **a desktop study** (Botha, 2015) on higher education tracer studies in South Africa. Botha found 14 studies (using a wide variety of research designs and methodologies) that had been conducted in South Africa before 2015. It is worth repeating many of the findings of this review study here:

1. There is clearly a need for reliable and updated information on the employment of master's and doctoral (as well as other levels of) graduates in South Africa.
2. All the reports considered in the desktop study reported on once-off research projects. Currently, there is no process or system that undertakes a comprehensive tracking of graduates in South Africa over a long period of time.
3. Eight of the 14 studies considered in this desktop study included master's and doctoral

graduates.

4. Graduate tracer studies are expensive and a high level of skill is required to conduct such studies.
5. Funders of postgraduate studies (such as the NRF) are important stakeholders and interested in information on the employment of master's and doctoral graduates. However, they are not the only role players with an interest in such information. The range of stakeholders and interested parties includes higher education institutions, employers, various government departments (e.g. the Department of Science and Innovation [DSI], the Department of Higher Education and Training [DHET], and the Department of Employment and Labour [DEL]), other government or statutory agencies (e.g. other science councils like the Council on Higher Education [CHE] and the Human Sciences Research Council [HSRC]), development agencies, and national and international foundations.
6. For much of the 40 years preceding 2005, the focus of national graduate studies was (a) to identify graduate outputs in the form of employment uptake, (b) entry into different economic sectors, (c) entry into economic sectors in which graduates were overemployed or underemployed and in which they had difficulty in finding jobs quickly, and (d) the contribution of higher education to graduate success and graduate competencies (Koen 2006:6).
7. A research database from which national graduate samples can be drawn is needed. The countrywide research record came in the form of the Graduate Register, which was compiled and updated from 1965 to about 2000 from records supplied by the HSRC. Subsequently, this function was transferred to the South African Qualifications Authority (SAQA), where the Graduate Register now forms part of the National Learner Records Database, along with entries on grade 12s. The availability of the Graduate Register as a national database led to a situation in which the HSRC ended up controlling national graduate data and assuming responsibility for national graduate tracer studies, while other academic research agencies conducted institutional, regional or local area-specific and profession-based studies (Koen 2006:6).
8. The Graduate Register (which includes the CESM categories) has been an important source of information on institutional, sector and discipline-specific studies, on, for example, providing alumni details to HEIs, establishing employment levels among graduates of specific HEIs, determining graduate output in high-level skill fields, and signalling overproduction of graduates in some fields (Koen 2006:6). The database has been a valuable research resource that also doubles as a national record of graduate output. It has been used to analyse trend data, but has not yet functioned as a tool for tracking graduate job changes and mobility in the labour market over a number of decades. There are serious gaps in attempts to understand the labour-market contribution of graduates.

1.2.3. The current demands for inputs into policy and strategy initiatives in the national system of innovation

One of the recurring themes in various national policy and strategy documents on human resources development for the national system of innovation in South Africa is the academic pipeline. This theme was central in the 1996 White Paper on Science and Technology (DST, 1996), the 2002 National Research and Development Strategy (DST, 2002) and the Ten-Year Innovation Plan (DST, 2008). It was further articulated in the Human Capital Development Strategy for Research, Innovation and Scholarship (DST, 2016). In very simple terms, three key imperatives underpin these various documents: First, to **expand**

and grow the academic pipeline (from honours to doctoral graduates to postdoctoral fellows, to early career academics and finally to established scholars); second, to **transform** the academic pipeline in order to make it more inclusive of black and women students and academics; and third, to make the pipeline more **efficient** by reducing dropout and increasing throughput and success rates.

The academic pipeline development and transformation project remains high on the agenda of all national STI agencies, science councils and universities. It finds expression in the White Paper on STI (DST, 2019), various DHET policy documents (such as the University Capacity Development Programme [DHET, 2017]), and the NRF's Vision 2030 (NRF, 2020). Various programmes and initiatives, such as DHET's New Generation of Academics Programme (nGAP) and Future Professors Programme, and NRF funding instruments, such as the centres of excellence, the South African Research Chairs Initiative and dedicated capacity-building funding programmes, all address the three imperatives (expansion, transformation and efficiency) listed above.

1.2.4. Setting a baseline for doctoral graduates in South Africa

The rationale for the national, cross-sectional tracer study of doctoral graduates in South Africa was informed by a pilot tracer study, which included a small sample of doctoral graduates in the water and sanitation fields (Pouris & Thopil, 2019). The pilot study was commissioned by the WRC and its objective was to investigate the employment of doctoral graduates who completed water and sanitation-related doctoral degrees at South African universities between 2013 and 2017. The current study was subsequently commissioned to explore whether the employment trends found for graduates in the water sector are representative of trends across all scientific disciplines. In Annexure B, we compare the main findings of the Pouris & Thopil (2019) pilot study with that of the current cross-sectional study to ascertain whether the trends in employability of graduates in the water and sanitation sector, based on a small sample, are comparable with that of the population of doctoral graduates.

In a similar vein, and at the specific request of the Reference Group, we include a sub-sector study of doctoral graduates in the water and water-related fields in Annexure A. This is informed by the need to benchmark the findings of the cross-sectional tracer study against other sectors and disciplines. As the current study is the first, comprehensive tracer study of doctoral graduates in South Africa – across all scientific disciplines – and given its large sample size, additional sub-sector studies could be benchmarked against the findings presented in this report.

1.3. Structure of the report

The design and methodology followed in this study is described in detail in Chapter 2. In Chapter 3 we address the question of whether the results from our survey can be taken to be representative of and generalised to the population of all doctoral students who graduated from a South African university between 2000 and 2018. The subsequent chapters are organised thematically: Chapter 4 is devoted to a discussion of the employment status of doctoral graduates during their studies and how they financed their studies. Chapter 5 addresses the topic of the current employment position of graduates and includes a discussion of the mobility of graduates from the commencement to the completion of their studies. Chapter 6 is devoted to postdoctoral fellowships and combines both survey and qualitative data to present a comprehensive but detailed picture of the typical postdoc in the South African system. The topic of the geographic mobility of doctoral graduates is discussed in Chapter 7, while Chapter 8 looks at

issues related to the perceived and reported value and utility of doing a doctoral degree. In Chapter 9 we present a set of key recommendations based on the findings of the study.

In Annexure A we include a sub-sector study on doctoral graduates in the water and water-related fields. Annexure B includes a comparison of the current study's main findings with that of the pilot tracer study of water graduates (Pouris & Thopil, 2019). The technical annexures (C, D and E) follow.

Chapter 2: Study design and methodology

2.1. Introduction

The single biggest challenge in graduate destination studies is to identify an individual after he or she has graduated from a university. In some countries, national databases are constructed and maintained (e.g. in Canada through Statistics Canada), and doctoral graduates are required to complete a questionnaire about their future destination and address. This is not unlike the National Register of Graduates that the HSRC introduced and maintained in the 1980s and 1990s. In the absence of such a national database or register, there are a limited number of methods available to researchers in the field. These are as follows:

1. Tracking graduates who pursue academic or scientific careers through research funding and publications data (bibliometric methods) as well as membership lists of professional societies.
2. Using web-based sources, including social media (Google/LinkedIn/Facebook).
3. Using ad hoc snowball techniques to identify graduates.
4. Using the alumni offices of universities to gain access to graduates through a web-based survey.
5. Placing adverts in media and other platforms inviting graduates to participate in a survey.

The study design for this study consisted of three main components:

1. Phase 1: Updating the SA Thesis Database (SATD), which CREST started developing in 2010 in order to produce a master list of graduate names that would form the target population for the survey.
2. Phase 2: Searching for the contact details of as many of these graduates as possible to constitute the sample frame of the survey.
3. Phase 3: Launching the web-based survey and distributing the questionnaire to the list of graduates for whom we could find email addresses.

In addition to the activities described in Phases 1 to 3, which set the groundwork for identifying respondents in the web-based survey, the team also conduced 113 in-depth qualitative interviews with respondents (mainly drawn from the water sector) in order to gather a more nuanced additional narrative to add to our understanding of the key findings from the survey. We discuss these elements in our research design in more detail below.

2.2. Updating of the SATD database and contact tracing of graduates

The updating of the information contained in CREST's database on doctoral dissertations (SATD) has been an ongoing enterprise since we started the development of the database in 2010. For the purposes of this study, additional effort was invested into this process. This involved (1) the development of an automatic search query (crawler) to search through the institutional repositories of all South African universities; as well as (2) a special effort by a team of database assistants to manually update, check and correct data on the SATD. The task of updating the SATD was intensified during the period between September 2019 and March 2020. Table 1 presents the state of the CREST database on doctoral dissertations as at March 2020 when we commenced with the next phase in the project (see next section). The table compares the records in the SATD with the official HEMIS data on doctoral graduates by university and year.

Table 1 Comparison between SATD and HEMIS data on doctoral graduates by university and year (2000 to 2018)

Source	University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Share 2018
SATD	CPUT	1	3	2	5	5	7	4	4	13	17	11	12	19	26	19	18	19	28	16	229	**95,8%**
HEMIS	CPUT	0	2	5	5	2	6	6	10	13	12	11	13	24	28	17	19	16	17	33	239	
SATD	CUT	6	4	1	4	8	12	5	5	13	3	3	4	4	9	10	4	8	15	19	137	**85,6%**
HEMIS	CUT	3	1	4	7	7	6	6	11	5	4	3	5	5	12	12	10	21	20	18	160	
SATD	DUT		1	2	1	1	5	4	13	3	3	11	6	14	8	16	30	29	44	57	248	**93,6%**
HEMIS	DUT	0	2	1	3	3	4	4	5	3	5	12	14	6	18	18	29	40	33	65	265	
SATD	NMU	17	10	28	26	29	33	25	29	38	52	62	62	90	63	64	49	71	77	86	911	**89,0%**
HEMIS	NMU	11	27	23	28	35	30	25	35	47	39	64	59	86	74	72	80	95	92	102	1 024	
SATD	NWU	70	51	66	92	93	77	73	107	102	128	143	101	127	110	175	193	204	24	0	1 936	**75,4%**
HEMIS	NWU	51	59	59	92	87	82	110	124	100	123	129	115	154	168	171	222	238	235	248	2 567	
SATD	RU	26	24	31	40	30	40	38	46	44	32	33	44	48	60	70	63	121	39	69	898	**90,8%**
HEMIS	RU	28	24	41	27	40	31	46	48	27	32	44	57	67	70	76	69	84	87	91	989	
SATD	SU	108	83	130	98	154	130	121	154	153	121	172	160	197	250	218	241	278	278	258	3 304	**98,9%**
HEMIS	SU	83	103	111	112	115	126	102	153	120	139	174	150	240	225	234	267	278	305	305	3 342	
SATD	TUT	3	1	12	5	3	11	16	9	28	23	17	22	39	27	40	38	46	51	26	417	**79,4%**
HEMIS	TUT	2	8	9	5	9	12	19	12	13	25	22	28	44	32	46	61	65	55	58	525	
SATD	UCT	108	78	121	105	96	142	147	148	173	186	152	174	175	182	212	246	262	251	210	3168	**100,7%**
HEMIS	UCT	104	86	109	103	99	182	133	142	151	178	160	163	198	205	204	223	233	277	195	3145	
SATD	UFH		1	1	2	2		1	4	11	17	36	23	32	27	32	30	45		0	264	**37,0%**
HEMIS	UFH	3	2	2	3	2	1	9	10	11	34	36	44	43	30	66	60	109	117	132	714	
SATD	UJ	78	59	73	80	82	86	65	78	69	81	42	54	98	71	87	94	95	125	178	1 595	**90,0%**
HEMIS	UJ	98	68	84	97	95	88	73	75	73	70	51	68	109	78	106	105	119	126	189	1 772	
SATD	UKZN	71	63	112	120	108	86	107	120	131	152	148	134	150	184	214	254	217	41	0	2 412	**66,9%**
HEMIS	UKZN	70	47	98	135	98	98	108	106	136	159	163	154	177	207	264	338	361	388	497	3 604	

Source	University	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Share 2018
SATD	UL	10	8	3	5	30	9	18	19	13	8	14	7	14	11	5	13	29	6	16	238	**90,5%**
HEMIS	UL	4	3	3	10	20	15	12	17	14	17	10	17	17	14	25	25	13	15	12	263	
SATD	UP	118	132	139	105	151	213	199	205	197	187	233	186	201	232	156	231	224	276	312	3 697	**90,0%**
HEMIS	UP	114	135	153	146	187	192	148	170	180	196	188	206	200	242	237	333	302	354	424	4 107	
SATD	UNISA	109	100	106	63	40	80	64	150	76	309	112	110	108	197	205	204	203	211	200	2 647	**99,5%**
HEMIS	UNISA	77	68	71	76	96	92	81	78	67	71	55	93	152	201	268	235	296	286	296	2 659	
SATD	UFS	59	66	58	59	67	62	66	64	80	81	62	48	57	78	78	96	82		0	1 163	**71,4%**
HEMIS	UFS	59	50	78	84	58	65	60	77	55	78	100	107	94	91	104	97	106	127	138	1 628	
SATD	UWC	13	23	21	17	37	28	37	36	39	43	47	64	59	77	86	79	100	85	78	969	**83,4%**
HEMIS	UWC	20	22	15	27	23	35	28	41	42	47	60	80	75	111	104	96	92	120	124	1 162	
SATD	Wits	70	73	75	76	81	78	118	132	135	67	113	214	160	192	214	281	290	262	229	2 860	**101,2%**
HEMIS	Wits	81	79	97	73	93	101	98	134	106	124	106	169	150	221	199	203	228	283	280	2 825	
SATD	UV	1	1	0	1	1	4	0	0	0	2	7	6	6	12	15	32	16	28	45	177	**104,7%**
HEMIS	UV	0	1	0	3	3	3	0	6	2	4	9	9	4	3	1	8	28	42	43	169	
SATD	UZ	12	28	40	21	31	34	31	34	18	17	26	15	25	16	15	18	11	39	32	463	**111,8%**
HEMIS	UZ	17	14	21	12	29	18	31	20	13	21	19	19	28	14	25	18	32	32	31	414	
SATD	VUT	2	3	1	2	3	1	2	0	2	1	3	0	1	1	2	8	1	0	1	34	**64,2%**
HEMIS	VUT	0	0	1	3	2	2	1	0	2	2	4	2	2	4	1	9	3	5	10	53	
SATD	WSU			1									3	2	4		3	1	0	0	14	**20,9%**
HEMIS	WSU	1	0	2	1	0	0	0	0	2	0	1	4	3	3	8	15	12	9	6	67	
SATD	TOTAL	949	895	1 097	988	1 126	1 265	1 344	1 546	1 440	1 671	1 536	1 556	1 714	1 958	2 070	2 380	2 582	2 105	1 948	30 170	**95,1%**
HEMIS	**TOTAL**	**826**	**801**	**987**	**1 052**	**1 103**	**1 189**	**1 100**	**1 274**	**1 182**	**1 380**	**1 421**	**1 576**	**1 878**	**2 051**	**2 258**	**2 530**	**2 782**	**3 040**	**3 307**	**31 737**	

The comparison shows that by the time we commenced with the contact tracing of doctoral graduates, our database included slightly more than 95% of all doctoral theses awarded between 2000 and 2018 by South African universities, i.e. 30 170 records in the database out of a possible 31 737 doctoral graduates. The 95% coverage meant that there are some discrepancies between the number of doctoral graduates reported in HEMIS and the SATD. Further cleaning of the database, however, revealed that there were about 500 records that were duplicate entries, so the population of doctoral theses (and hence graduates) that we worked with is estimated at 29 593 (see Table 2). There were also a number of master's theses which were erroneously tagged as doctoral theses by the respective universities and these errors resulted in some instances where the SATD listed more records than HEMIS. It is important to remember that the table above shows the state of the database at the time when the sampling frame was constructed, and precedes the ongoing cleaning and updating of the doctoral thesis database.

The next main task was to search for any kind of contact information for the approximately 29 600 graduates in our database. We brought together a team of seven assistants who worked on this task from the first week of February 2020 to the end of June. Over this period the team completed nearly four iterations of looking for contact information for the 29 600 graduates. The team members spent on average between 10 and 15 minutes searching for any contact information (on Google, LinkedIn, ResearchGate and published papers by candidates for inclusion in the sample). This translates into approximately 735 person days invested in this activity.

Table 2 Summary of process and results of contact tracing of doctoral graduates

Number of eligible doctoral graduates in the database (candidates who graduated between 2000 and 2018 from a South African university)	n=29 593
Candidates found to have either retired or deceased	n=216
Final sample frame for study	n=29 377
Graduates for whom email addresses only were found	n=15 073 (51%)
Graduates for whom LinkedIn information was found	n=14 046 (47,8%)
Graduates for whom either an email address or a LinkedIn contact was found	n=25 115 (85,4%)
Number of graduates for whom an email address (sometimes two addresses) was found	n=17 166 (58,4%)

The result of this contact tracing exercise – arguably the most comprehensive of its kind ever undertaken in the South African system – resulted in us finding different categories of contact information (emails, LinkedIn profiles, and profiles on ResearchGate and organisational websites). In the final analysis, we found email addresses (sometimes two or more emails for each graduate) for 17 166 of the graduates.

2.3. Web-based survey

The main data-collection method for this study was a web-based survey of the doctoral graduates for whom we could find contact details (n=17 166). While the process of contact tracing was under way, the teams started with the construction of the questionnaire. We describe this process in the section below, followed by a discussion of the administration of the survey.

2.3.1. Constructing the questionnaire

Five senior team members started the work on the development of the first versions of the draft questionnaire to be used for the web-based survey (on the Survey Monkey platform). The drafting of the questionnaire was informed by the version used during the Pouris & Thopil (2019) study, the terms of reference and a review of similar questionnaires used in other doctoral tracer studies.

A final draft version was sent to the project's Reference Group in preparation for a meeting on 20 May 2020. After discussion at this meeting, the draft questionnaire was accepted. However, the research team continued to refine the questionnaire. In addition, a pilot study was completed with 25 doctoral graduates during the month of August 2020. In response to the feedback received from the pilot survey, final improvements were made to the questionnaire (Annexure D). The questionnaire was subsequently designed on the Survey Monkey platform. In addition, a cover invitation letter was drafted for approval and sign-off by the WRC and the Reference Group (Annexure E).

2.3.2. Launching the survey

PhD graduates were invited, via email, to participate in the survey. Emails were sent to 17 166 email addresses (we included duplicate emails for individuals when we had them) between Friday, 16 October 2020, and Sunday, 1 November 2020. Emails included standard information for CREST surveys (purpose of the study, assurance of ethical clearance, average time to complete survey, etc.). Recipients consented to participate by clicking on a URL link that connected to the online survey. The Survey Monkey platform was used to conduct the survey. The survey closed on 1 December 2020, after which all information was exported to a statistical programme (IBM SPSS) for analysis.

A web collector created on the Survey Monkey platform allowed us to create a unique URL link (directing email recipients to the online survey) for each person invited to participate in the survey. The benefit of this feature is that by creating unique URL links we were able to monitor the responses to the survey. This ensured that we would not send any reminders (to participate in the survey) to individuals that had already completed the survey. It also allowed us to follow-up on correspondence when there were queries regarding a specific survey response. Finally, it allowed us to link responses to the records in our doctoral thesis database.

Emails were sent to intended recipients in four batches. Between 16 and 18 October, the first 17 166 emails were sent. We received an undelivered message for 2 196 of these (after amendments were made to 161 email addresses to rectify obvious mistakes such as misplaced full stops, misspelt domain names, etc.). Between 30 October and 1 November, a reminder was sent to all the individuals who had not responded to the initial survey invitation (in total 10 953 emails). The subsequent batches of emails followed as the team was able to identify additional potential respondents, with 898 emails sent on 30 October to PhD graduates identified, 381 on 5 of November to PhD graduates that had been identified by staff and students based at various universities across the country, and the final 133 on 11 November to students at the Da Vinci Institute. In total, undelivered messages were received from 2 264 email accounts, and 50 email responses were received that indicated email recipients (linked to 58 email accounts) were unwilling to participate.

In total, approximately[3] 17 581 intended recipients were included in the 18 578 email accounts identified. Table 3 shows the breakdown of email recipients. From subsequent email correspondence, we ascertained that five intended recipients had passed away, six had not completed their PhDs, 12 had not received a PhD from a South African institution, six had received their PhD before 2000, and 10 indicated that they did not want to participate in the survey (see Table 4 below). One email address was listed as no longer active. In addition, 1 966 intended recipients (out of the 2 264 email accounts that returned an undelivered notification) could not be contacted.

Table 3 Breakdown of email recipients

	Batch 1	(Batch 1 reminder)	Batch 2	Batch 3	Batch 4	Total
Email recipients	16 169	(10 490)	898	381	133	17 581
Total recipients not receiving any email due to undelivered emails	1 898	n/a	64	4	0	1 966
Recipients removed from list	50	0	0	0	0	50
Total recipients emailed (excludes undelivered emails and recipients removed from list)	14 221	N/A	834	377	133	15 565

Table 4 Reasons for the removal of recipients from the survey

	Total
Deceased	5
Did not complete PhD	6
Did not receive PhD in South Africa	12
Email no longer active	1
PhD before 2000	6
Wrong email	10
Not happy to be on list	10
Four emails with duplicates	8
Total	58

By the end of December 2020, a total of 6 452 unique completed surveys had been captured on the Survey Monkey platform. This translates into a response rate of 41,4% (6 452/15 565)[4]. This is a comparatively high response rate for a web survey, probably because of the interest in this topic (we received many comments to this effect) as well as the very efficient management of the survey process.

The unique survey link inserted in each email made it possible to track responses from individuals and

[3] Individual respondents were identified by removing thesis duplicates. In cases where alternative thesis titles were used or where an individual completed more than one PhD thesis it is possible that individual PhD graduates were not identified.

[4] It is important to note that there is a small margin of error associated with this response rate as there may have been some double counting of PhD graduates (see footnote above). Also, in a (very) limited number of cases, the survey link was redistributed by the recipient, thereby inflating the sample size. However, we do not believe that these two factors change the estimated response rate fundamentally.

match survey responses to our PhD thesis database. A Microsoft Excel spreadsheet was used to keep a record of all undelivered emails, survey completions, responses from email recipients, follow-up actions required, required changes to the database of PhD graduates, etc. As it was not feasible to embed an abbreviated link within each email, a unique link was pasted in its entirety. The URL link was in the following format https://www.surveymonkey.com/r/PhDTracer?N=[N_value]. A unique value was inserted into the square bracket of each URL creating a unique link sent to all PhD graduates. Unfortunately, in a limited number of cases, respondents copied and pasted the URL without the unique value. In these cases, email addresses provided were used to match responses to respondents. In total we were able to match 6 263 completed surveys to our database of intended recipients (out of a total of 6 452 completed responses). Unmatched survey respondents were retained in our dataset, but as we were unable to match their information, we were unable to populate the dataset with some information, such as the institution from which they graduated, the year the PhD was awarded, the thesis title and so on.

Survey responses were merged with the expanded SATD using the Microsoft Excel VLOOKUP function, merging survey responses with their corresponding expanded SATD entry through a common Survey Monkey link number. Further VLOOKUP merges were then performed, matching respondents on the basis of the email addresses used to send them the questionnaire, and the addresses provided by respondents on the questionnaire. Finally, the remaining records were manually checked and merged as evident in email addresses. Using this methodology, we were able to match and validate the maximum number of respondents to the corresponding SATD database, while also eliminating responses that originated from respondents not in the target population, such as participants who gained access to the survey through shared links.

The final process of validating the completed questionnaires for statistical analysis commenced in February 2021. In this process we identified a small number of duplicate questionnaires (respondents who completed more than one questionnaire) as well as a small number of questionnaires which were not completed (too many individual items not completed). A small number of records of respondents who had graduated either before 2000 or after 2018 (n=195) were also filtered out in order to ensure that we remained consistent with the time frame of the study (2000 to 2018). This left us with a dataset of 6 211 valid records for statistical analysis. Our sample thus translates into 19,4% of the population (32 025 doctoral graduates between 2000 and 2018).

2.3. Interviews with a selection of survey respondents

Phase 4 of the project consisted of interviews with a small sample of survey respondents who agreed to be interviewed. The main purpose of the interviews was to explore the key themes and questions of the study in greater depth. In particular, the interviews focused on the following:

- The circumstances surrounding the inception of the PhD (e.g. whether the individual had moved straight from a master's degree to a PhD or whether pursuing a PhD was a mid-career decision) and what their motivations and expectations were for doing a PhD.
- The enablers (e.g. prior work experience or networks) and obstacles (e.g. limited job opportunities in particular fields or sectors) encountered with regard to employment following graduation.

- The ways in which the PhD was used to find employment and in particular work contexts.
- General perceptions of and observations relating to the value and return on investment of having obtained a doctoral degree.

The target for this study – as requested by the Reference Group – was to conduct at least 100 interviews with survey respondents whose doctorates were in the water and water-related fields. The focus of the interviews, specifically on the water sector, was added after a specific request from the Reference Group to corroborate and extend the research of Pouris and Thopil (2019) in their pilot tracer study of doctoral graduates in the water sector.

Our point of departure, therefore, was to demarcate these fields and develop a set of search terms that could be used to identify potential interviewees.[5] The search terms that were used in the first round of selection are indicated in Figure 1 below. These were applied to the thesis title and scientific field entries in the survey database. The output records were then reviewed manually to ensure that they accurately reflected the search criteria. This process generated a list of 118 potential interviewees. Of these, interviews with 85 respondents were initially secured. In order to reach the target of 100 interviews, it was thus necessary to run a second round of selection. In this phase, we elected to focus on two other critical areas of research linked to national and global challenges, namely energy and food security. The search terms used to identify participants in this second group are also captured in the figure below.[6] These generated an additional 54 potential interviewees. Of these, 23 interviews were secured. In total, 113 interviews were conducted.

[5] We based this initial demarcation on three sources: (1) the section on water research in the 2019 SciSTIP report, *The State of the South African Research Enterprise*, (2) commonly used bibliometric approaches to identifying water-related articles according to subject journal categories, and (3) a review of the WRC and Department of Water and Sanitation websites.

[6] In addition to the terms "energy" and "food", commonly used bibliometric terms for identifying energy and food-security-related articles according to subject journal categories were included.

Group 1: PhDs in water-related fields

General:

- Water supply, catchment, hydrology
- Water sources, rivers, oceans, lakes, estuaries, aquifers, wetlands, groundwater
- Water storage, dams, reservoir, catchment
- Water demand
- Water distribution, services
- Water infrastructure
- Water quality, pollution, effluent, wastewater treatment
- Water scarcity, drought, desalination
- Sanitation, effluent, sewage

In relation to specific industries, especially mining and agriculture:

- Water use efficiency, irrigation, wastewater treatment, water technology

Cross-cutting aspects:

- Water-related planning, management, governance, funding, human resources, education and training

Oceanographic:

- Ocean, marine, aquatic, polar, Arctic

Within biological or chemical domains:

- E.g. limnology, bioprocessing or nanotechnology

Group 2: PhDs in energy and food security-related fields

Energy:

- Energy – green, renewable, wind, solar, wind
- Electricity generation, transmission, distribution
- Biofuel, biogas, shale, hydro fuel
- Clean technology, clean energy
- Coal
- Green technology, PV technology
- Nuclear – engineering, fuel
- Decarbonisation, low carbon

Food security:

- Food security/insecurity
- Food crisis
- Food supply, access, availability, abundance
- Food shortage, scarcity, limitation
- Food consumption, use
- Food limitation, insufficiency, poverty
- Food system
- Nutrition security
- Household dietary diversity
- Household food expenditure

Figure 1 Key terms used to identify interview respondents

The range of scientific disciplines within which respondents' PhDs fell are highlighted in the word cloud in Figure 2 below.

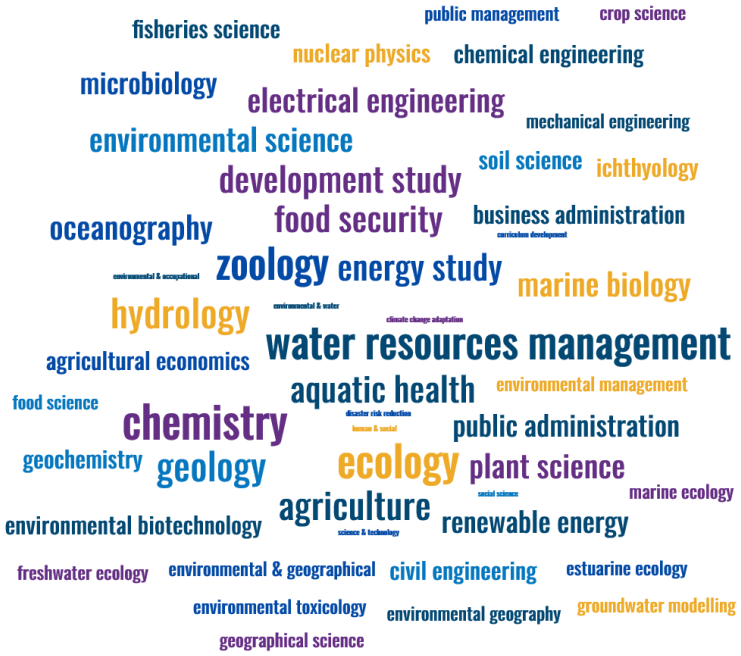


Figure 2 Range of scientific disciplines of interviewees' PhD theses

Once the interviewees had been identified, they were allocated to members of the four-person interview team. The interviewers sent email invitations to the prospective interviewees using the template provided in Annexure C. Among other things, the invitation letters provided a brief overview of the broad areas that the questions would cover and requested consent to record the interviews. Ethical clearance from Stellenbosch University for the interviews had already been obtained at the start of the study.

In parallel to the scheduling of interviews, the survey responses from each prospective interviewee were generated as outputs in MS Word documents. The interviewers used these survey responses as the basis for the development of interview schedules that were tailor-made for each respondent. An anonymised example of an interview schedule is provided in Annexure D. The interviews were conducted during April and May 2021, mostly online via Zoom, MS Teams or Skype. In a few cases where Internet connectivity was problematic, the interviewers sent respondents their interview questions via email and received written responses.

The interviewers transcribed their own interviews – although in a few cases also transcribed some of the interviews conducted by other team members. The team used the online software application Otter.ai to generate the first draft of the transcripts. These were then reviewed and checked for accuracy by the interviewers. Where interviewees asked for the interview schedule before the interview or for an opportunity to review the transcript of their interview, this was facilitated.

The interview data were analysed by two of the interview team researchers. The coding of the data was undertaken using the data analysis software ATLAS.ti. An initial set of codes was developed based on the key focus areas and questions of the study and in consultation with the survey team. Additional codes were generated inductively as the transcripts were analysed. Inter-coder reliability was maintained via

ongoing communication and reviewing of coding between the two team members involved.

Once the coding was complete, analysis proceeded with the concurrent activities of grouping of codes into categories; the identification of patterns, spectrums and linkages within and among the codes and code categories; the development of themes; and writing up the first level of description of the data and analysis.

2.4. Analytical framework for data analysis

The general aim of this study is to trace the employability, career paths, mobility and other attributes of a representative sample of PhD graduates from South African universities across a range of sectors and disciplines. The study implemented a mixed-method design, more specifically an explanatory sequential design (Cresswell & Clarke, 2011). The relevant design, as applied in this study, began with a quantitative phase (the survey), followed by a qualitative phase (the interviews). The purpose of the qualitative follow-up was to explain and contextualise the patterns and trends of the survey, and to illustrate the findings of the survey with selected excerpts from the interviews. Due to the nature of the mixed-method design used, the results of the survey were prioritised in data analysis, with the interview data providing additional insight into the phenomena studied. The development of an analytical framework for data analysis was also mainly informed by the survey questions.

The survey questions – which guided the analytical framework – were developed to address a set of key themes, which are summarised in Table 5, together with their associated topics and the relevant variables used in the quantitative analysis.

The qualitative interview data, which was analysed using procedures of theme development, played a subsidiary – yet crucial supplementary – role in the execution of the analytical framework. The coded themes and the short extracts from the contextually rich interviews were used to illustrate and elaborate on the different topics of the survey component of data analysis.

The analytical framework also informed the structure of the report, specifically the data presentation sections, as will be evident in the next chapters.

2.5. A reflection on the research process

We have, in our description of our methodology, explained that the data collection for this study was done during the latter half of 2020 and early months of 2021. During these months, the COVID-19 alert levels of South Africa were continuously updated and both the quantitative and qualitative data collection were done via online platforms. The research team did not experience any particular challenges associated with the limitations imposed by the COVID-19 pandemic. No adjustments had to be made to the web survey, as electronic surveys have become the norm in survey methodology. In terms of the interviews, the research team felt that the pandemic accelerated the need to implement new technologies in communication which were ultimately advantageous to the team. With technologies such as Zoom, Skype and Microsoft Teams becoming widely used, the research team was able to conduct face-to-face interviews with little difficulty. Without the widespread use of these technologies, the team would have most likely had to conduct telephonic interviews, which might have been less effective for

establishing rapport with interviewees. The use of technology in the transcription of the interviews was also advantageous to the team.

Some limitations, however, were experienced where the members of the research team were not able to regularly meet and reflect on the process and findings, but generally the negative impact of COVID-19 on the research process was negligible.

This study is the first national tracer study of doctoral graduates in South Africa. What we have presented in the current report are the main findings on the career trajectories of doctoral graduates, but given the invaluable nature and size of the data collected, there are many avenues for further research or analyses that could build on what is presented here. One such avenue is identifying trends in the career trajectories of doctoral graduates in sub-sectors. In Appendix A we present such an analysis of graduates in the water and water-related sector. Such studies on could inform sectoral trends and subsequent policy recommendations. The research team would welcome follow-up studies both internally and by external users. The future use of the data would then be subject to standard rules and protocols related to the secondary analysis of data.

2.6. Overview and structure of report

The general aim of the tracer study is to trace the employability, career paths, mobility and other attributes of a representative sample of PhD graduates from South African universities across a range of sectors and disciplines. As such, the survey questions were developed to address a set of key themes, namely the interrelated matters of career paths; post-graduation decisions about employment and career; opportunities – and limitations and constraints – for employment following graduation; the application or use of skills, expertise and/or outputs of the PhD in post-graduation employment; and mobility – between sectors, places of work and/or geographic locations. The dimensions and constructs studied in the survey are summarised in the table below.

Table 5 Outline of data analysis and structure of the report

Broad theme	Questions/variables	Grouping variables
Chapter 4: Employment status during doctoral studies	• Employment status during the PhD ○ Financing of doctoral studies	• Year PhD awarded (four periods) • Age • Gender • Race • Citizenship • Scientific domains • Sector of employment
Chapter 5: Tracking the employment pathways of doctorate holders	• Employment following immediate completion of the PhD ○ Challenges to finding employment • Most recent employment • Intersectoral mobility	• Year PhD awarded (four periods) • Age • Race • Gender • Citizenship • Scientific domains (incl. STEM and SSH) • Sector of employment

Broad theme	Questions/variables	Grouping variables
Chapter 6: The postdoctoral research fellowship career path	• Changes over time • Profile of postdoctoral fellows • Reasons underpinning the acceptance of (a) postdoctoral fellowship(s) • Geographic mobility of postdoctoral fellows • Employment after the postdoc	• Year PhD awarded (four periods) • Age • Race • Gender • Citizenship • Scientific domains (incl. STEM and SSH)
Chapter 7: Geographic mobility of doctoral graduates	• General trends in the geographic mobility of graduates • Reasons underpinning mobility-related choices • Outward mobility of South African graduates	• Year PhD awarded (four periods) • Age • Race • Gender • Citizenship • Scientific domains (incl. STEM and SSH)

Chapter 8:
Utilisation and value of the doctorate
	• Utilisation of the PhD
	  ○ Research skills
	  ○ General, transferable skills
	  ○ Managerial responsibilities
	• Reflections on the value of a PhD degree
	  ○ Overall levels of satisfaction
	  ○ Motivations for and expectations of doing the doctorate
	  ○ Value of the PhD in terms of professional development and advancement
		• Year PhD awarded (four periods)
		• Age
		• Scientific domains (incl. STEM and SSH)
		• Sector of employment

Chapter 3: The sample and its representativeness

In this chapter we address two key issues: (1) the size and nature of the cohorts of doctoral graduates who graduated from any South African university between 2000 and 2018; and (2) a discussion of the key features of our sample and why it can be regarded as being representative of the population of doctoral graduates over this period.

3.1. A description of doctoral graduates in South Africa: 2000 to 2018

We begin our discussion with a statistical overview of the key patterns and trends in the production of doctoral graduates at South African universities on the basis of selected demographic indicators. Using the database containing the records of all PhD graduates from South African universities for the period 2000 to 2018 as captured by the Higher Education Management Information System (HEMIS), we present the basic statistics on the following features:

1. Total number of doctoral graduates per year: 2000 to 2018.
2. Graduates per year disaggregated by gender: 2000 to 2018.
3. Number of South African black doctoral graduates: 2000 to 2018 and doctoral graduates disaggregated by race (2000 to 2018).
4. Graduates per year disaggregated by nationality grouped as RSA/RoA/RoW: 2000 to 2018.
5. Average age of graduates at time of graduation by year: 2000 to 2018.
6. Graduates by main science domains: 2000 to 2004, 2005 to 2009, 2010 to 2014, 2015 to 2018.
7. Graduates per year disaggregated by STEM and non-STEM fields: 2000 to 2018.
8. Doctoral graduates disaggregated by universities and year: 2000 to 2018.

3.1.1. Total number of doctoral graduates per year: 2000 to 2018

Between 2000 and 2018, a total of 32 025 doctoral students graduated at South African universities. As is clear from Figure 3, annual output remained relatively stable during the first decade of the 2000s and then displayed rather steep growth from 2009 onwards. The compound annual growth rate (CAGR) for the entire period is 7,1%, but for the period 2009 and 2018 it was 12,2%.

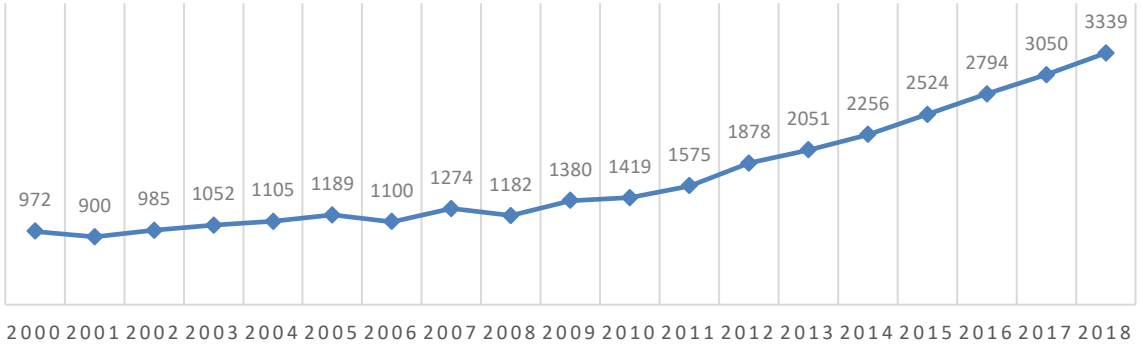


Figure 3 Number of doctoral graduates from 2000 to 2018

As we have indicated in other studies (Mouton et al., 2019), this growth was mainly due to the steep increase in the number of doctoral enrolments and graduates from other African countries.

3.1.2. Doctoral graduates per year disaggregated by gender (2000 to 2018)

The overall increase in the production of doctoral graduates between 2000 and 2018 has not been accompanied by any change in the relative shares of male and female graduates. As Figure 4 shows, the percentage of female doctorates has remained quite stable at about 42% over this period.

Figure 4 The proportion of female to total graduates

3.1.3. Number of black South African doctoral graduates (2000 to 2018)

While the relative shares of female and male graduates remained unchanged between 2000 and 2018, this is not true for the racial distribution of these graduates.

Figure 5 shows a steep increase in the number of black (South African) graduates between 2000 and 2018. The increase from only 194 graduates in 2000 to 987 in 2018 (as illustrated by the blue line) translates into a high CAGR value of 9,8%.

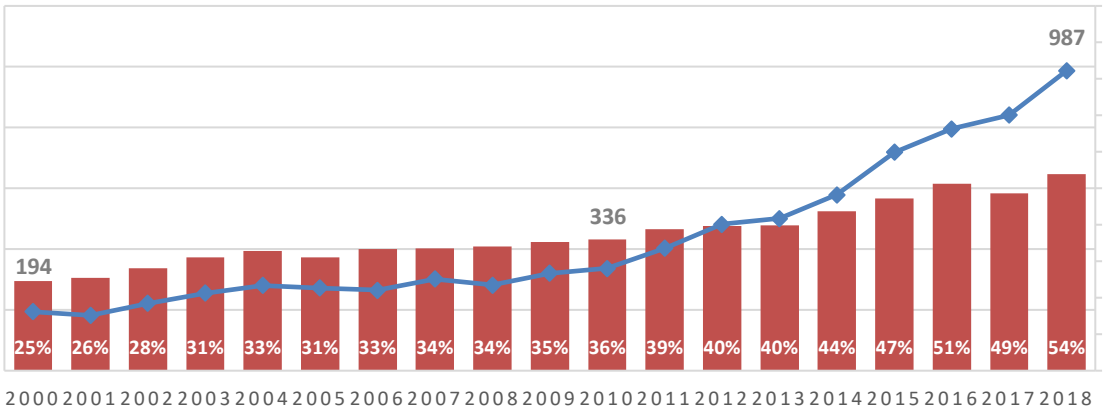


Figure 5 Increase in the number and percentage of black South African graduates

As a result of this growth, the overall demographic profile of South African doctoral graduates changed drastically between 2000 and 2018. The data, as illustrated in Figure 6, show that the shares of black students among all doctoral students more than doubled over the past two decades – from 25% in 2000 to 54% in 2018 (as illustrated by the red bars in the graph above).

When we further disaggregate the race of doctoral graduates, we see that there have been slight increases in the proportional share of coloured and Indian doctoral graduates between 2000 and 2018, where the number of graduates has increased fourfold in the same period – an increase for coloured students from 31 in 2000 to 116 in 2018, and for Indian/Asian students from 46 in 2000 to 171 in 2018.

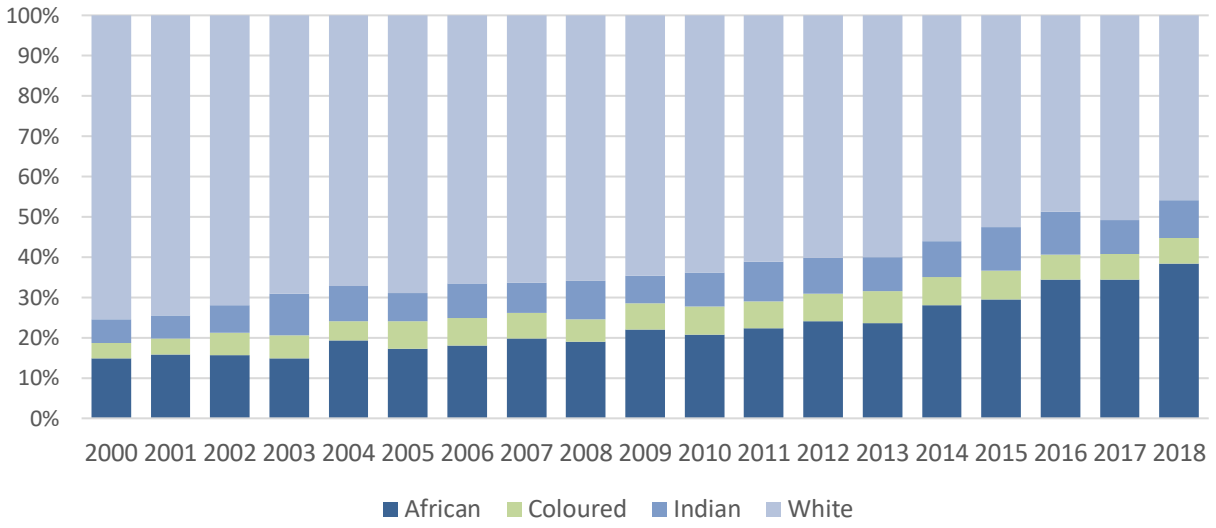


Figure 6 Breakdown of doctoral graduates by race

3.1.4. Doctoral graduates disaggregated by nationality (2000 to 2018)

In Figure 6 we display the differences in the annual numbers of doctoral graduates of South African students, with those from the rest of Africa (RoA) and the rest of the world outside Africa (RoW).

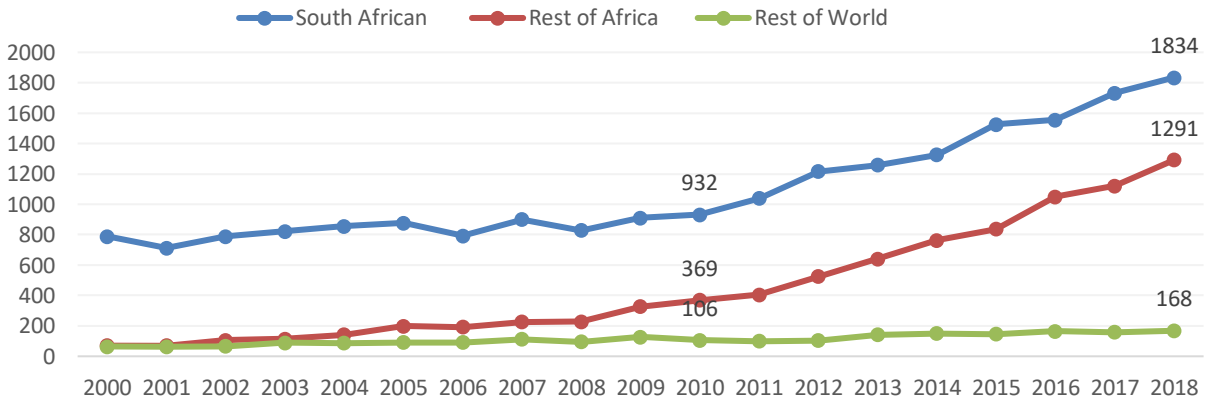


Figure 6 Comparison of annual production of South African and international doctoral graduates (2000 to 2018)

SciSTIP has documented the substantial increase in the numbers and shares of doctoral students from the rest of Africa (RoA) over the past 19 years in many of its documents (Mouton et al., 2019, and Mouton, Cloete and Sheppard, 2016). Figure 7 shows the increase in the share of doctoral graduates from the rest of African over this period, from 7% of all doctoral graduates in 2000 to 39% in 2018.

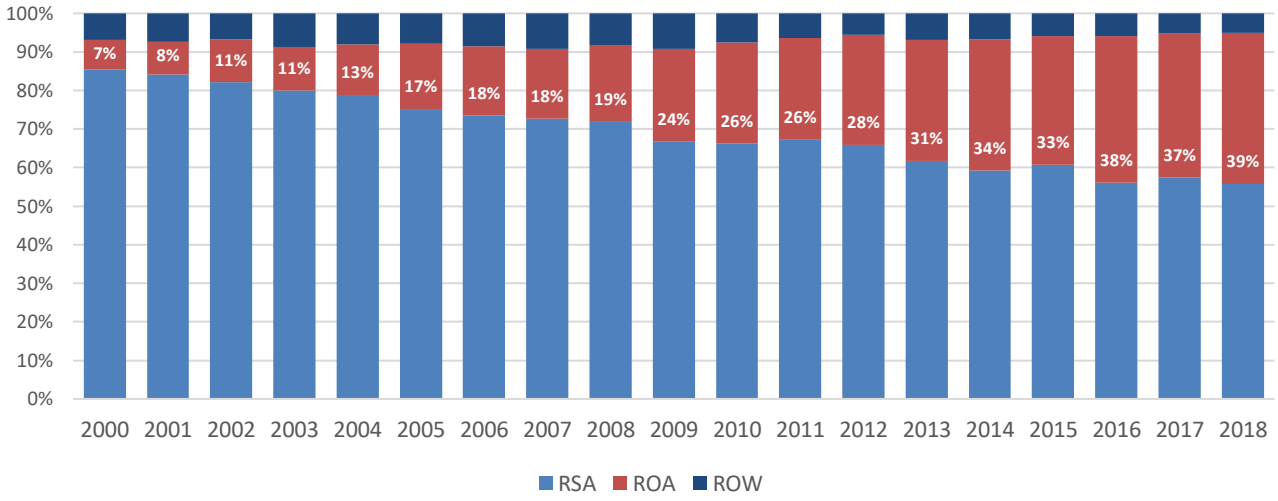


Figure 7 Percentage of doctoral graduates from the rest of Africa (RoA) and the rest of the world (RoW) from 2000 to 2018

3.1.5. Average age of graduates at time of graduation by year: 2000 to 2018

The age profile of doctoral students at South African universities – both at the commencement and the completion of their studies – differs quite dramatically from countries in northern Europe, the USA and elsewhere. In these countries the majority of doctoral students study full time and often receive sufficient funding to study full time towards their doctoral degrees for four to five years. As CREST has indicated in numerous studies, the fact that approximately 60% of all doctoral students in South Africa enrol for doctoral studies while they are in some form of full-time employment invariably translates into an older average age for South African doctoral students. This is clearly illustrated in Figure 8 below where the analysis of the HEMIS data shows no real change in the average age of the South African doctoral student at graduation (between 40 and 41 years old) over the past two decades. Given that the average doctoral student takes about four to five years to complete their studies, this means that the average age at the commencement of doctoral studies is about 37 years. However, we should immediately point out that there are large field-specific differences as far as these statistics are concerned. We will return to this point later in the report.

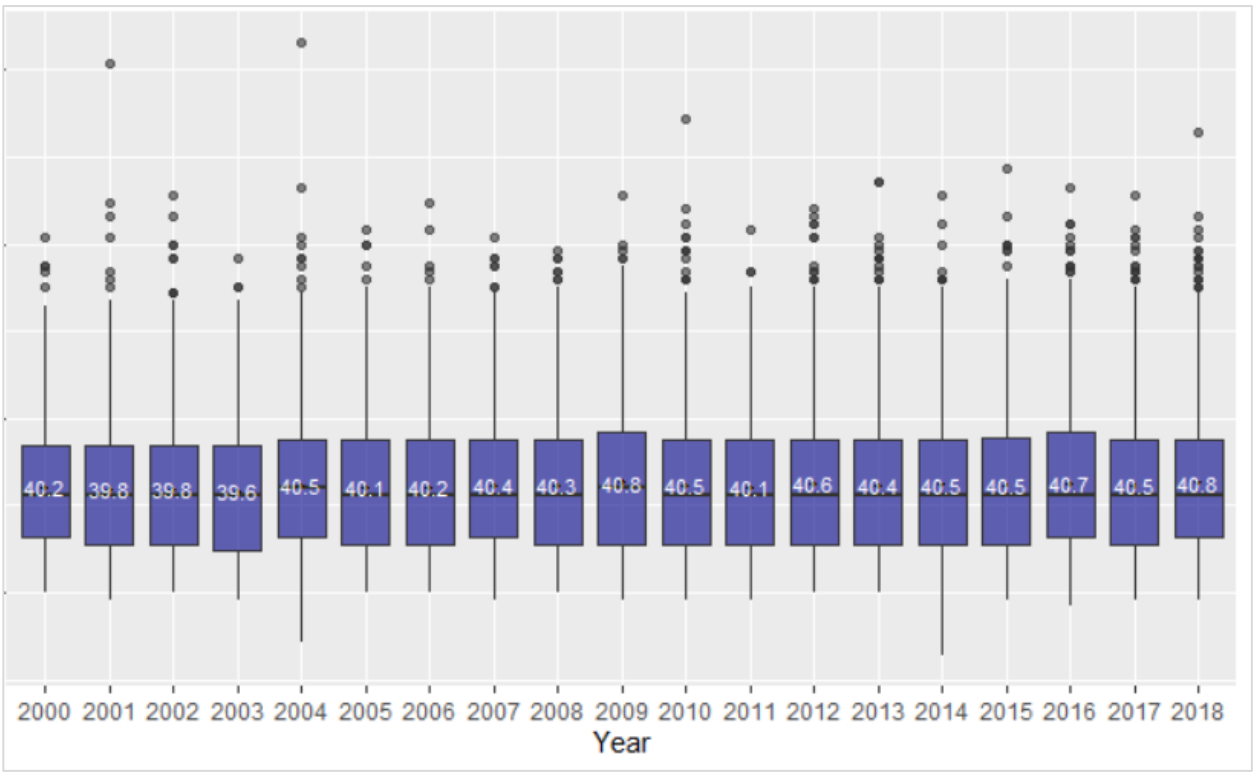


Figure 8 Average age of graduates between 2000 and 2018

3.1.6. Graduates by main science domain: 2000 to 2018

Given the fact that trends in doctoral production vary significantly across scientific fields and disciplines, we include two graphs (Figure 9 and Figure 10) that highlight the differences in the profile of South African doctoral graduates over this period. We have recoded the standard CESM fields (at level) into nine science domains (see below) and compared our sample with the profiles of the national population for the four graduation windows (Figure 9). The purpose was to establish whether there were any significant shifts in the relative shares of graduate production by field. In Figure 10 we collapsed these nine main domains into two standard categories, namely, of STEM (science, technology, engineering and mathematics) and non-STEM (social sciences and humanities).

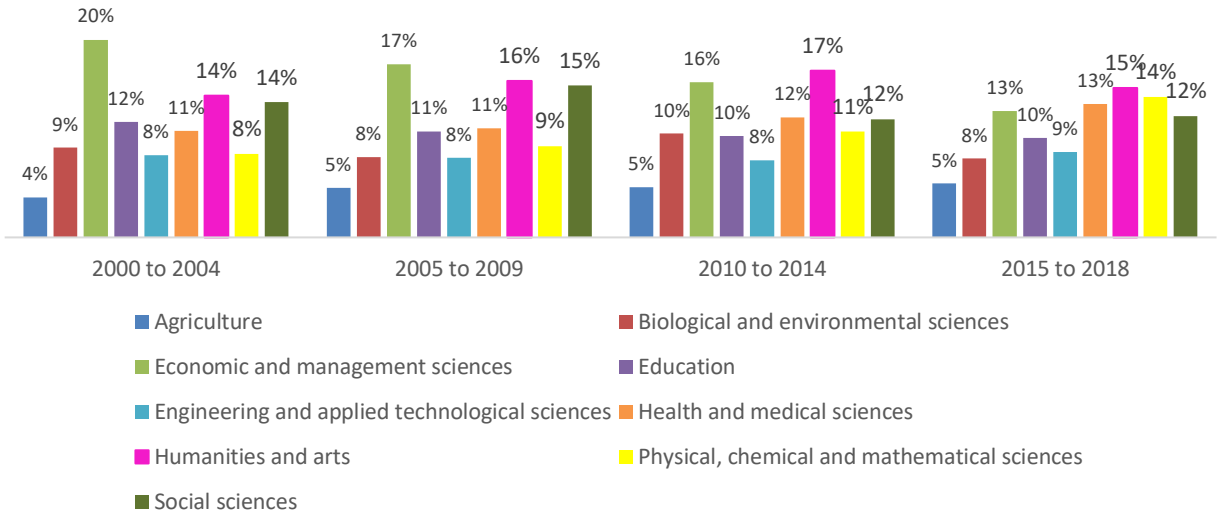


Figure 9 Percentage of doctoral graduates in nine scientific domains for the four graduation windows

The results show very few big shifts in the relative shares of doctoral graduates by four-year window. The most obvious shift is the decline in the share of doctoral graduates in the economic and management sciences (from 20% in the first period to 13% in the most recent period). The domain that has recorded the largest relative increase are the physical, chemical and mathematical sciences (from 8% to 14%). There has also been a small increase in the relative production of doctoral graduates in the health and medical sciences (11% to 13%). For the remainder, relative shares have remained constant.

3.1.7. Graduates per year disaggregated by STEM and SSH: 2000 to 2018

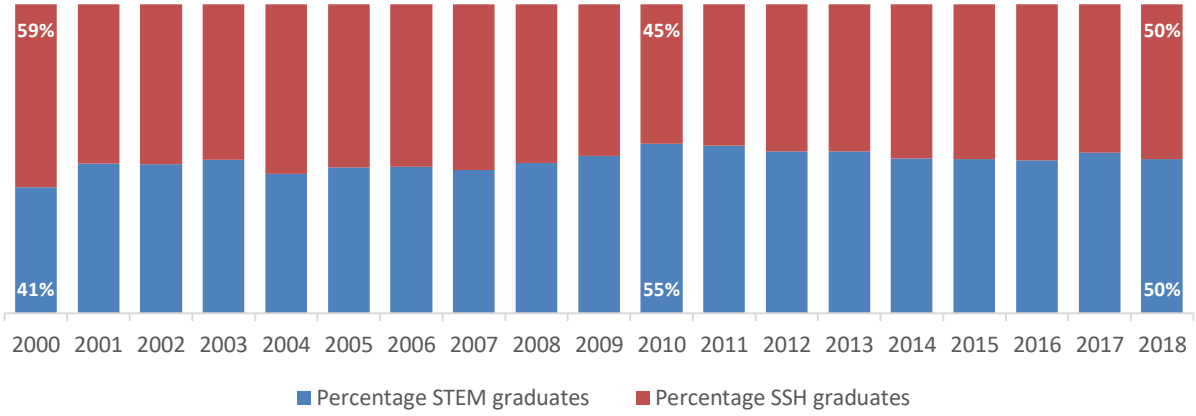


Figure 10 The relative share of STEM graduates

Given the increases in the relative shares of doctoral students in the physical, chemical and mathematical sciences, as well as the health and medical sciences, it is not surprising that the STEM fields have witnessed an overall increase of 9 percentage points between 2000 and 2018, as illustrated in Figure 10. However, it is worth pointing out that this simply means that by 2018 the shares of STEM and non-STEM graduates were equal. This is despite the aspiration expressed in many national policy documents that the country should produce more graduates in the STEM-fields than the SSH fields.

3.1.8. Main contributing universities

In our final analysis we summarise the contributions of individual universities to the overall production of doctoral graduates in the country between 2000 and 2018 (Figure 11).

It is well known that the bulk of doctoral graduates in the country are produced by a small number of universities. One way to illustrate this point is to show the relative contribution of the top 12 universities (in terms of the production of doctoral graduates), which together produced 91% of all doctoral graduates. In fact, four universities – UP, UKZN, SU and UCT – produced nearly half of all doctoral graduates in South Africa over this period (Figure 12).

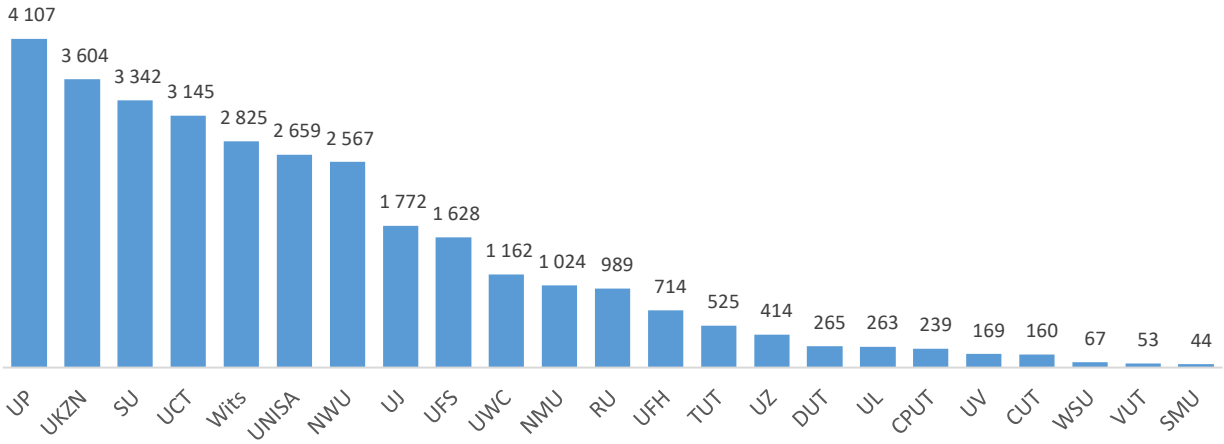


Figure 11 Total contribution to doctoral production by university for the period 2000 to 2018

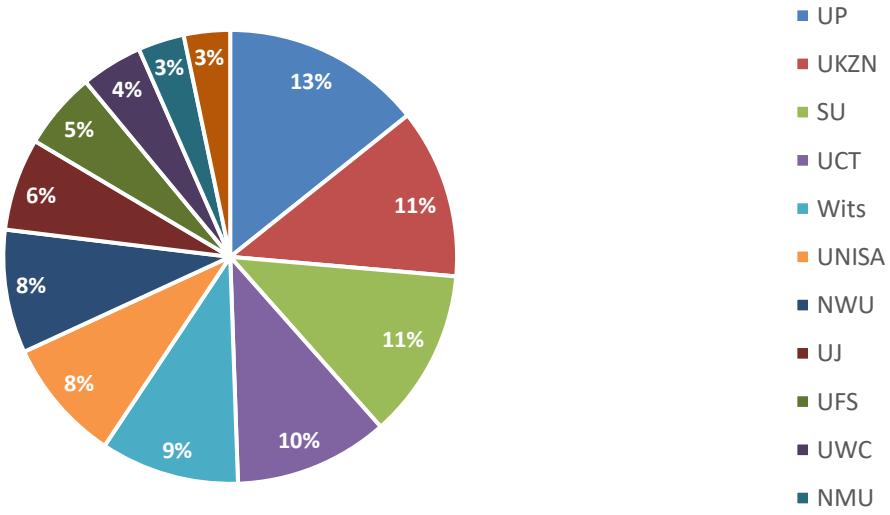


Figure 12 Relative share of top 12 universities to doctoral production in South Africa (2000-2018)

The actual numbers of doctoral graduates produced by each university between 2000 and 2018 are listed in Table 6 (presented in descending order by highest numbers for 2018). It is important to point out that the number of doctorates per university are the absolute counts and are not normalised for the size of the staff (with doctorates) at each university.

Table 6 Number of doctoral graduates by universities and year: 2000 to 2018

Institution	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
UKZN	70	47	98	135	98	98	108	106	136	159	163	154	177	207	264	338	361	388	497
UP	114	135	153	146	187	192	148	170	180	196	188	206	200	242	237	333	302	354	424
SU	83	103	111	112	115	126	102	153	120	139	174	150	240	225	234	267	278	305	305
UNISA	77	68	71	76	96	92	81	78	67	71	55	93	152	201	268	235	296	286	296
Wits	81	79	97	73	93	101	98	134	106	124	106	169	150	221	199	203	228	283	280
NWU	51	59	59	92	87	82	110	124	100	123	129	115	154	168	171	222	238	235	248
UCT	104	86	109	103	99	182	133	142	151	178	160	163	198	205	204	223	233	277	195
UJ	98	68	84	97	95	88	73	75	73	70	51	68	109	78	106	105	119	126	189
UFS	59	50	78	84	58	65	60	77	55	78	100	107	94	91	104	97	106	127	138
UFH	3	2	2	3	2	1	9	10	11	34	36	44	43	30	66	60	109	117	132
UWC	20	22	15	27	23	35	28	41	42	47	60	80	75	111	104	96	92	120	124
NMU	11	27	23	28	35	30	25	35	47	39	64	59	86	74	72	80	95	92	102
RU	28	24	41	27	40	31	46	48	27	32	44	57	67	70	76	69	84	87	91
DUT	0	2	1	3	3	4	4	5	3	5	12	14	6	18	18	29	40	33	65
TUT	2	8	9	5	9	12	19	12	13	25	22	28	44	32	46	61	65	55	58
UV	0	1	0	3	3	3	0	6	2	4	9	9	4	3	1	8	28	42	43
CPUT	0	2	5	5	2	6	6	10	13	12	11	13	24	28	17	19	16	17	33
UZ	17	14	21	12	29	18	31	20	13	21	19	19	28	14	25	18	32	32	31
CUT	3	1	4	7	7	6	6	11	5	4	3	5	5	12	12	10	21	20	18
UL	4	3	3	10	20	15	12	17	14	17	10	17	17	14	25	25	13	15	12
SMU															0	8	11	15	10
VUT	0	0	1	3	2	2	1	0	2	2	4	2	2	4	1	9	3	5	10
WSU	1	0	2	1	0	0	0	0	2	0	1	4	3	3	8	15	12	9	6
MUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPU																	0	0	0
UMP															0	0	0	0	0
TOTAL	**826**	**801**	**987**	**1 052**	**1 103**	**1 189**	**1 100**	**1 274**	**1 182**	**1 380**	**1 421**	**1 576**	**1 878**	**2 051**	**2 258**	**2 530**	**2 782**	**3 040**	**3 307**

3.2. The representativeness of the sample

In this section we describe the key characteristics of our sample of respondents and comment on the representativeness of the realised sample. We report on five demographic variables – gender, nationality, race, age of the respondent and disciplinary domain (STEM/SSH) – to test the representativeness of our sample against the population data (derived from HEMIS).

3.2.1. Representativeness of the sample in terms of gender

Our first comparison relates to the gender of our respondents and their relative shares by four-year window in comparison with the national (population) data. The comparison shows, as illustrated in Figure 13, that female respondents were slightly better represented in our sample than in the national population (HEMIS data). However, the differences are very small (ranging from 1 to 4 percentage points).

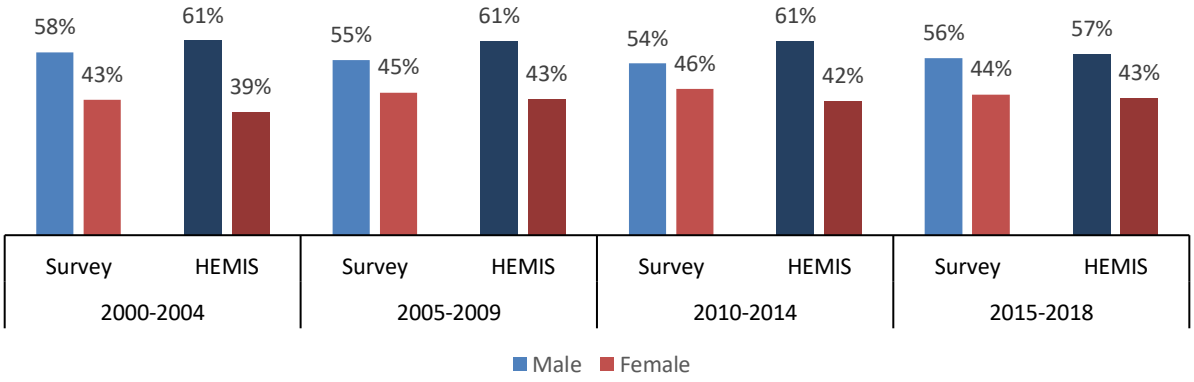


Figure 13 Female respondents in our sample compared with the national population

3.2.2. Representativeness of the sample in terms of country of birth

Our second variable used to test the representativeness of our sample is the country of birth of the graduates as indicated in the HEMIS data. The comparison by four-year window displayed in Figure 14 shows no marked differences between the sample and population distributions. Only in the first period (2000-2004) was there a statistically significant difference ($\chi 2 = 7.445$, $df = 2$, $p < 0,05$).

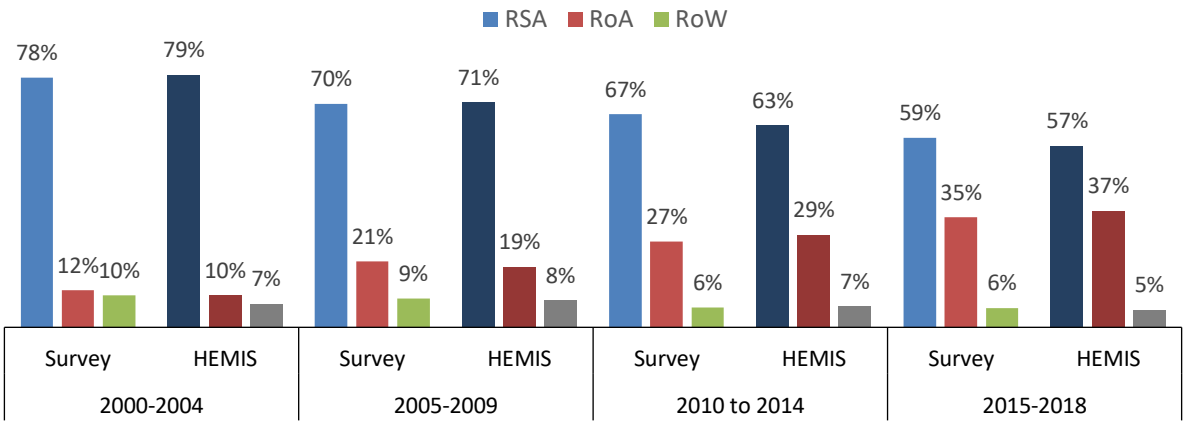


Figure 14 The distribution of survey respondents by citizenship compared to the national population

3.2.3. Representativeness of the sample in terms of race

In Figure 15 below we compare the race[7] distribution of survey respondents with that of the national population as reported in HEMIS. For all four-year windows white respondents (as illustrated by the purple bar) are better represented in our sample (81% compared to 72%, 78% compared to 76%, 69% compared to 60%, and 62% compared to 49%). By extension, we see that black African respondents, illustrated by the blue bars, are under-represented across all years. We also see that coloured respondents are under-represented, while the distribution of Indian respondents is better aligned with that of the population of doctoral graduates.

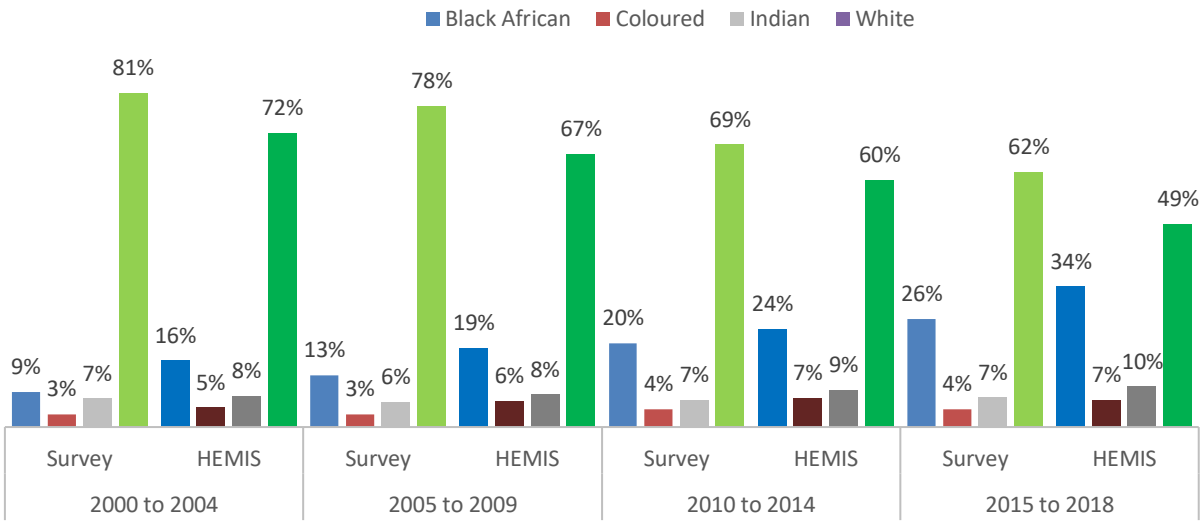


Figure 15 Racial representation in sample compared to national population

From the results presented here we find that in terms of race the survey sample is not representative of the doctoral graduate population. There may be two instances where bias may have been introduced: (1) in the selection of the sampling frame, specifically the collection of email addresses from the SATD, there could be an under-representation of black graduates, or (2) the under-representation of black graduates could be attributed to a low response rate of black respondents.

For this reason, in our analysis of race, we have weighted the survey dataset to be representative of the doctoral population. Due to the small numbers of Indian and coloured doctoral graduates, we report on race as a binary variable by referring to African black, Indian and coloured respondents as "black" and comparing these groups to white South African students. It is important to reiterate that our analysis of

[7] The ethical clearance received for this study did not allow for the collection of information about the race of survey respondents. Given the importance of the transformation imperative within the South African policy landscape, the research team had to collect information about survey respondents post hoc. Through the linking of survey respondents to the doctoral thesis database (SATD), the research team could assign racial categories to survey respondents by means of another database (SA Knowledgebase) curated by CREST, which includes demographic information on South African authors of publications, as compiled by DHET. The research team was able to assign a racial category to approximately 80% of South African survey respondents.

race refers only to South African nationals.

In the weighting of our dataset we also considered the interaction between race and gender, and therefore weighted the survey dataset accordingly. In the table below we compare the share of survey respondents (by race and gender) with that of the doctoral population reported in HEMIS. We find that black male and female respondents are consistently under-represented in our survey and we therefore applied weighting to our dataset to correspond to that of the national doctoral population to eliminate possible response bias. In Table 7 below we show the weighted distribution of our sample in terms of race compared with the population as reported in HEMIS.

Table 7 Share of respondents' race and gender of survey compared to HEMIS

	HEMIS				Survey			
	Black		White		Black		White	
	Female	Male	Female	Male	Female	Male	Female	Male
2000 to 2004	2,0%	3,5%	6,2%	7,5%	1,4%	1,8%	6,3%	7,4%
2005 to 2009	3,0%	4,0%	7,1%	6,7%	2,2%	2,5%	9,3%	8%
2010 to 2014	5,1%	6,1%	9,0%	7,7%	4,5%	4,8%	11,6%	8,7%
2015 to 2018	8,0%	8,2%	9,0%	6,8%	5,9%	6,1%	11,6%	8%

3.2.4. Representativeness of the sample in terms of age of respondents at graduation

As far as the age at graduation of doctoral graduates is concerned, we saw earlier that the average age of doctoral graduates has remained basically constant at about 40/41 years of age over the period 2000-2018. The comparison with the survey respondents shows very few differences (the biggest difference is for the earliest period, where the average age of this group is slightly younger at 38 years of age) (Figure 16). Statistically significant differences were observed for the first two periods only: 2000-2004 ($t = 7,019$, $df = 791$, $p < 0,05$) and 2005-2009 ($t = 5,301$, $df = 1124$, $p < 0,05$).

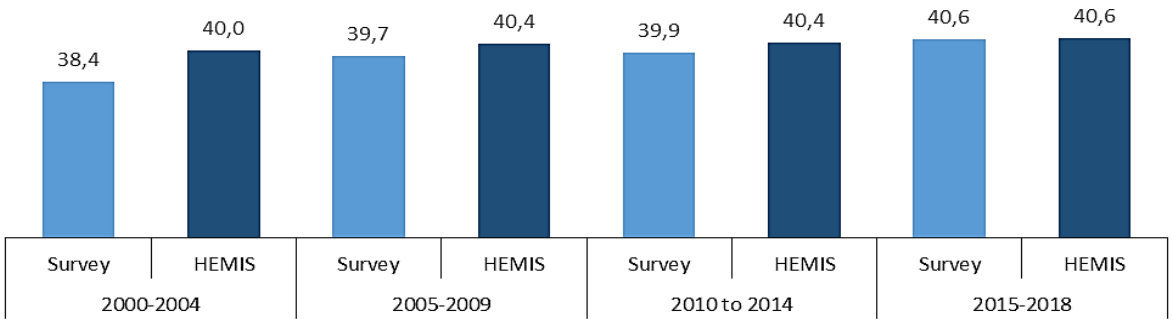


Figure 16 The distribution of mean age at graduation of sample and population

3.2.5. Representativeness of the sample in terms of STEM and SSH fields

The final variable that we used to check for the representativeness of our sample and hence the generalisability of our results was a comparison between STEM and SSH fields. The results in Figure 17 show that graduates in the STEM fields were better represented in the first two windows compared to the population shares for STEM (53% compared to 47% during the first period, and 52% compared to 48% in the second period). The relative shares of graduates by STEM and SSH for the most recent periods in our sample, however, correspond closely with the population values. However, in terms of statistical significance, a significant difference was found for all four periods: 2000-2004 (χ^2 = 18,167, df = 1, p < 0,05), 2005-2009 (χ^2 = 8,864, df = 1, p < 0,05), 2010-2014 (χ^2 = 6,339, df = 1, p < 0,05) and 2015-2018 (χ^2 = 4,109, df = 1, p < 0,05). The differences between our sample and the population values are small and we can conclude that our sample is generally representative in terms of STEM/SSH fields.

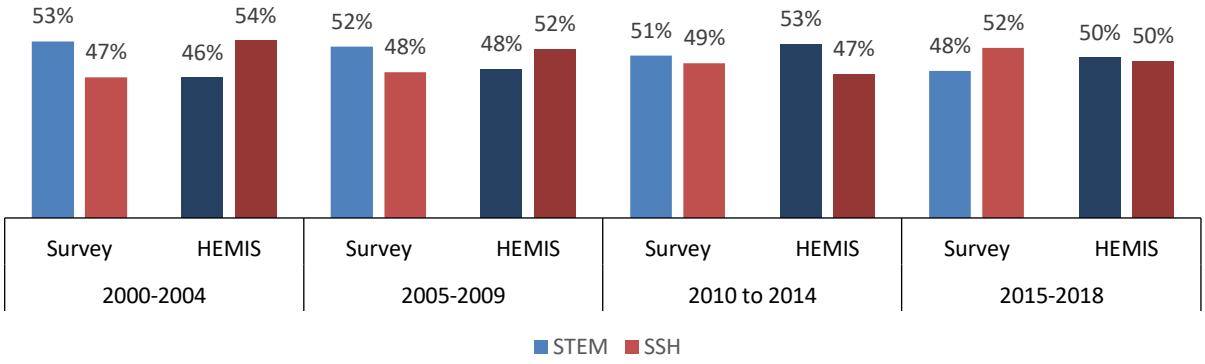


Figure 17 Distribution of respondents in STEM and SSH disciplines

Additional checks on the representativeness of the sample includes disaggregating the respondents by scientific discipline (Table 8), by university where doctoral degree was obtained and by year of graduation (Table 9).

Table 8 Distribution of survey respondents by scientific domain compared to HEMIS

	2000-2004		2005-2009		2010-2014		2015-2018	
	Survey	HEMIS	Survey	HEMIS	Survey	HEMIS	Survey	HEMIS
Agriculture	5%	4%	5%	5%	3%	5%	4%	5%
Engineering and applied technological sciences	8%	8%	7%	8%	8%	8%	8%	9%
Health and medical sciences	12%	11%	10%	11%	11%	12%	13%	13%
Humanities and arts	18%	14%	16%	16%	15%	17%	13%	15%
Biological and environmental sciences	17%	9%	16%	8%	13%	10%	9%	8%
Social sciences	14%	14%	15%	15%	15%	12%	18%	12%
Economic and management sciences	8%	20%	9%	17%	10%	16%	13%	13%
Physical, chemical and mathematical sciences	12%	8%	13%	9%	14%	11%	12%	14%
Education	7%	12%	9%	11%	10%	10%	10%	10%

Table 9 Distribution of survey respondents by university where PhD was awarded compared to HEMIS

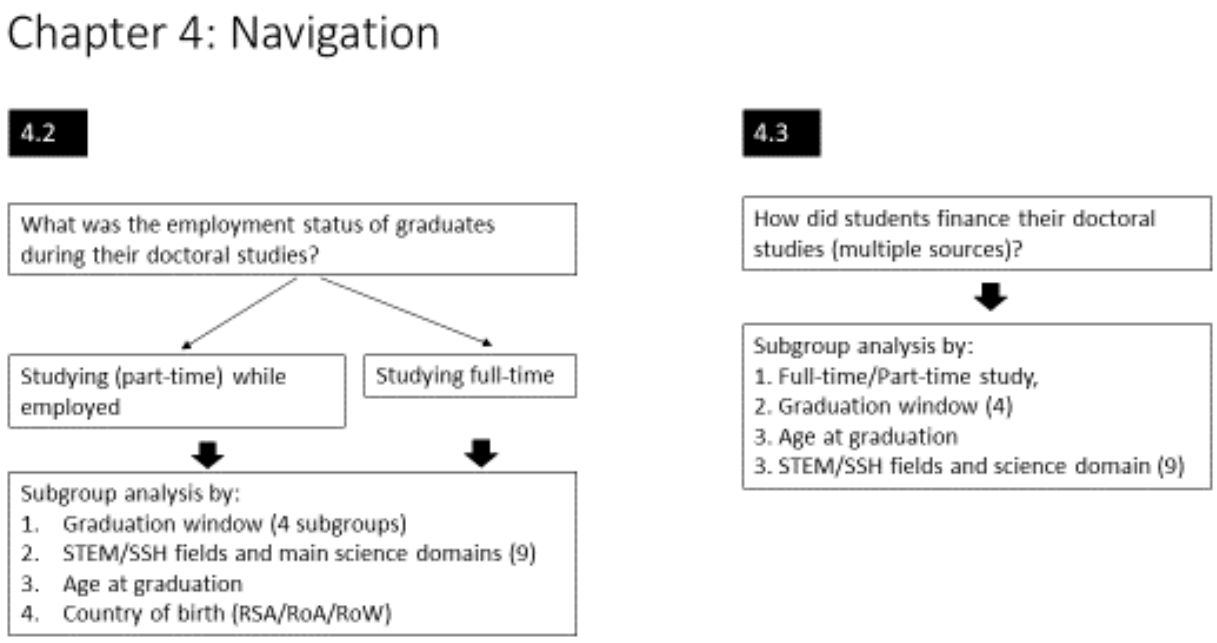
	2000-2004		2005-2009		2010-2014		2015-2018	
HEI	Survey	HEMIS	Survey	HEMIS	Survey	HEMIS	Survey	HEMIS
UKZN	10%	10%	9%	10%	12%	11%	9%	14%
UP	16%	14%	15%	14%	12%	12%	13%	12%
Unisa	8%	12%	9%	6%	7%	8%	8%	10%
SU	13%	10%	13%	10%	12%	11%	12%	10%
Wits	8%	8%	9%	9%	10%	9%	10%	8%
NWU	7%	7%	5%	9%	6%	8%	7%	8%
UCT	14%	10%	15%	13%	14%	10%	12%	8%
UJ	7%	8%	5%	6%	4%	4%	5%	5%
UFS	6%	7%	5%	5%	4%	5%	4%	4%
UFH	0%	0%	0%	1%	1%	2%	2%	4%
UWC	2%	2%	3%	3%	5%	5%	4%	4%
NMU	3%	2%	2%	3%	5%	4%	4%	3%
RU	3%	3%	5%	3%	4%	3%	4%	3%
Total		93%		94%		93%		91%

In conclusion: Based on these assessments and taking into account the large sample size (nearly 20% of the population), it is clear that our survey respondents can be regarded as being representative of the South African population of doctoral graduates over the past 19 years, except in respect of race, and that the results presented in this report can be generalised to all South African doctoral graduates over this period.

Chapter 4: Employment status of doctoral graduates during their doctoral studies

4.1. Introduction

This chapter is devoted to a discussion of the employment status of the graduates at the time when they were enrolled for their doctoral studies (Section 4.2) and how their doctoral studies were financed (Section 4.3). The logic of the chapter is illustrated in the navigation pane below.



4.2. Employment status during the PhD study

A first main finding of our study is that just over 60% of South African doctoral graduates over the past 19 years were employed full time during their doctoral studies. This means that the majority of doctoral students in this country study part time. Slightly less than 39% of all students study toward their doctorate on a full-time basis. These results correspond with the findings from a previous study conducted by CREST (2009). In that study, which was completed in 2009 (and included students who had graduated before 2008), it was found that approximately 30% of doctoral students at the time were studying full time while the remaining 70% were studying part time. This split compares favourably to the split of 33/67 of our first subgroup in Table 10 below.

To test whether this split between part-time and full-time students applied over the entire period covered by our survey, we assigned all doctoral graduates into four graduation windows according to the year in which they were awarded their PhD. Table 10 and Figure 18 show that there has been a significant (but not great) shift over time with regard to the ratio of full-time to part-time students. Recent graduates are

more likely to study full time compared to graduates who completed their studies in the early 2000s[8].

Table 10 Employment status of doctoral student by graduation window

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
	n	%	n	%	n	%	n	%
Studying full time	276	33,3%	450	38,2%	693	40,3%	854	41,5%
Studying while employed full time	554	66,7%	727	61,8%	1 026	59,7%	1 202	58,5%

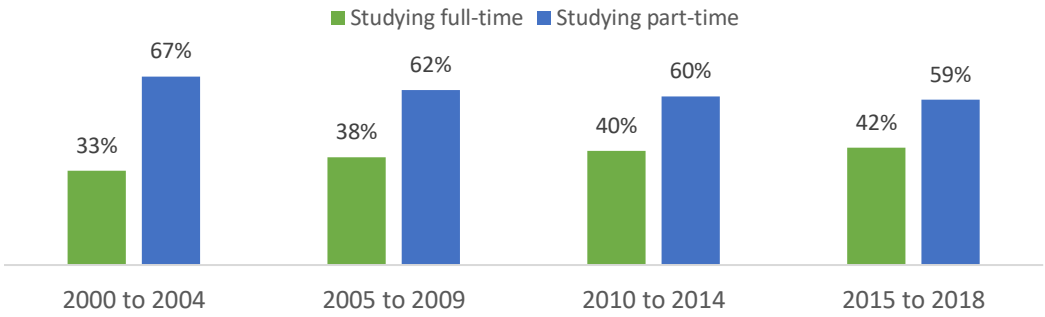


Figure 18 Comparison of respondents who studied full time and part time

One possible explanation for this shift may be explained by increasing numbers of STEM graduates in recent years. When we look at the enrolment status of respondents across the STEM and SSH fields we see that 49% (n=1 509) of STEM respondents were studying full time compared to 29% (n=895) in SSH. Among respondents who studied towards the doctorate while employed, 51% (n=1584) were in STEM compared to 71% (n=2 196) in SSH. Again, the results corroborate the findings of other studies at CREST, which indicated that graduates in the STEM fields were much more likely to study full time than their counterparts in SSH.

In our discussion of the age of doctoral graduates at graduation in South Africa (Chapter 3), we indicated that the average age of graduates at graduation over the past two decades has remained constant at 40/41 years old. But disaggregation of the respondents into full-time and part-time students reveals a substantial and statistically significant difference – students who study full time are on average six years younger than those who study while employed, as shown in Table 11 below.[9]

Table 11 The average age at graduation of full-time respondents

	Mean	N	Standard deviation
Studying full-time	36,1	2 158	7,948
Studying while employed full-time	42,0	3 328	8,674
Total	39,7	5 486	8,878

[8] Pearson chi-square = 18,336, df = 3, p = 0,000.

[9] Analysis of variance (Anova) results: F = 649,231, df = 1, p = 0,000.

Looking at the nationality of respondents during their doctoral studies, as illustrated in Figure 19, we find that respondents from the rest of Africa are more likely to study full time. We see that nearly 60% (n=871) of respondents from these countries indicated that they were not employed while enrolled for the PhD. This compares to 31% (n=1 217) of South African respondents and 45% (n=87) of respondents from elsewhere in the world.

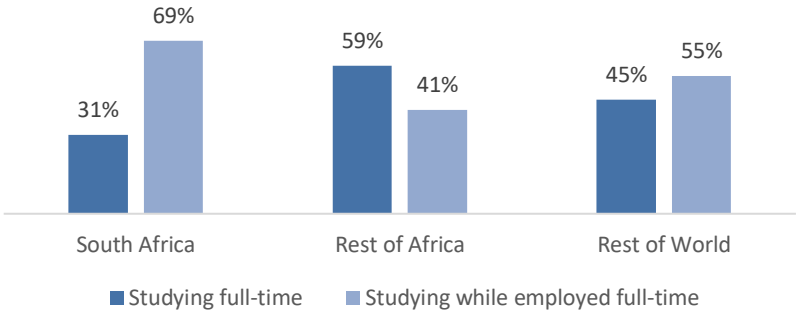


Figure 19 Students from the rest of Africa studying full time and part time for a PhD

The figure below compares the employment status of black and white graduates at the time of their doctoral studies. We find that 32% (n=425) of black graduates studied full time compared to 31% (n=628) of white graduates. Likewise, 68% (n=919) of black graduates were employed full time while they were studying towards their doctorate, as were 69% (n=1 404) of white graduates. These results show black and white graduates are equally likely to study full time towards their doctoral degrees.

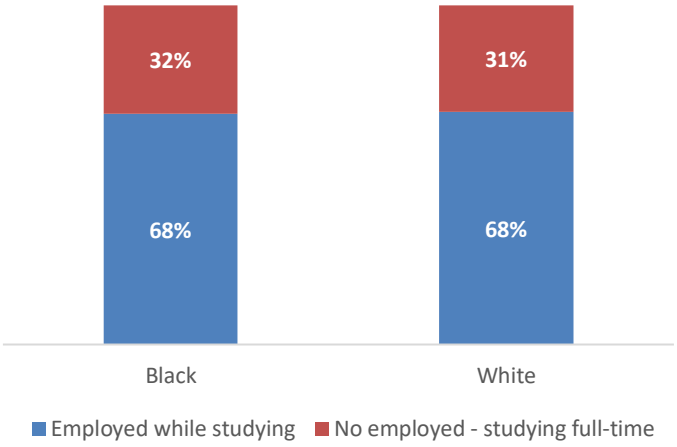


Figure 20 Employment status of black and white respondents during PhD studies

Figure 21 below displays the results of a chi-square automatic interaction detection (CHAID) analysis, which looks at the interaction effects between predominantly categorical variables (full-time/part-time study, SET/SSH and country of birth) and the age of the graduate at graduation. The strength of this technique is that it can look at the inter-relationships between these variables together and then apply means tests to create descending subgroups according to the interaction variables. In the subsequent table (Table 12) we summarise the main results of this analysis.

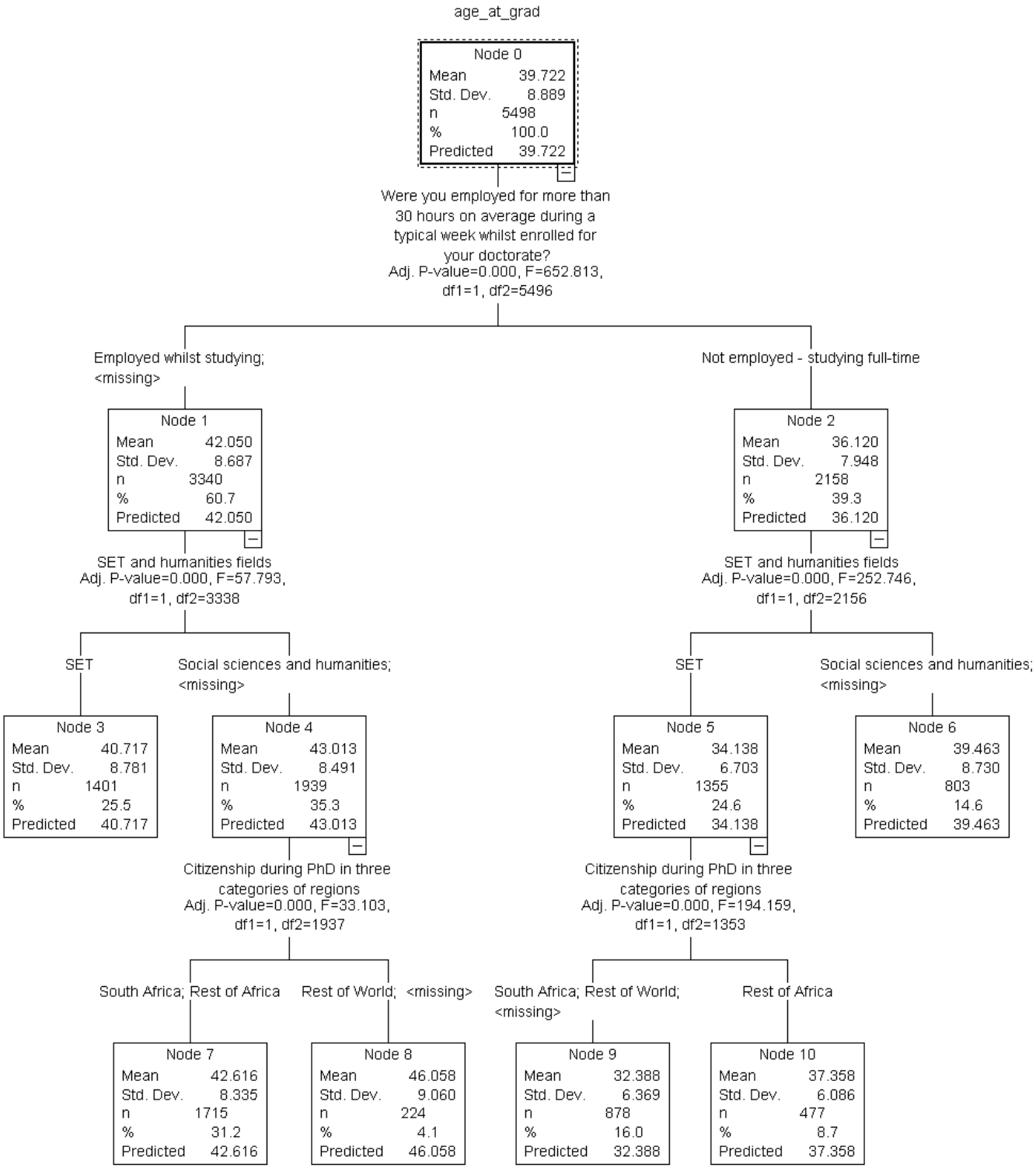


Figure 21 Classification tree of doctorate holders' enrolment status, disciplinary field and citizenship during the PhD and age at graduation (CHAID analysis)

We see that the oldest group of respondents, with a mean age of 46,1 years, constitutes 4,1% (n=224) of our sample and includes respondents who were employed while studying towards their doctorate, completed their studies in the SSH, and were born in another country in Africa. Conversely, the youngest group of our sample, at a mean age of 32,3 years, which constitutes 16% (n=878) of our sample, studied full-time in a STEM discipline and were either South African nationals or from outside of Africa.

Table 12 Summary for classification tree nodes

Employment status	Field	Citizenship	Node	N	Percent	Mean age at graduation
Employed while studying	SSH	Rest of the world	8	224	4,1%	46,06
		RSA, Rest of Africa	7	1 715	31,2%	42,62
	STEM/SET		3	1 401	25,5%	40,72
Study full-time	SSH		6	803	14,6%	39,46
	STEM/SET	Rest of Africa	10	477	8,7%	37,36
		RSA, Rest of the world	9	878	16,0%	32,39

In Figure 22 below we look at the interaction effect between South African graduates' mode of study, disciplinary field (SET/SSH), race and age at graduation to test whether there are any significant differences between black (black African, Indian/Asian and coloured graduates) and white graduates. In Table 13 below we summarise the results. We see that the only significant differences between black and white graduates are for full-time study in the STEM field, where black graduates are older (by 1,7 years) than their white counterparts.

Table 13 Summary for classification tree nodes

Employment status	Field	Race	Node	N	Percent	Mean age at graduation
Employed while studying	SSH		4	1 369	39,4%	42,6
	STEM		3	1 017	29,3%	40,5
Full-time study	SSH		6	348	10,0%	39,1
	STEM	Black	8	242	7,0%	33,4
		White	7	498	14,3%	31,7

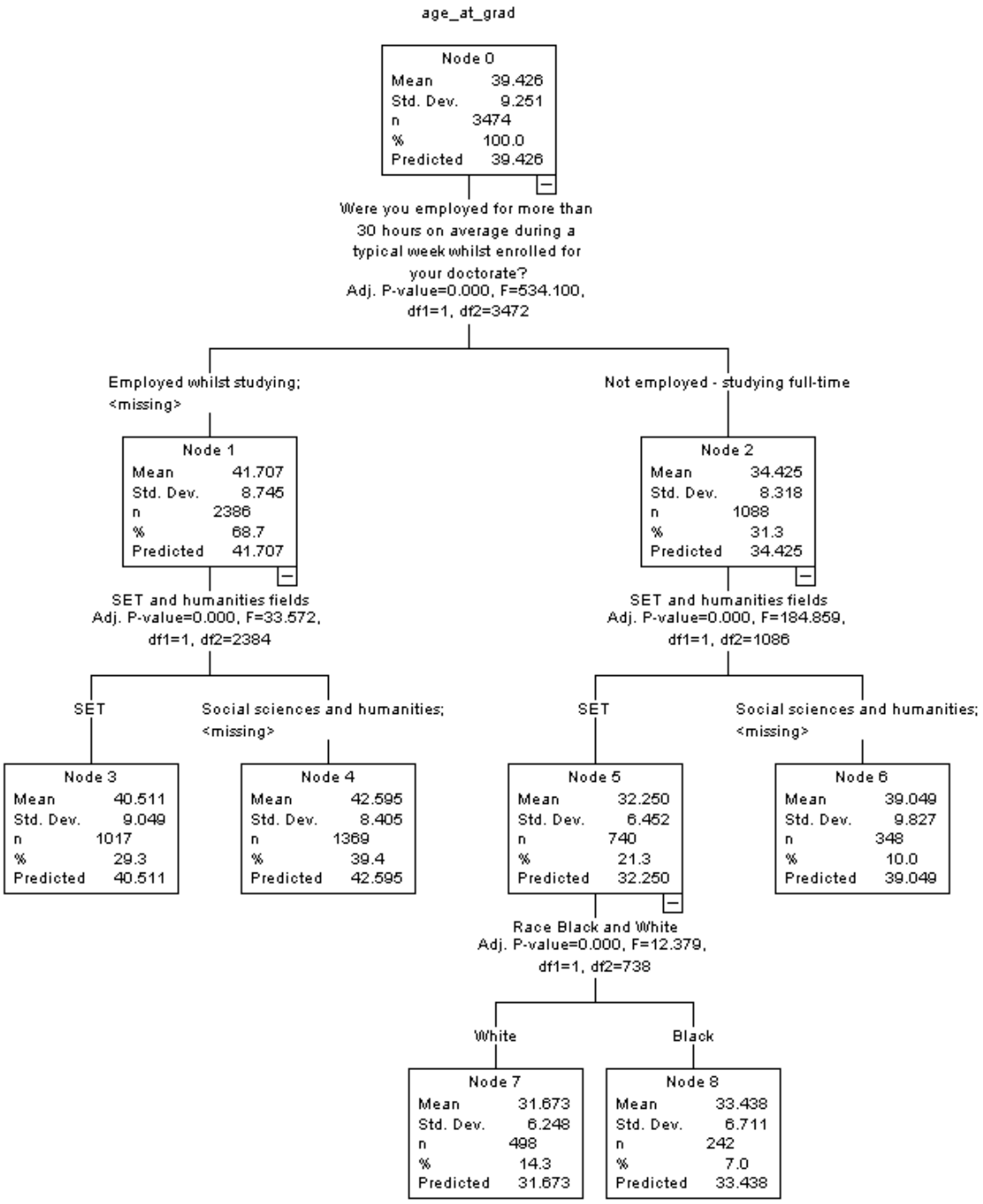


Figure 22 Classification tree of South African doctorate holders' enrolment status, disciplinary field, race and age at graduation (CHAID analysis)

In the following figures and tables, we disaggregate the STEM and SSH fields into nine science domains in order to gain a more nuanced picture of the relationship between the graduate's field of study and the other variables discussed above (nature of studies, age and country of birth). Figure 23 and Table 14 show that respondents in the natural sciences, which include the biological and environmental sciences (66%, n=524), and physical sciences and mathematical sciences (54%, n=413), are more likely to study full time towards their doctorates than respondents in education (22%, n=132), economic and management

sciences (24%, n=159), and other social sciences (31%, n=304). We showed earlier that students in the STEM sciences have a higher likelihood of studying full-time than their counterparts in the SSH. These results are therefore not surprising, as many students in the STEM fields require access to laboratories, equipment and clinical facilities to complete their studies. On the whole, this does not apply to students in the SSH.

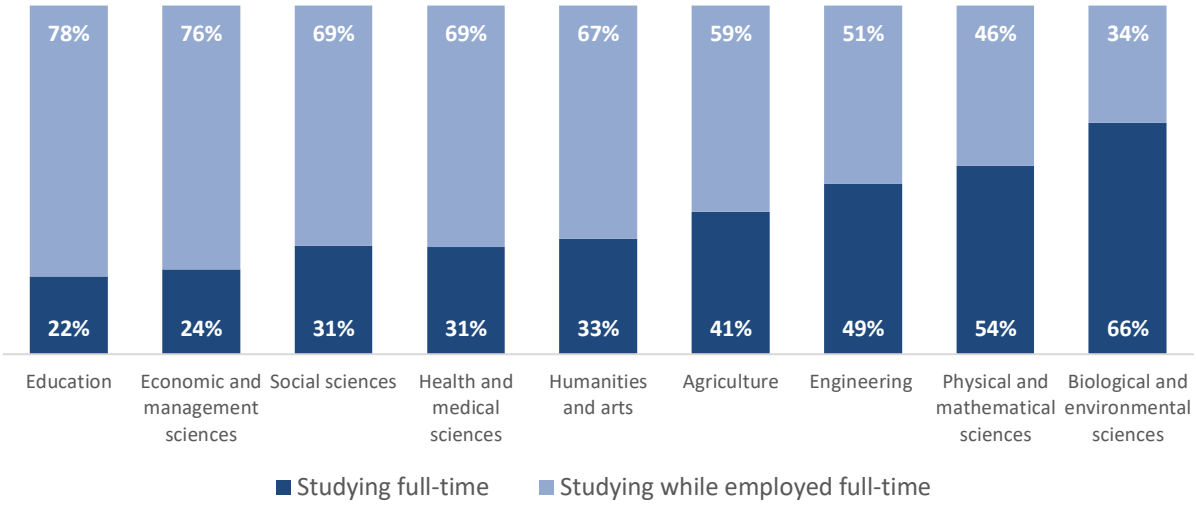


Figure 23 Full-time vs part-time PhD studies for STEM and SSH doctoral students

Table 14 Doctoral students in the natural sciences are more likely to study full time towards the doctorate

		Agriculture	Engineering and applied technological sciences	Health and medical sciences	Humanities and arts	Biological and environmental sciences	Social sciences	Economic and management sciences	Physical, chemical and mathematical sciences	Education
Studying full time	n	106	233	221	314	524	304	159	413	132
	%	41%	49%	31%	33%	66%	31%	24%	54%	22%
Studying while employed full time	n	153	244	496	636	265	675	497	352	461
	%	59%	51%	69%	67%	34%	69%	76%	46%	78%

We again ran a CHAID analysis to look at the interaction effects between these variables (Figure 24). The main findings, summarised in Table 15, illustrate the relationship between doctoral students' age at graduation, enrolment status during the PhD, and scientific domain in which they completed their doctoral studies.

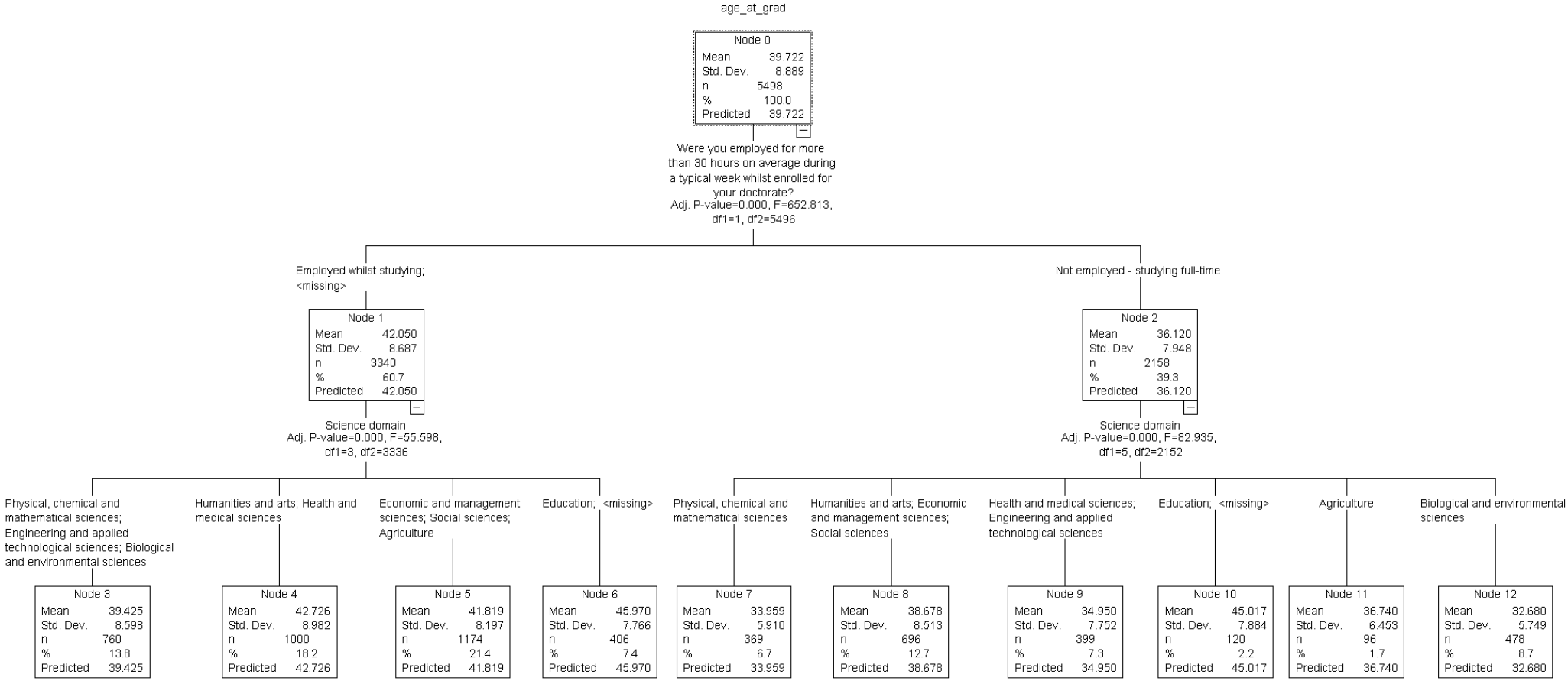


Figure 24 Classification tree of doctorate holders' age at graduation, enrolment status and scientific domain

We see that the youngest group in our sample, with a mean age at graduation of 32,7 years (node 12), completed their doctoral studies in the biological and environmental sciences while enrolled full time. With the exception of graduates in education (node 10), graduates who were enrolled full time were on average younger than those who were employed while studying, while graduates in the STEM fields (biological, physical, health, engineering and agriculture) were on average younger than their counterparts in the SSH (node 8). Doctorate holders in education were on average the oldest at time of graduation (nodes 6 and 10) at 45 to 46 years.

Table 15 Doctorate holders in who study full-time in the natural sciences are on average the youngest

Node	Employment status	Scientific domain	N	%	Mean
12	Studied full time	Biological and environmental sciences	478	8,7%	32,68
7	Studied full time	Physical, chemical and mathematical sciences	369	6,7%	33,96
9	Studied full time	Health and medical sciences Engineering and applied technological sciences	399	7,3%	34,95
11	Studied full time	Agriculture	96	1,7%	36,74
8	Studied full time	Humanities and arts Economic and management sciences Social sciences	696	12,7%	38,68
3	Employed while studying	Physical, chemical and mathematical sciences Engineering and applied technologies Biological and environmental sciences	760	13,8%	39,43
5	Employed while studying	Economic and management sciences Social sciences Agriculture	1 174	21,4%	41,82
4	Employed while studying	Humanities and arts Health and medical sciences	1 000	18,2%	42,73
10	Studied full time	Education	120	2,2%	45,02
6	Employed while studying	Education	406	7,4%	45,97

4.3. Financing of doctoral studies

An important theme explored in this study is how doctoral students finance their studies. The results are reported in Table 16. A key finding is that self-financing was the most frequently mentioned source of financial support is (n=3 086, 33%), which included taking out loans and financial support by family members, spouses and partners.[10] The second most cited source of funds was assistance from the respondent's university (n=2 810, 30%). These first two results are perhaps not surprising given that 60% of graduates indicated that they were employed at the time of doing their doctorates and, of these, many were in the higher education sector. Getting a bursary or scholarship from a South African national funding agency such as the NRF, SAMRC or WRC (n=2 107, 22%) was the third most frequently cited source of financing. Eight per cent of respondents (n=794) received financial assistance from an international organisation compared to 6% (n=593) who received assistance from an employer where the employer was not a university. A small number of respondents received financial support from industry or another (private) organisation/donor.

Table 16 Sources of financing of doctoral studies in descending order from highest to lowest

Means of financing the doctorate	n	%
Self-financed/loan/supported by family, etc.	3 086	33%
Financial assistance from my university	2 810	30%
Received a bursary/scholarship from the NRF, SAMRC, WRC or any other South African national funding agency	2 107	22%
Received a bursary/scholarship from an international organisation (e.g. DAAD, the German Academic Exchange Service, or the Andrew W Mellon Foundation)	794	8%
Received financial assistance from employer (where the employer was not a university)	593	6%
Industry or another institution/organisation	58	1%

In Figure 25 and Table 17 we show the most frequently cited source of financial support by graduates' employment status during their doctoral studies. As one would expect, graduates who were not employed during their PhD studies were more likely to cite financial assistance from a South African national funding agency (20%, n=1 245), compared to 14% (n=862) of respondents who were employed on a full-time basis. Graduates who were employed full time during their doctoral studies were more likely to be self-financed (32%, n=1 987) and receiving financial assistance from their universities (30%, n=1 846). The latter group refers to the large proportion of academic staff at South African universities who pursue their doctoral qualification and receive a staff rebate or tuition support.

We see that 2% of respondents who enrolled full time received financial assistance from their employer. These respondents are likely to have held tutoring positions or research assistantships during the time of their doctoral studies. Our definition of full-time enrolment, in the survey questionnaire, was whether graduates were employed for less than 30 hours a week. There was therefore a small percentage of full-time enrolled graduates who held casual or part-time positions during their doctoral studies.

It is important to note that doctoral students' financing may include more than one source and may

[10] Note that respondents could select more than one option and the categories were not mutually exclusive. The percentages reported here are therefore percentages of the total count of respondents indicated.

change at any stage of their doctoral studies. In many cases, as reported in the open-ended survey questions, respondents became employed during the final year of their doctoral studies. In cases where students receive bursaries from the NRF, these bursaries funded students for a limited number of years, after which many students had to seek alternative sources of financing.

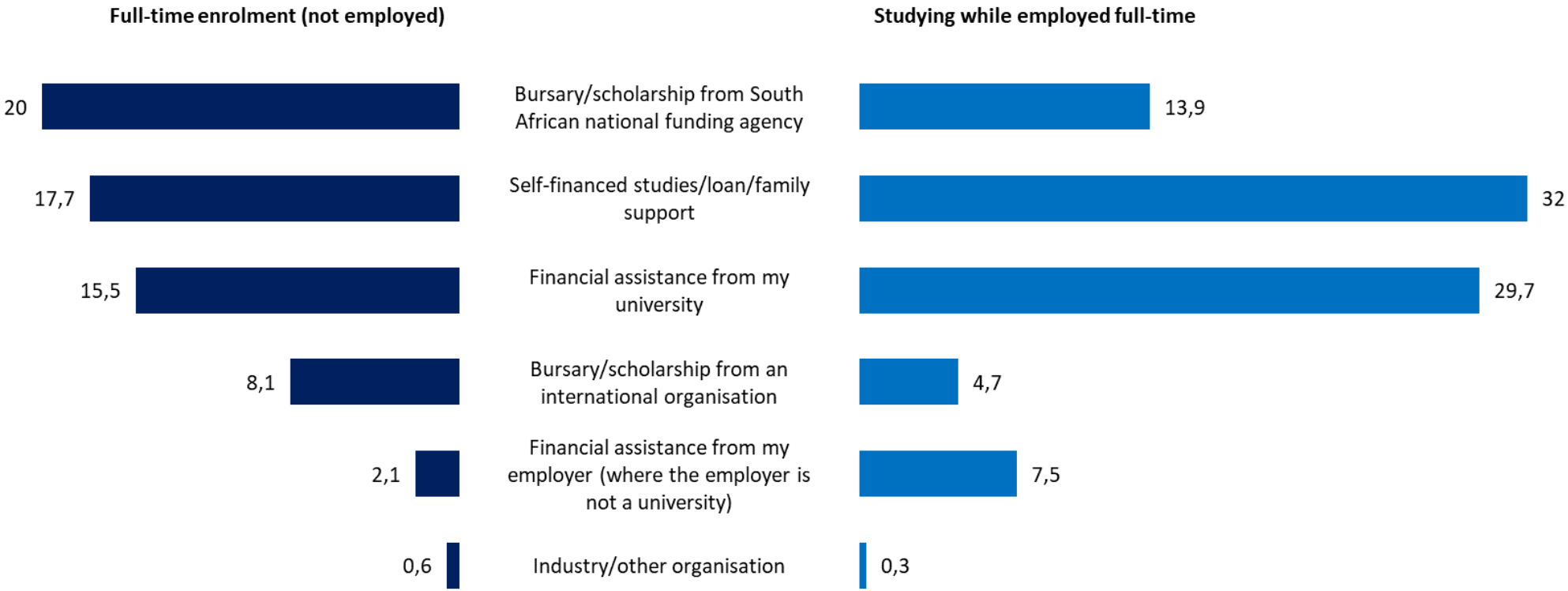


Figure 25 Financing of the doctorate for students employed full time and part time

Table 17 Sources of financial support of doctorate holders by employment status during the PhD

	Full-time		Part-time	
Financial support	n	%	n	%
Received a bursary/scholarship from the NRF, SAMRC, WRC or any other South African national funding agency	1 245	20,0	862	13,9
Received financial assistance from my university	964	15,5	1 846	29,7
Self-financed	628	10,1	1 987	32
Received a bursary/scholarship from an international organisation (e.g. DAAD or Mellon)	976	17,7	289	4,7
Received financial assistance from employer (where the employer was not a university)	128	2,1	465	7,5
Support from industry or another institution/organisation	38	0,6	20	0,3

Table 18 shows the sources of financial support for black and white respondents (the percentages are calculated from all respondents (who had been full-time or part-time PhD students) per source of financial support). When looking at full-time students, we find that the most cited sources of financial support for black students were from a South African national funding agency (22%) and self-financing (19%). Sixty percent of white students reported that they were more likely to be self-financed – which is three times more than the percentage reported among black students – while 34% received funding from a South African funding agency.

For part-time students we find that white graduates were more likely to have received financial assistance from their university (40%) than black graduates (25%). Larger shares of white, part-time students also reported receiving financial assistance from a South African funding agency (36% compared to 27% black graduates) and financial support from an employer (not a university)(36% compared to 25%). A third of black graduates, however, reported funding received from an international organisation compared to a fifth of white graduates. A much larger percentage of white students who studied full time reported that they financed their studies themselves (60%, n=372) compared to black students (19%, n=120).

Table 18 Sources of financial support of doctorate holders by employment status during the PhD by race

	Full-time				Part-time			
	Black		White		Black		White	
Financial support	n	%	n	%	n	%	n	%
Received a bursary/scholarship from the NRF, SAMRC, WRC or any other South African national funding agency	279	22%	426	34%	239	27%	308	36%
Received financial assistance from university	152	16%	239	25%	456	25%	742	40%
Self-financed	120	19%	372	60%	372	19%	183	9%
Received a bursary/scholarship from an international organisation (e.g. DAAD or Mellon)	102	10%	91	9%	95	33%	61	21%
Received financial assistance from employer (where the employer was not a university)	11	8%	25	20%	117	25%	166	36%

	Full-time				Part-time			
Received financial assistance from industry or another institution/organisation	7	18%	11	29%	4	20%	6	30%

Financial assistance from a South African funding agency

In the remaining analyses, we look more closely at the results presented thus far and further explore the financial support of full-time doctoral students by a South African national funding agency, such as the NRF, the SAMRC or the WRC.

When looking at a possible shift over time (Table 19), we see that there has been little change in the percentage of full-time enrolled respondents who received bursaries or scholarships from national funding agencies, with 51 to 53% of graduates receiving such financial support. As far as the average age of respondents at graduation was concerned, there was a slight increase in the average age, from 32 for the earlier years to 35 in recent years.

Table 19 Financial support of full-time enrolled doctoral graduates by South African national funding agencies

Year in which PhD was awarded	Bursary/scholarship a South African national funding agency	Full-time enrolment	
	n	n	%
2000 to 2004	146	276	53%
2005 to 2009	228	450	51%
2010 to 2014	356	693	51%
2015 to 2018	433	854	51%

When we look at the financial support of black, full-time students, we find that nearly 70% of them received a bursary or scholarship from a South African funding agency between 2000 and 2009, while the percentage declined to 63% in the period 2015 to 2018.

We see that 63% (n=953) of full-time enrolled graduates in STEM received funding from a national funding agency compared to 33% (n=292) in SSH, as illustrated in Figure 26.

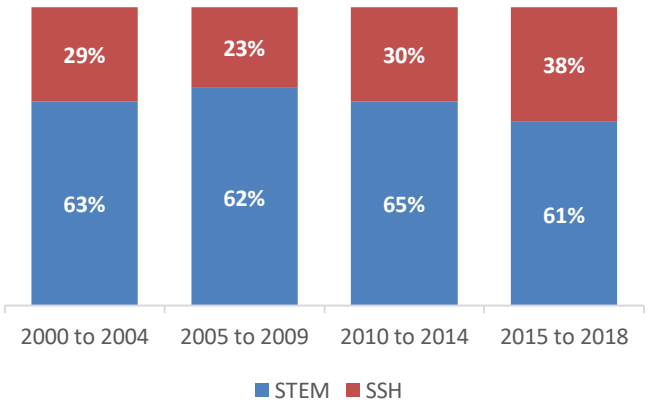


Figure 26 Bursary/scholarship from South African national funding agency by field

Looking at the scientific domains, full-time students who enrolled in the biological and environmental sciences (72%, n=379) and physical, chemical and mathematical sciences (63%, 262) were more likely to receive funding from a South African funding agency than full-time graduates in the social sciences and arts.

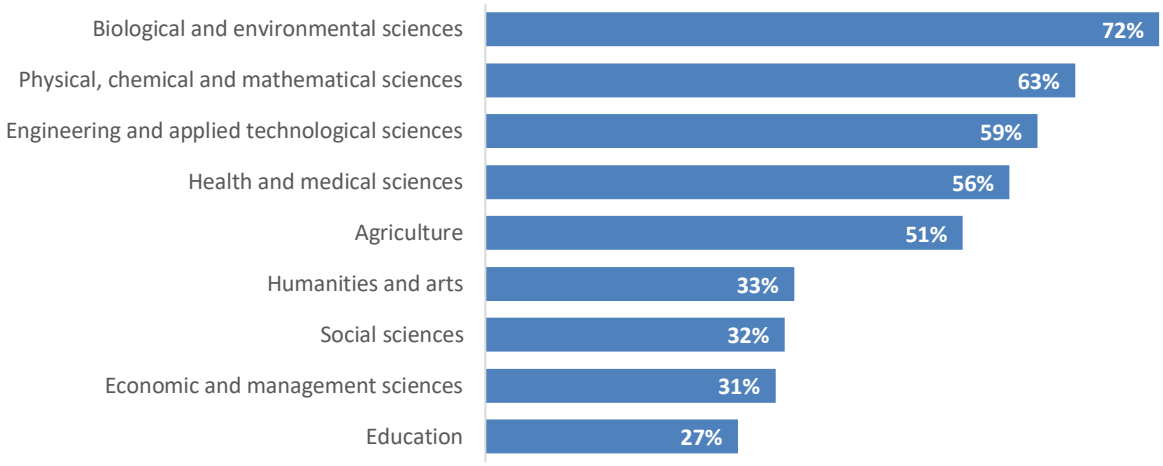


Figure 27 Bursaries/scholarships from South African national funding agency by domain

4.4. Summary of key findings

The salient findings on the employment status of doctoral graduates during their doctoral studies can be summarised as follows:

1. The majority (61%) of all doctoral students in South Africa study part time; in other words, they are enrolled for doctoral degrees while employed. This percentage has not changed over the past 19 years.
2. Disaggregation of the results show that the percentage of students studying full time or part time differ by scientific domain/field – students in STEM fields are more likely to study full time – and by the nationality of the student.
3. The differences in the employment status of students in the STEM vs SSH fields are, in turn, linked to the age of the students. The youngest subgroup of doctoral students are full-time students in the STEM fields, while the oldest group at graduation are part-time students in education.
4. Full-time graduates are more likely to receive bursaries or scholarships from South African funding agencies (especially in STEM), while graduates who are employed while studying are more likely to self-finance their studies or receive assistance from their university.
5. The most cited source of financial support for full-time black students was a South African national funding agency (22%), while white full-time students reported that they were more likely to be self-financed. For part-time students, 40% of white graduates had received financial assistance from their university, compared to 25% of black graduates. Larger shares of white, part-time graduates also reported receiving financial assistance from a South African funding agency (36% compared to 27% of black graduates) and financial support from an employer (not a university)(36% compared to 25%).

Chapter 5: Employment following completion of the PhD

5.1 Introduction

Having discussed the employment status of South African doctoral students while pursuing their doctoral degrees, we now turn to what happens after they obtain their degree. In this regard, the survey focused specifically on the first year following completion of doctoral studies. One of the possible next steps for newly graduated doctorate holders is to take up one or more postdoctoral fellowships, and the findings of our study related to this are presented and discussed separately in the next chapter (Chapter 6). In this section, we confine our discussion to all other forms of employment.

In the study we asked respondents a general question and to indicate whether they had found employment after completing their doctoral studies. This question was followed by a number of supplementary questions aimed at understanding more about the different employment trajectories after completing their studies.

- Have there been any major shifts in the employment status over the past two decades?
- Are there big field differences in terms of the employability of doctoral graduates?
- Are there any big intersectoral shifts in terms of where doctoral students find employment after graduation?
- What are some of the challenges graduates face in finding employment?

We discuss the results pertaining to these questions in Section 5.2. In the second main section of the chapter (5.3), we focus on their current (or most recent) employment. We asked about the nature of their current employment and disaggregated the responses by graduation window and STEM/SSH fields. We then used a Sankey diagram to map the mobility between their sector of employment during their doctoral studies and their current or most recent employment. The chapter concludes with a short discussion of how respondents rated two job rewards (security and income).

Chapter 5: Navigation

Do SA graduates find employment after completing their doctoral studies and if so, how soon after completion of their studies? 5.2

Have there been any major shifts in the employment status of doctoral graduates over the past two decades (results disaggregated by ful-time and part-time studying students [Sankey diagram])

1. Results disaggregated by age of graduate at graduation
2. Results by STEM/SSH
3. Alignment between employment and field of doctoral expertise
4. Challenges in finding employment

Current or most recent employment of respondents and rating of employment rewards? 5.3

1. Results disaggregated by graduation window (4 subgroups)
2. Results disaggregated by STEM/SSH field
3. Inter-sectoral mobility between employment during studies and current employment sector
4. Rating of employment in terms of job security and income

5.2 Finding employment immediately after graduation

One of the key findings of our study is that over half South Africa's doctoral graduates over the past 19 years stayed with the same employer. Figure 28 below shows respondents' employment status in the first year after graduation. The fact that the majority of graduates indicated that they remained with the same employer (52%, n=3 169) is not surprising, as we have already discovered that on average about 60% of all doctoral students in the country were employed when they enrolled for doctoral studies. It is also worth noting that a substantial number of students (20%, n=1 235) indicated that they accepted a postdoctoral fellowship on completion of their studies. An equally important finding of our study is that **only 2% (n=138) indicated that they could not find employment after completing their doctoral degree**.

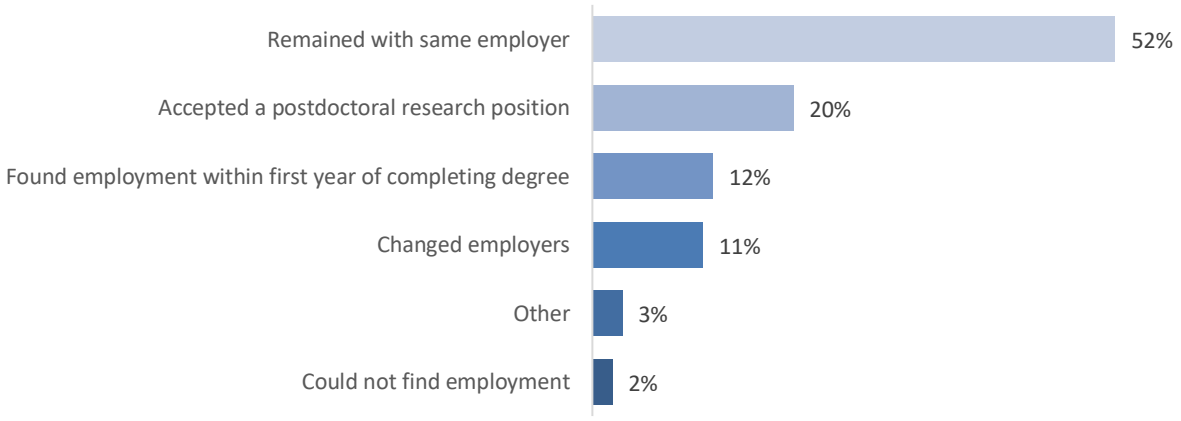


Figure 28 Distribution of responses by employment after completion of doctoral studies

In Table 20 below, we investigate whether there has been a shift in the employability of graduates in the last 19 years.

Table 20 Employment status of respondents within the first year of graduation by graduation window

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
	n	%	n	%	n	%	n	%
Remained with the same employer (organisation/institution/business)	428	52,8%	574	50,8%	880	53,1%	1 067	53,7%
Accepted a postdoctoral research position	141	17,4%	205	18,1%	374	22,6%	439	22,1%
Found employment within the first year of completing degree	107	13,2%	174	15,4%	175	10,6%	192	9,7%
Changed employers	111	13,7%	160	14,1%	181	10,9%	185	9,3%
Could not find employment within the first year after completing my degree	17	2,1%	9	0,8%	29	1,8%	78	3,9%
Was not economically active for other reasons (e.g. retirement, health)	3	0,4%	1	0,1%	6	0,4%	13	0,7%
Was not economically active due to family care responsibilities (e.g. household duties, child rearing)	4	0,5%	8	0,7%	12	0,7%	12	0,6%

Discussion of salient findings:

- There has been little change in the percentage of respondents who remained with the same employer (51% to 54%).
- There has been a slight increase in the percentage of respondents who accepted a postdoctoral fellowship in the earlier years, 17% (2000 to 2009) to 22% in more recent years (2010 onwards).[11]
- Conversely, the percentage of respondents who changed employers within the first year of obtaining the doctorate has decreased over time,[12] with more recent graduates being less likely to change employment within the first year of graduation.
- There has been a small increase in the percentage of doctoral graduates who could not find employment within the first year after graduating (from 2,1% for our earliest group to 3,9% for our most recent graduates). Recalling that the average percentage of those who could not find employment within the first year after graduating is 2,2%; we would not at this stage conclude that there is any significant increase in the share of "unemployed" doctoral graduates in the country.

[11] The difference in the percentages between the percentage of postdoctoral fellowships in 2010-2014, 2015-2018, 2000-2004 and 2005-2009, are statistically significant based on two-sided tests at 0,05. Results are based on two-sided tests.

[12] The difference in the percentages between the percentage respondents who changed employers in 2015 to 2018, 2000 to 2004, and 2005 to 2009, are statistically significant based on two-sided tests at 0,05. Results are based on two-sided tests.

We have already shown that more than 60% of survey respondents were employed full time during their doctoral studies. When investigating the employability of doctorate holders, it is therefore imperative to distinguish between graduates who are seeking employment for the first time and graduates who already held employment during their PhD studies. Figure 29 below compares the employment status of doctoral graduates during their doctoral studies with their situation within the first year of graduation.

Figure 29 displays the results of Sankey diagrams. These diagrams emphasise the major transfers or flows within a "system" and illustrate the most important contributions to a flow. We use a Sankey diagram to illustrate the "flow" of respondents into employment positions within the first year of completing their studies. The two blocks in the left column of the diagram (dark and light blue) show the distribution of our sample by enrolment status **during their doctoral studies** (39% of respondents studied full-time compared to 61% who were employed full-time while studying). The coloured flow bands show the proportional share of either full-time or part-time respondents who (1) accepted a postdoctoral fellowship, (2) changed employers, (3) could not find employment, (4) found employment in the first year, and (5) remained with the same employer/organisation/institution. The employment status of respondents **in the year following completion of their doctoral studies** is illustrated in the blocks on the right side of the diagram. By way of illustration, the broad orange band indicates that 15,9% of the total sample studied full time and accepted a postdoctoral fellowship within the first year. This compares to 5% of the total sample who were employed while studying and accepted a postdoctoral position. Together, these two groups constitute 20,9% of our total sample of those who accepted a postdoctoral position, as reported in the text boxes on the right-hand side of the diagram.

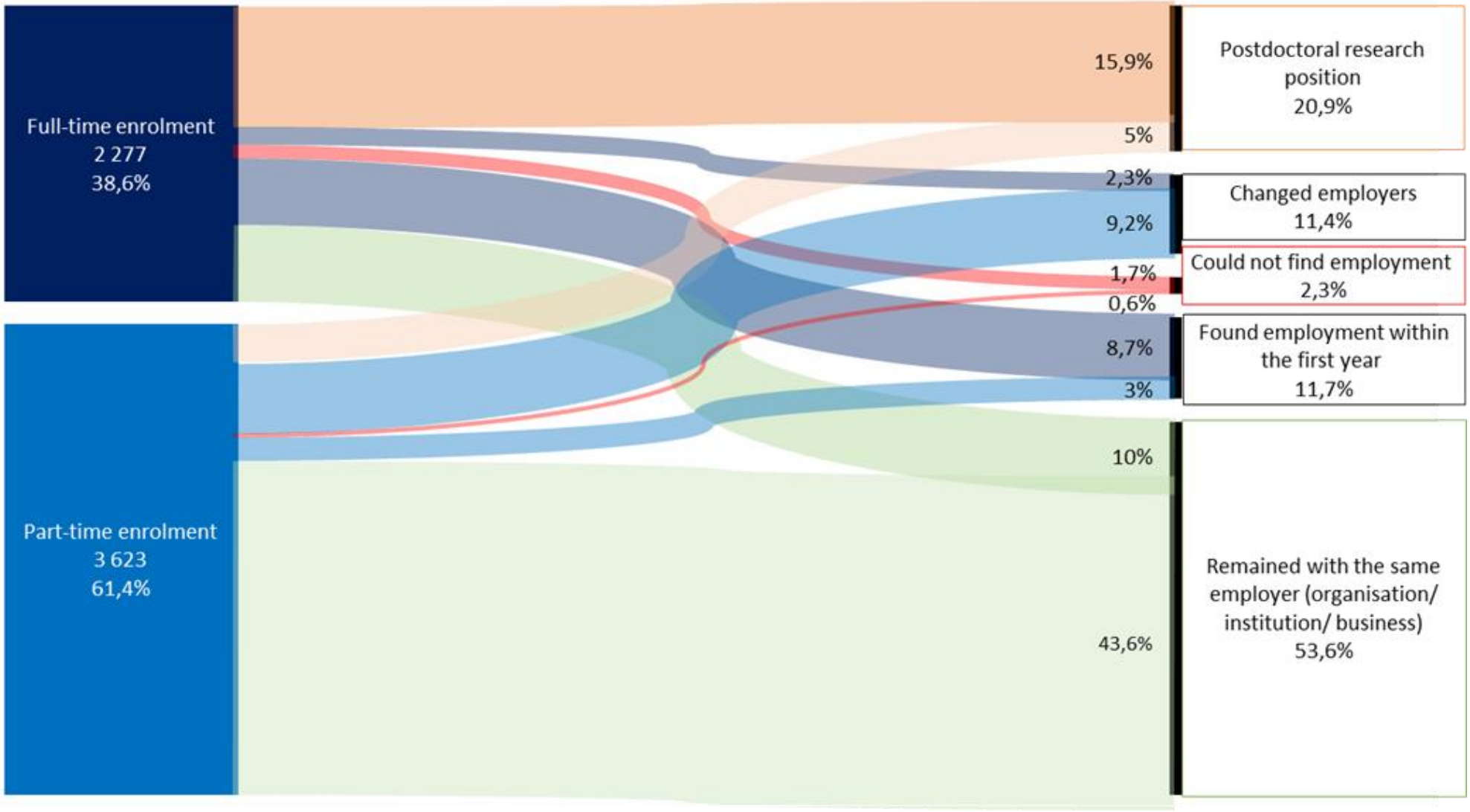


Figure 29 Sankey diagram displaying employment status of doctoral graduates within the first year after graduation

The easiest way to read the Sankey diagram is to read it from right to left, i.e. to focus on the right-hand band of results which presents the percentages of students either remaining in their current employment or finding employment after graduation.

- The largest single group of respondents in our sample (53,6%) remained with the same employer in the first year after obtaining the doctorate. The biggest percentage of this group (43,6%) are graduates who were enrolled part time and remained with their employer upon completion of their studies. This group most likely consists of academics who pursued their doctoral studies as an integral requirement of advancement in an academic career and thus remained in academia after graduation. However, this group also benefited from students who were studying full time (10% of the total sample), who assumed positions in academia after graduation. It is not impossible that most of this group included respondents who may have been employed at universities as teaching assistants, research assistants, etc. during their doctoral studies.
- The second largest group of respondents (21%) are those who accepted a postdoctoral fellowship within the first year of completion. This group is made up of those who were studying full time and then immediately moved to a postdoctoral fellowship (16%) and those who received a fellowship after having studied part time (5%). A significant difference between these two groups is their average age at graduation – 33 years for the former group and 37 years for the latter.
- The smallest group in our sample (2,3%) are respondents who reported that they could not find employment within the first year after completion of their doctoral studies. This group combines a small number (n=103 or 1,7%) of respondents who were not employed during their PhD studies, as well as 35 graduates (0,6%) who were employed (probably in part-time or temporary positions) and who indicated that they were unable to find employment.
- The remainder are those who could find employment within one year of obtaining their PhDs (11,7%), including both full-time and part-time students and those who changed employers (11,4%) after graduation.
- A further nine percent (9,2%, n=51) were employed full time during their doctoral studies and changed employers within the first year of completing their doctoral studies.

Table 21 Employment status of full-time and part-time graduates within the first year of graduation

	Full-time enrolment		Part-time enrolment	
Accepted a postdoctoral research position	39,9%	938	8,0%	295
Changed employers	5,7%	134	14,6%	541
Could not find employment within the first year after completing degree	4,4%	103	0,9%	35
Found employment within the first year of completing degree	21,9%	514	4,8%	178
Remained with the same employer (organisation/institution/business)	25,0%	588	69,5%	2574
Was not economically active due to family care responsibilities (e.g. household duties, child rearing)	1,1%	26	0,4%	13
Was not economically active for other reasons (e.g. retirement, health)	0,5%	12	0,4%	14
Other	1,2%	28	1,0%	38
Opened own practice/self-employment	0,3%	8	0,5%	18

5.2.1. Employability trends and differences in the age at graduation

We have already shown that the age profiles of doctoral graduates who studied full time and those who studied part time differed significantly. We also showed that these differences correlate with the field of study of the graduate. In Table 22 below we compare the mean age at graduation of doctoral graduates by career pathway following the immediate completion of the doctorate.

Table 22 Mean age at graduation of doctoral graduates by employment status within the first year of completing the doctorate

	Not employed – studying full time		Employed while studying	
	Mean	n	Mean	n
Accepted a postdoctoral research position	33	938	37	295
Found employment within the first year of completing degree	34	514	39	178
Was not economically active due to family care responsibilities (e.g. household duties, child rearing)	36	26	38	13
Could not find employment within the first year after completing degree	37	103	42	35
Changed employers	38	134	41	541
Remained with the same employer (organisation/ institution/ business)	40	588	43	2 574
Was not economically active for other reasons (e.g. retirement, health)	56	12	59	14

The results in Table 22 are presented in descending order for full-time students from the youngest to oldest. If we ignore the results in the two groups who were economically inactive (given the small numbers), the salient findings are not unexpected.

- The overall trend is that the mean age of students who studied part time (most South African doctoral graduates) is higher (ranging between two and five years) than those who studied full time, in every category.
- The youngest age cohort for both full-time and part-time studies pursued a postdoctoral position immediately after completing their studies. This group (n=514) arguably constitutes the typical and expected career trajectory of early career academics who complete a PhD and are then immediately offered a postdoctoral fellowship. The older group (n=178) is less typical, as these are postdoctoral fellows who completed their doctoral studies while working and hence are on average five years older than the first group by the time they accept a postdoctoral fellowship.
- By far the single largest group in this table are those graduates (n=2 574) who remained with the same employer where they worked while studying – the majority of these would be junior academics who are enrolled for PhDs to advance their academic careers. It is concerning that the members of this group were on average 43 years old when completing their doctoral studies. It is difficult to describe these group as "emerging scholars" or "early career" academics when they are already in their forties.

5.2.2. Employability trends and differences between black and white students

Given the transformation imperative in higher education, we are interested in exploring whether there are differences in the employability of black and white doctoral graduates. For the purposes of our analysis we "collapsed" race into two groups: (1) black, comprising black African, coloured and Indian/Asian students, and (2) white students.

Figure 30 below shows that there are few differences in the employment status of black and white graduates who had studied full time within the first year of completing their doctoral degrees. Slightly more black graduates than white graduates (6% compared to 4%) indicated that they could not find employment within a year after graduation. This difference is not statistically significant.

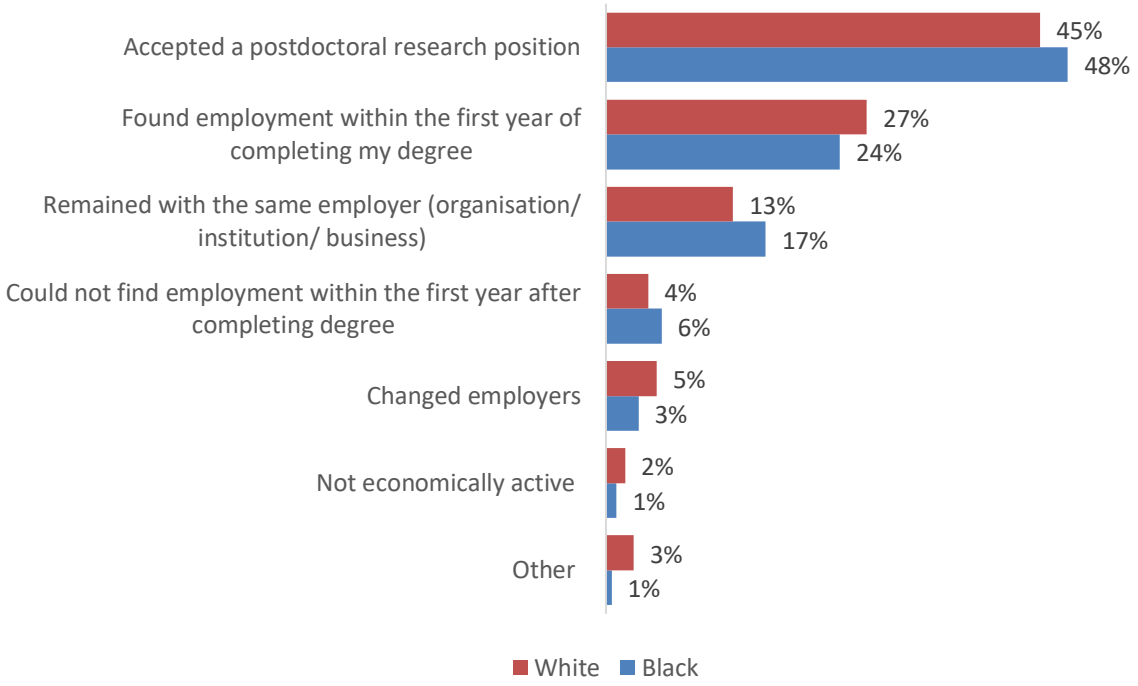


Figure 30 Employment status of full-time black and white graduates within first year after graduation

In Figure 31 below we illustrate the immediate employment status of graduates who had studied part-time. For both full-time and part-time graduates, there were no significant differences between white and black graduates as far as accepting a postdoctoral position after completion of their doctoral studies was concerned (see also Table 23). There were statistically significant differences [13] for graduates who were employed during their doctoral studies. White graduates were more likely to remain with the same employer/organisation (75% compared to 68%), while black graduates were more likely to change employers (18% compared to 13%).

[13] Among part-time students, there are statistically significant differences (at 0,05) in column percentages between black and white respondents who indicated that they (i) changed employers is within the first year after graduation, (ii) could not find employment within the first year of graduation, and (iii) remained with the same employer/organisation after graduation. Results are based on two-sided tests.

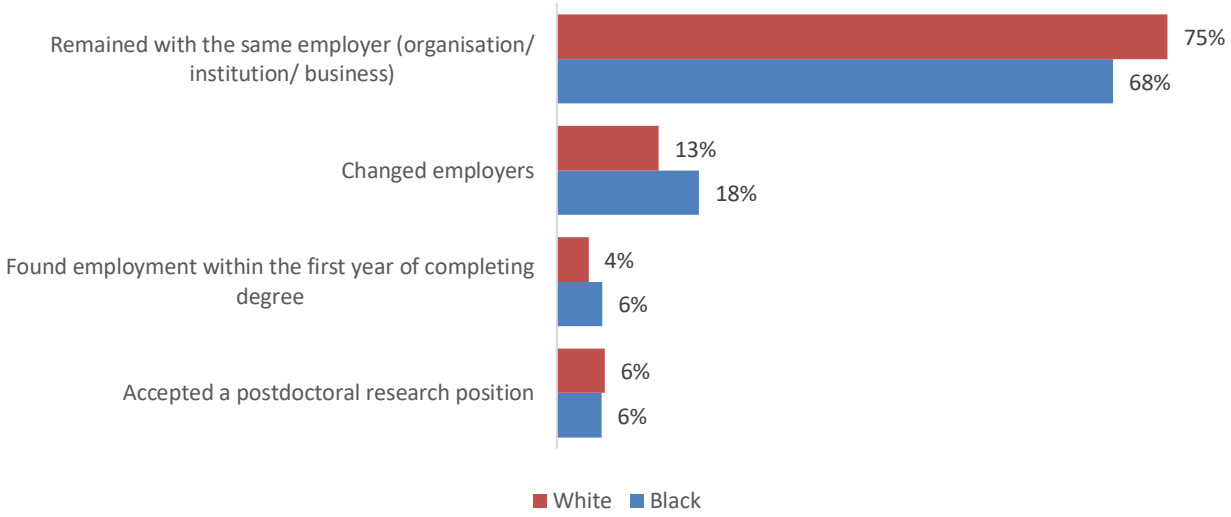


Figure 31 Employment status within first year of graduation of part-time black and white graduates

Table 23 Employment immediately after PhD graduation for black and white graduates

	Not employed – studying full time				Employed while studying			
	Black		White		Black		White	
	n	%	n	%	n	%	n	%
Accepted a postdoctoral research position	202	48%	282	45%	50	6%	83	6%
Changed employers	14	3%	33	5%	159	18%	175	13%
Could not find employment within the first year of completing degree	24	6%	27	4%	14	2%	8	1%
Found employment within the first year of completing degree	102	24%	169	27%	51	6%	55	4%
Remained with the same employer (organisation/institution/business)	70	17%	82	13%	623	68%	1 054	75%
Not economically active	5	1%	12	2%	5	1%	8	1%
Other	2	1%	19	3%	8	1%	20	1%

The results presented above show that black, part-time graduates were more likely to change employers, than their white counterparts upon completion of their doctoral qualifications. In Table 24 we show where these graduates went and whether they moved between sectors when they changed employers after completing their doctoral studies. In the table below we show the number of black, part-time graduates who indicated that they changed employers after their PhD by the sector in which they were employed during their PhDs (rows) and the sector in which they were employed at the time of the survey (column). The grey cells indicate the number of graduates whose employment during PhD and current employment were in the same sector. When we look at movement between sectors, we find that larger numbers of black graduates moved into the higher education sector (18 from the government/public sector, 10 from the business sector, nine from the non-profit sector, and 18 from the "other" education sector, such as schools). It is positive that black doctorates are taken up by the higher education sector, where a number of national programmes (such as nGAP) are supporting the academic careers of black graduates.

Table 24 Intersectoral mobility of black, part-time graduates who changed employers on completion of doctorate

		Sector of employment **during PhD**				
		Higher education	Government / Public	Business enterprise	Private non-profit	Other education
Sector of **current** employment	Higher education	71	18	10	9	18
	Government/public	11	18	1	0	2
	Business/industry	5	0	8	1	0
	Private non-profit	2	6	1	0	0
	Other education	2	0	0	0	2

5.2.3. Field differences in changes in employment status

We continue our discussion on the career trajectories of graduates upon completion of their doctoral degrees. Given that we have already established that there are large differences between the STEM and SSH fields in terms of full-time and part-time study, we wanted to find out whether these field differences also affected the employment status of graduates. The results in Figure 32 and Table 25 are as expected. Graduates in the social sciences and humanities – the majority of whom studied part-time while employed in academia – were more likely to remain with the same employer immediately following graduation (60%, n=1 808) than their counterparts in the STEM fields (45%, n=1 358). Conversely, we found that graduates in the STEM disciplines – most of whom were studying full-time – were more likely to accept a postdoctoral position (28%, n=855) compared to graduates in the SSH (12%, n=377).

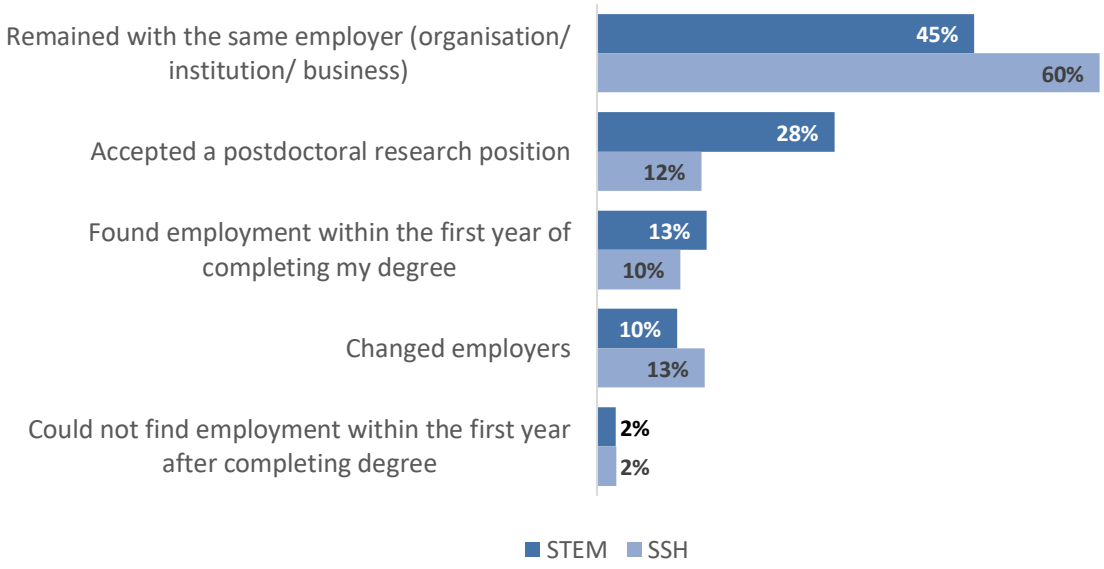


Figure 32 Employment status of respondents within the first year of graduation by STEM and SSH fields

Table 25 Employment status of respondents within the first year of graduation by STEM and SSH fields

	STEM		SSH	
	n	%	n	%
Remained with the same employer (organisation/institution/business)	1 358	44,8%	1808	59,7%
Accepted a postdoctoral research position	855	28,2%	377	12,4%
Found employment within the first year of completing degree	393	13,0%	301	9,9%
Changed employers	287	9,5%	389	12,8%
Could not find employment within the first year of completing degree	68	2,2%	70	2,3%
Other	33	1,1%	33	1,1%
Was not economically active due to family care responsibilities (e.g. household duties, child rearing)	20	0,7%	19	0,6%
Was not economically active for other reasons (e.g. retirement, health)	10	0,3%	16	0,5%
Opened own practice/self-employment	10	0,3%	16	0,5%

5.2.4. Alignment between current employment and field of doctoral expertise

The results discussed thus far have shown that the majority of South African doctoral graduates are employable. A very small percentage (2 to 3%) do not find employment immediately following the completion of their doctoral studies. Being able to quantify the exact percentage of doctoral graduates who are not immediately employable is a major contribution to our understanding of the state and dynamics of the labour market for doctoral graduates in the country. In our discussion thus far, however, we have not yet addressed more qualitative aspects related to employment. Although it is positive that most South African doctoral graduates are employed or employable at the time of graduation, we need to know more about the nature of this employment, and specifically the alignment between the expertise and skills gained during doctoral studies and the demands and requirements of specific positions.

Our survey included a number of questions that address these issues. One question in the survey asked respondents to indicate whether they were able to find a position directly related to their field of expertise/technical skills. The results show that the majority (70%) of respondents indicated that they found employment directly related to their fields of expertise or training. However, it is also interesting that nearly one in five (18%) of respondents (n=901) indicated that they could **not** find an employment position related to their field of expertise, as illustrated in Figure 33.

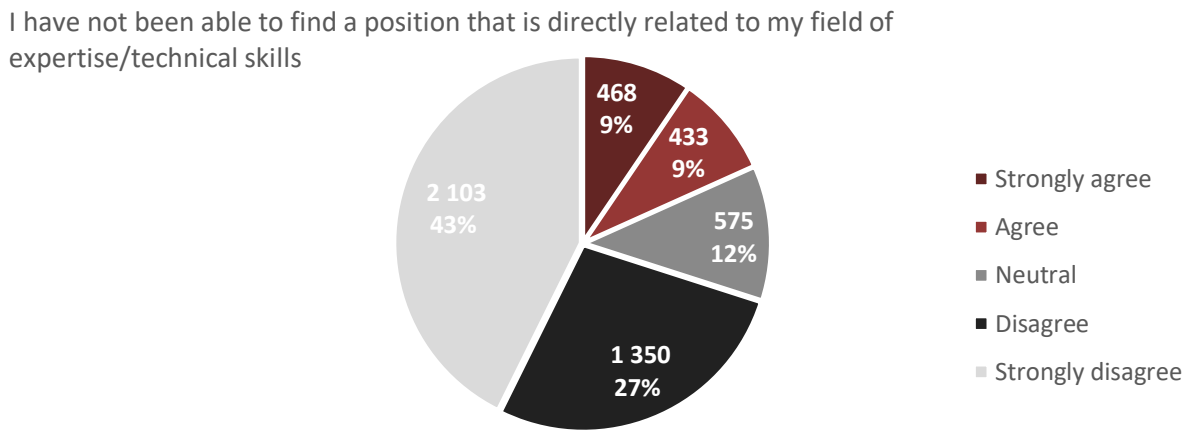


Figure 33 Ability to find employment related to field of expertise (n=901)

Since the results in Figure 33 represent the average responses over the entire period between 2000 and 2018, we decided to investigate further in order to establish whether there had been a shift over time. The results, as presented in Table 26, show that graduates who received their doctoral degrees in the past five years were more likely (22%) than those who received their degrees more than 15 years ago (13%) to indicate that their current job or position is **not** related to the field of expertise of their doctorate. These results raise questions about policy – even though South African doctoral graduates are successful in finding employment they are increasingly indicating that the employment is not what they expected or wanted.

Table 26 Difficulty in finding employment directly related to field of expertise

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
	n	%	n	%	n	%	n	%
Agree	89	13.1%	133	13,5%	274	19.7%	353	22,7%
Neutral	75	11.1%	103	10,4%	156	11.2%	202	13,0%
Disagree	514	75,8%	751	76,1%	962	69,1%	1 000	64,3%

In Figure 34 below we compare whether black and white graduates experienced differences in finding employment directly related to their doctoral studies. The results show that 22% of black graduates felt that they could not find employment directly related to their studies compared with 18% of white students. Conversely, 70% of white respondents did not feel that they experienced difficulty in finding relevant employment compared to 66% of black respondents[14].

[14] The differences in column percentages between black and white respondents who strongly agreed are statistically significant at 0,05. Similarly, the differences in column percentages between black and white respondents who indicated that they strongly disagreed are statistically significant at 0,05. Results are based on two-sided tests.

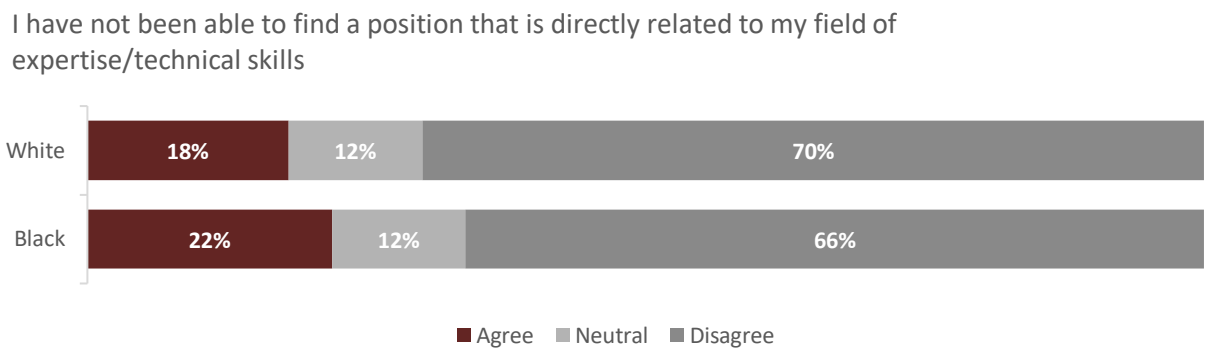


Figure 34 Difficulty in finding employment directly related to field of expertise by race

Figure 35 below shows the results of the statement in relation to finding a position directly relate to fields of expertise, by scientific domains. The results show that 21% (n=100) of respondents in education reported difficulty in finding employment linked to their technical skills, 21% (n=150) in the humanities and arts, followed by 19% (n=151) in the social sciences. The data therefore show that graduates in the social sciences and humanities reported more challenges in finding suitable employment compared to graduates in the STEM fields.

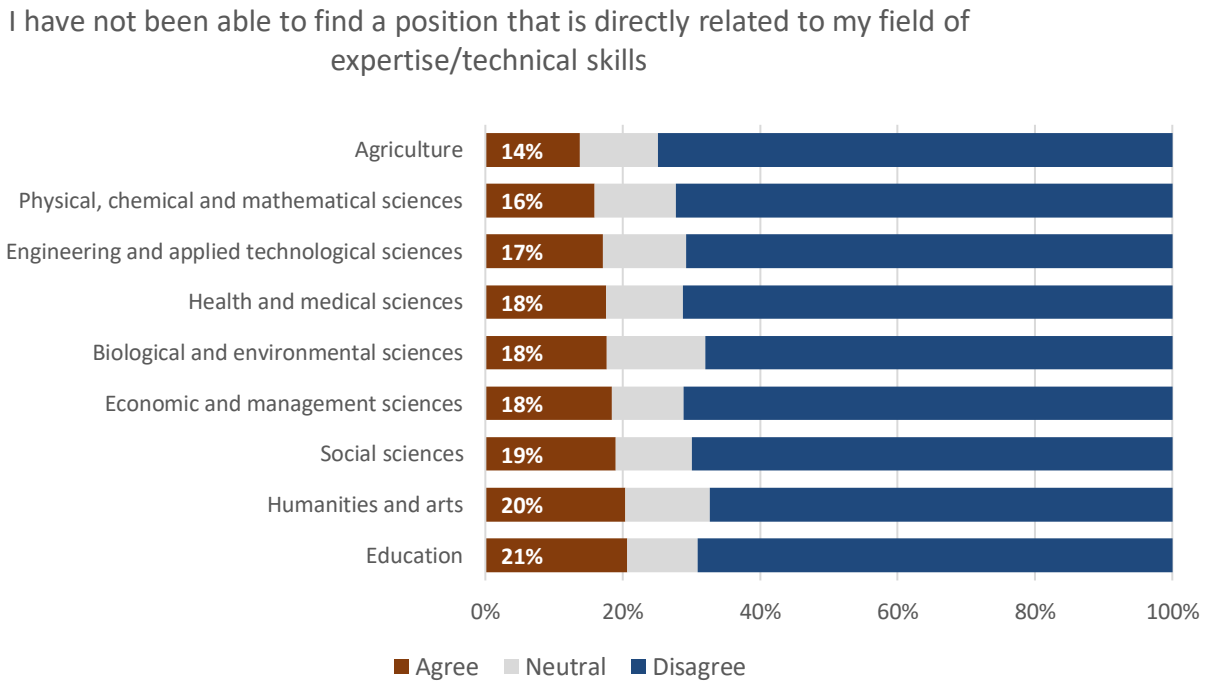


Figure 35 Difficulty in finding employment related to field of expertise by domain

When asked about their most recent/current employment position, 27% (n=1 457) respondents indicated that their current employment was the only option available, as shown in Figure 36.

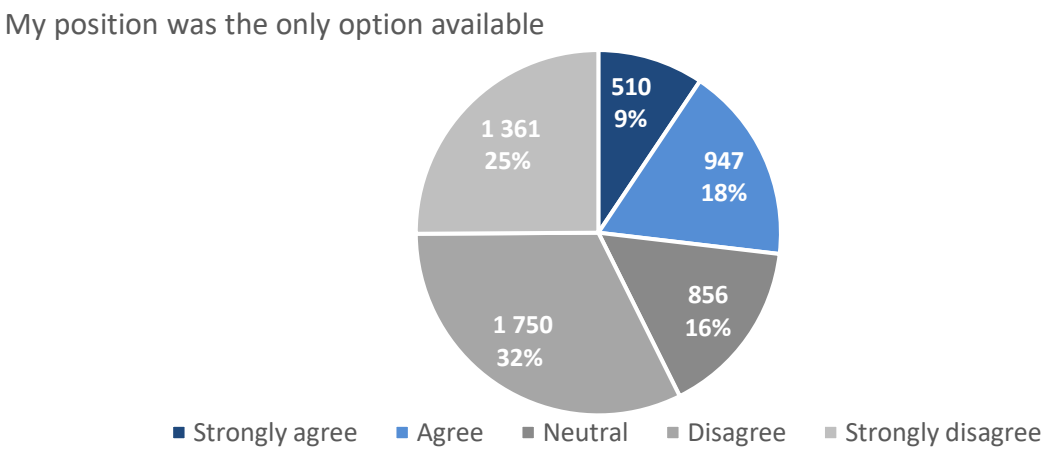


Figure 36 Availability of options other than current employment position

We disaggregate these results by race to investigate whether there are differences in the challenges of finding employment between black and white graduates. Figure 37 shows that black graduates were more likely to select "agree" or "strongly agree" to the statement that employment found within the first year of graduation was the only option available (31%), compared to white graduates (26%)[15] (the categories "agree" and "strongly agree" were collapsed into "agree", while "disagree" and "strongly disagree" were collapsed into "disagree").

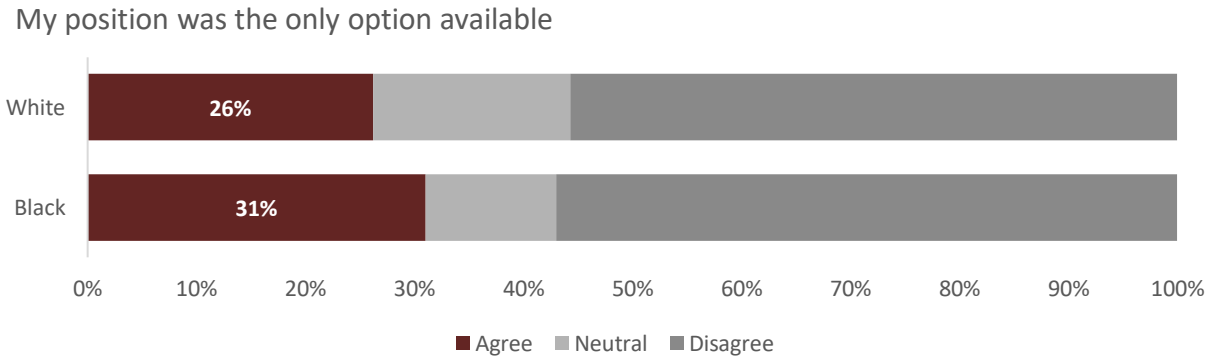


Figure 37 Availability of options other than current employment position by race

These findings, along with others reported above, suggest that black graduates were more likely to experience challenges in finding employment and reported greater difficulty in finding employment directly related to their doctoral qualifications.

When we look at graduates who reported difficulty in finding skills-related employment, we argue that the findings are meaningful when we disaggregate the responses by graduation window (Table 27).

[15] Pearson chi-square = 23,424, df = 2, p=0,000. The differences in the column percentages between respondents who selected "agree" are statistically significant at the 0,05 level and the results are based on the two-sided tests.

Table 27 A third of recent graduates reported their current employment position as the only one available (n=564)

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
	n	%	n	%	n	%	n	%
Agree	145	19,6%	219	20,3%	430	27,9%	564	32,9%
Disagree	475	64,1%	691	64,0%	839	54,5%	900	52,5%
Neutral	121	16,3%	170	15,7%	270	17,5%	249	14,5%

The results show that **one third** of recent graduates indicated that their employment was the only option (compared to 20% of graduates 10 to 19 years ago). The fact that 33% of recent graduates indicated that they took a job because it was the only option available suggests that the labour market for certain kinds of doctoral qualifications may already be saturated. It may also suggest – as a corollary – that certain forms of employment have become more specialised and interdisciplinary, making doctoral degrees in some fields increasingly irrelevant or even redundant.

In the next section we report on the results of the qualitative interviews. As is shown in the discussion in the next section, it is clear that some graduates (especially in the natural sciences) found it increasingly difficult to find employment that aligns with their doctoral degree – especially in applied fields and in industry. In the worst-case scenario, this forced graduates to look for employment outside South Africa.

5.2.5. Challenges in finding employment

Interview respondents were asked to reflect on the types of challenges they had experienced in finding employment, where relevant, and/or to make any general observations about employment opportunities for PhD graduates in their field or sector. In this section we capture some of the main issues highlighted.

Individuals on the academic track – in other words, who were either working at a university or had previously sought a position within academia – pointed to the limited posts available in the higher education sector and indicated that, in some fields at least, obtaining academic positions is highly competitive.

> *When I talk to the Dean and the Vice Rector, they both reckon they really would like to keep me here. You know, the … research also got the university in very high profile international newspapers and BBC and so it's making the institution look good. So, they want to keep me but they don't have a position for me. Or they could open an associate researcher position for me next year, but I need to get my own funding for it.* (Entrepreneur)
>
> *A lot of them [PhD students] like to think that they would also like to be in the academic field, but you might know that in the academic field, there [are] not a lot of position openings, so they have to go into industry.* (Senior lecturer at a university)
>
> *I think career prospects – getting into a career in academia – are not good, because it's so competitive. And in my own case, a lot of it is time and place, and a little bit of luck here and there, and opportunities that you get … Obviously, one has to work hard, and you have to have the CV, and that sort of helps, but that's not a guarantee. You can be an excellent scientist, with a fantastic publication record and still be without a job. So, certainly, from that perspective, it's not great.* (Senior lecturer at a university)

One interviewee, who had moved from zoology to the health sciences, pointed to the loss of high

potential candidates because of the squeeze on academic or research posts and the lack of flexibility universities have to create posts as and when required.

> *I think in the health sciences there are many more research opportunities compared to the natural sciences. So I think that's the one positive is that there's a lot of space to continue research and to become a principal investigator. I think the one barrier is that the number of research posts and the slow growth of an institution like [the University of Pretoria]. UP is so huge, and it's so difficult to create new posts and new space for researchers. I think that's the barrier that we've got at the moment. I think that it would be beneficial if we could create research posts sort of on the fly, if we can identify young researchers or middle-aged researchers that have a lot of potential to drive their own research and make room for them and give them the resources that they need. That would improve research and increase the number of opportunities as well*. (Scientific writer at a university)

Challenges were also reported with regard to PhD holders who sought employment outside of academia. It appears that positions for scientists or researchers in other sectors such as government or industry are also in short supply. Some respondents commented on differences in specific disciplines.

> *Moving out of tertiary education to jobs, there are obviously [many] fewer opportunities. I guess it depends on what you look at. So the marine NGO sector is quite big. There are options within that area. There [are] lots of consultancies as well that deal with marine-like issues. And then obviously, there's big government departments. And in places like the research institutes and then the universities. So if you want to get into academia, or the academic and pure research side of marine biology, then I think the options are fewer. But as soon as you get into more applied things, like the conservation NGOs or the environmental consultants or the fisheries managers, then there are quite a few more options available.* (Researcher in a government-funded research institute)
>
> *I love zoology. I would still stay in that but the job opportunities aren't that massive. If I had relooked at it I would probably have gone the chemistry line from a labour market point of view. There is far more scope. If you're a zoologist, you're either going to be an academic, you could end up in a museum as a collection specialist, or you're going to end up in an environmental consultancy. I was more interested in staying in my field. When you start getting into consultancies, you really hardly ever tend to work in your actual field.* (Principal scientist in a science council)
>
> *Currently for PhDs in chemistry, and I feel very guilty about this, I'm always encouraging students to study, whether it's chemistry, whether it's anything, I'm always preaching that. But I'm telling you, I know people who have PhDs in chemistry who have not been able to find a job for a year or two years. It really frustrates me because our government says we need PhD students for these jobs. I actually feel so bad, recommending to people to do a PhD but people are not getting jobs, because there [are] only so many academic jobs and there [are] no jobs for PhDs in industry in South Africa.* (Senior lecturer at a university)
>
> *It's not like you do a PhD in accounting, or an MBA or whatever, and then you have the private sector to consider. There's not that much work in biology, or in biological fields, outside of governmental agencies. Except if it's very product-based, like pharmaceuticals and that sort of thing. Or in terms of pest control, or the chemical side of things, or becoming a sales rep for a science company.* (Independent researcher and content developer)

Some interview respondents also pointed to contexts within which having a PhD was regarded as a negative in terms of employment opportunities, and particularly in relation to jobs in the industry sector.

A number of interviewees referred to the fact that having a PhD could create the perception that a person was "overqualified". In this regard, it seems the concern was the doctorate holder would still require on-the-job retraining and/or demand too much in terms of income.

> *It's not easy to get employment because you find that … companies, like private companies that deal with water … rarely hire people who have reached the level of PhD. They rather hire people who have attained their diplomas or degrees and then they train them at your job.* (Senior lecturer at a university)

> *I had a PhD in ecology and I thought environmental consulting, that seems like a very practical kind of area in which I could find a job. And I was horrified to discover that in environmental consulting, all they wanted was environmental lawyers or accountants or engineers. Anyone who has a PhD in ecology was considered overqualified. So then I started looking around a bit more and I kind of stumbled on to general management consulting. And they didn't really care what qualifications you had so long as you could learn their methodology.* (Professor at a university)

> *A PhD is a disadvantage if you want to go into industry to work. I think most jobs, they're not willing to take someone on a high level. They prefer someone at an entry level and then train you. It's assumed that if you have a PhD, you already know a lot and would expect to be paid more. At least that's my experience.* (Lecturer at a university)

> *I've never practically experienced that. But my husband, he's also got a PhD in microbiology. Often when he applied for positions, it's like, oh, you're overqualified, we're not going to interview you because we can't pay you what we presume you're going to want.* (Researcher in a government department)

> *Once, when I went for interview, I was asked why somebody with a PhD would apply for a job like this. So, in some cases people think you're overqualified for a job. And I just keep on motivating that that's my passion. That's what I really want to do. The doctorate was just a research project. Three years of my life that I dedicated to completing [my PhD] – that doesn't make me a different person. It's just the skills that I have from the time that I spent on the research. So I think a lot of people, the common public, have a misconception about the PhD.* (Market lead for a private enterprise)

In some instances, the kind of challenges highlighted above resulted in individuals moving into employment trajectories unrelated to their chosen (PhD) field. In others, as we know, the result is that scientists leave South Africa for opportunities abroad. As one respondent remarked:

> *Scientists are leaving the country. There [are] a lot of scientists that actually can't get jobs. I see a lot of youngsters getting into the field and I don't even know where they're going to get jobs because there aren't any.* (Senior researcher in a government department)

Finally, as would be the case in any scenario, younger PhD graduates can struggle to find employment because they lack previous work experience. They might also lack the capacity to work out how to translate their very specific topics or skill sets into more generalised or transferable assets that could be of value in the labour market – particularly outside of academia. One respondent described this as follows:

> *I think PhDs often struggle with imagining themselves outside of this concentrated area that they've spent a few (two, three, four, five) years working on a PhD, that I can't move because I would be wasting that knowledge. Yes, that knowledge, I don't think seeing it as specialist knowledge in that area that's useful rather than the skills that you have learned in that area that can be applied in other disciplines or in another position.* (Director in provincial government)

Salient findings on the employment of graduates *during the first year after completion* of the PhD

1. More than half of graduates remained with the same employer within the first year of completing their doctoral studies. The overwhelming majority of these respondents were already employed full time in the higher education sector during their doctoral studies.
2. Graduates in the SSH were more likely to remain with the same employer during the first year after graduation than their counterparts in the STEM fields.
3. One in five respondents indicated that they accepted a postdoctoral fellowship on completion of their studies. Graduates in the STEM fields were twice as likely to accept a postdoctoral fellowship after graduating.
4. Only 2% (n=138) indicated that they could not find employment within the first year of completing their doctoral degree.
5. Our results show that doctoral graduates are by and large employable, but that graduates in the social sciences and humanities were more likely to experience challenges in finding employment directly related to their fields or expertise or technical skills compared to graduates in the STEM fields.
6. Our findings suggest that black graduates are more likely to experience challenges in finding employment and reported greater difficulty in finding employment directly related to their doctoral qualifications.
7. Recent graduates reported more difficulty in finding employment directly related to their field of expertise than students who graduated 10 to 19 years ago. This result, coupled with the finding that one third of recent graduates indicated that their current employment was the only job they could find, may be an early warning that future graduates will find it increasingly difficult to find employment in areas where their newly acquired knowledge and skills are appropriately used and recognised.

5.3. Current employment: status and type

In this final section we describe doctorate holders' employment status/position at the time of completing the survey.

5.3.1. General profile of the current employment of respondents

The majority (82,4%) of our respondents indicated that they were employed, defined as performing work for a wage or salary, at the time of completing the survey.

Table 28 shows that a small percentage (3,5%, n=241) indicated that they were not economically active, while 8,7% (n=530) reported being self-employed. Slightly more than 5% (n=321) of respondents held a postdoctoral fellowship at the time of the survey.

Table 28 Employment status of doctorate holders at the time of completing the survey

	n	%
Employed (performing work for a wage or salary)	4 994	82,4
Self-employed (working for myself as a freelancer or the owner of a business rather than for an employer)	530	8,7
Has a postdoctoral fellowship	321	5,3
Not economically active but have been employed or self-employed at some stage after my doctoral degree	153	2,5
Not economically active and this has been the case since completion of my doctoral degree	61	1
Total	6 059	100

In order to establish whether this general picture has changed over the past two decades, we disaggregated the results by year of graduation of our respondents as illustrated in Figure 38 and Table 29. It is clear from the results that the general picture applies to the first three subgroups of respondents, who graduated between 2000 and 2014. Since 2015 there have been some changes. We witness a decline in the percentage of respondents working for an employer (from 84% in 2015 to 74% in 2018). This trend coincides with a concomitant increase in the percentage of respondents in postdoctoral fellowship positions, from 6% in 2015 to 17% in 2018. These trends would suggest that it has become increasingly difficult for doctoral students in recent years to find permanent employment. We also discuss this topic in Chapter 6.

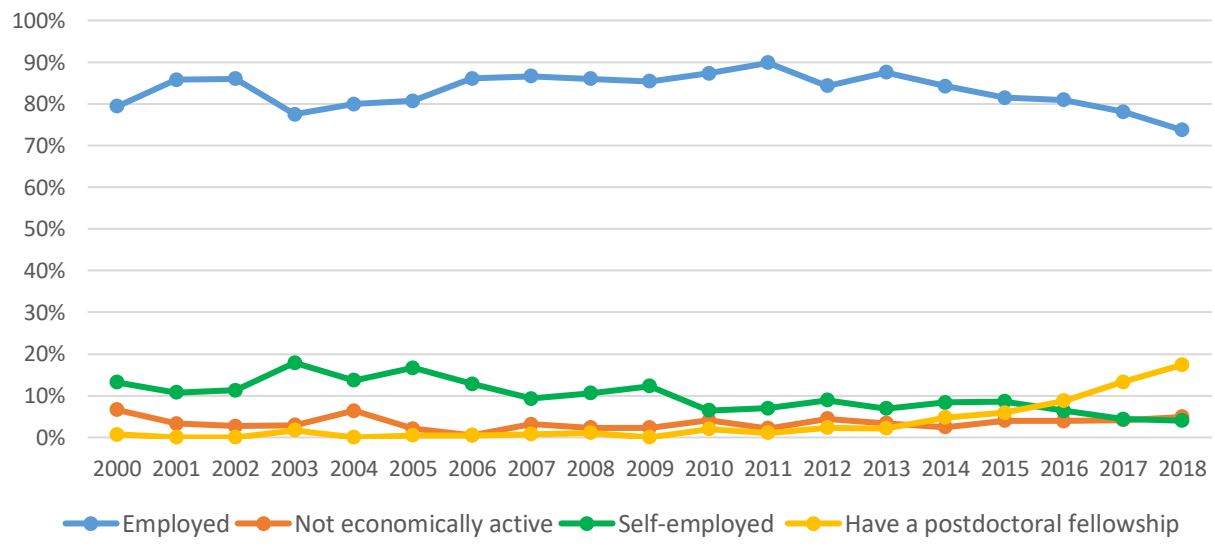


Figure 38 Current employment status by graduation year

Table 29 Current employment status of doctoral graduates by graduation window

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
	n	%	n	%	n	%	n	%
Employed (performing work for a wage or salary)	668	81,6%	980	85,1%	1452	86,4%	1579	78,4%
Self-employed (working for myself as a freelancer or the owner of a business rather than for an employer)	111	13,6%	139	12,1%	128	7,6%	117	5,8%

	2000 to 2004		2005 to 2009		2010 to 2014		2015 to 2018	
Not economically active and this has been the case since completion of my doctoral degree	3	0,4%	4	0,3%	14	0,8%	37	1,8%
Not economically active but have been employed or self-employed at some stage after my doctoral degree	33	4,0%	21	1,8%	42	2,5%	49	2,4%
Has a postdoctoral fellowship	4	0,5%	7	0,6%	44	2,6%	231	11,5%

When we consider differences between white and black graduates we find that nearly 90% of black graduates – compared to nearly 80% of white graduates – worked for an employer (for a wage or salary) at the time of the survey. The results in Figure 39 also show that white graduates (13%) are more likely to be self-employed (working for themselves as a freelancer or the owner of a business rather than for an employer) than black graduates (4%)[16].

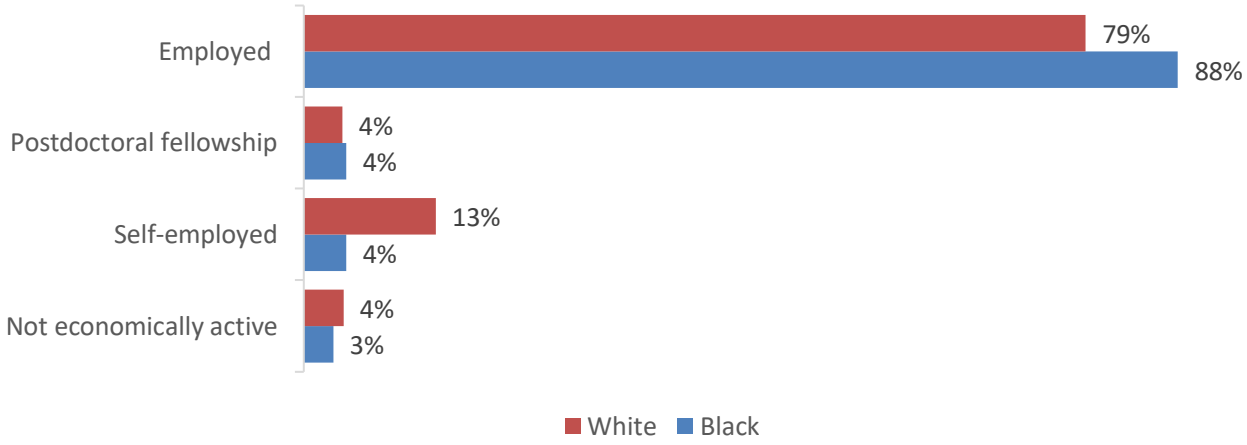


Figure 39 Likelihood of graduates being self-employed at the time of the survey by race

The general picture that emerges when we disaggregate the respondents' current employment position by STEM and SSH fields (Figure 40) reveals only a few, small differences. Respondents in the social sciences and humanities were more likely to be self-employed (10,5%, n=318) than the respondents in the STEM disciplines (7%, n=211). We also see that graduates in the STEM fields are more likely to accept a postdoctoral position than those in the SSH.

[16] The differences in column percentages between black and white respondents working for an employer are statistically significant at 0,05. Similarly, the differences in column percentages between black and white respondents who are not economically active or who are self-employed are statistically significant at 0,05. Results are based on two-sided tests.

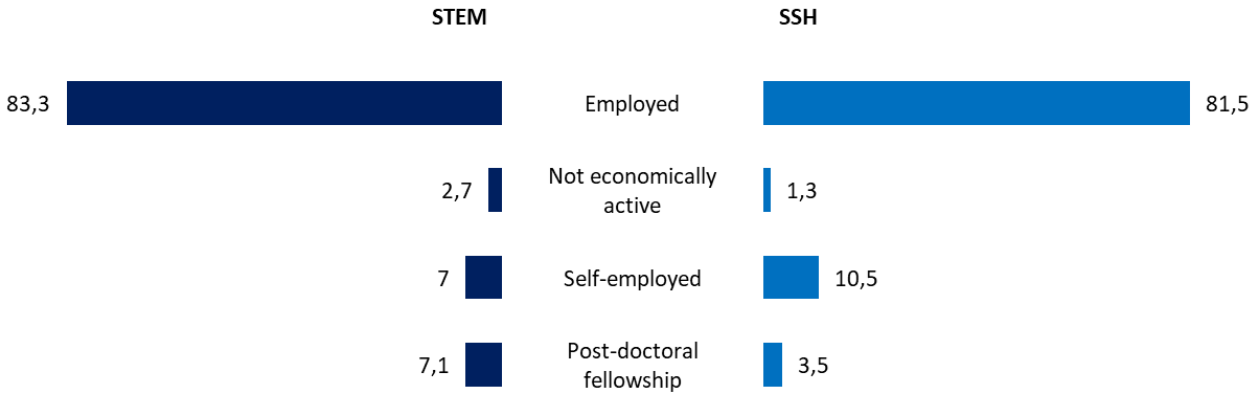


Figure 40 Comparison of STEM and SSH graduates by current form of employment

The results in Figure 40 are further disaggregated by science domain, displayed in Figure 41 and summarised in Table 30 below. It is worth commenting on the higher proportions of subgroups of graduates who are self-employed in engineering, the social sciences, and economic and management sciences. Respondents who were self-employed were asked to provide details of their current employment. For graduates in engineering, "self-employment" typically refers to having their own companies and engineering consulting firms; for graduates in the social sciences and economic and management science, self-employment typically refers to some professional practice (such as psychotherapy, tax consultancy, life coaching, research or training consultancy).

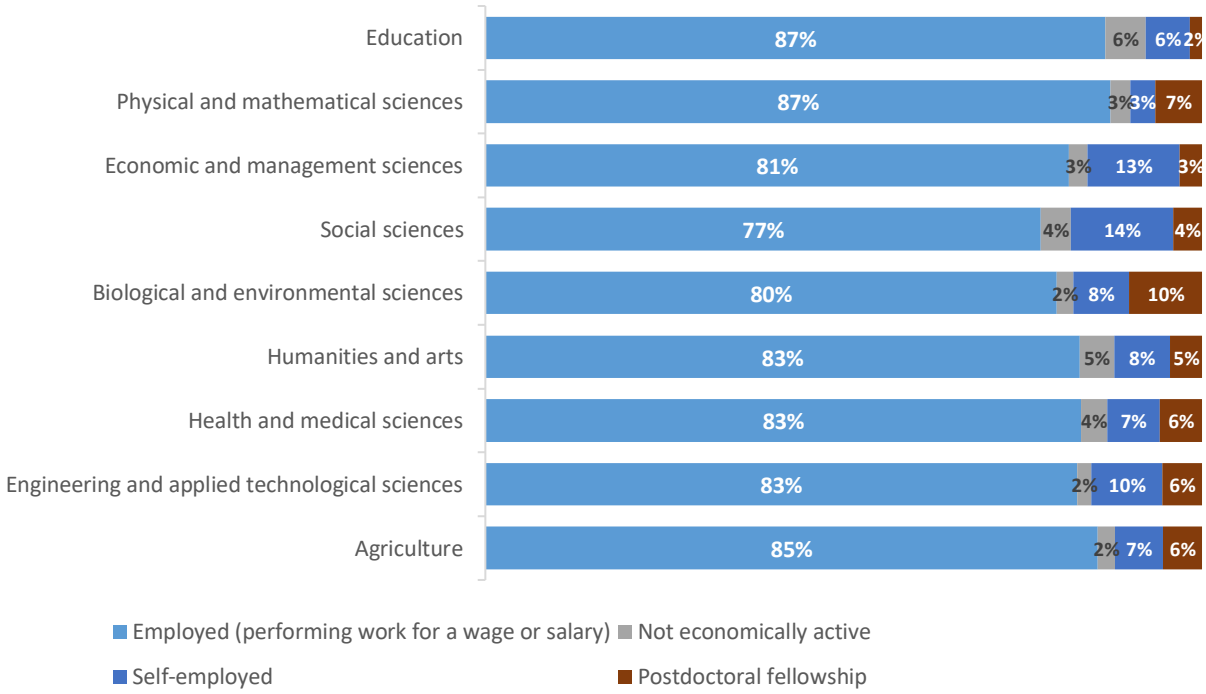


Figure 41 Current employment status of doctoral graduates by scientific domain

Table 30 Current employment status of doctoral graduates by scientific domain

	Agriculture		Engineering and applied technological sciences		Health and medical sciences		Humanities and arts		Biological and environmental sciences		Social sciences		Economic and management sciences		Physical, chemical and mathematical sciences		Education	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Employed (performing work for a wage or salary)	216	85,4%	386	82,7%	580	83,1%	767	82,8%	620	79,7%	740	77,4%	528	81,4%	650	87,2%	501	86,5%
Self-employed	17	6,7%	46	9,9%	52	7,4%	72	7,8%	61	7,8%	136	14,2%	83	12,8%	25	3,4%	36	6,2%
Postdoctoral fellowship	14	5,5%	26	5,6%	41	5,9%	42	4,5%	79	10,2%	39	4,1%	21	3,2%	49	6,6%	10	1,7%
Not economically active but have been employed or self-employed at some stage after doctoral degree	6	2,4%	5	1,1%	16	2,3%	31	3,3%	12	1,5%	32	3,3%	10	1,5%	18	2,4%	23	4,0%
Not economically active and this has been the case since completion of doctoral degree	0	0,0%	4	0,9%	9	1,3%	14	1,5%	6	0,8%	9	0,9%	7	1,1%	3	0,4%	9	1,6%

5.3.2. Sector of most recent employment position and mobility between sectors

Survey respondents were asked to indicate in which sector they were employed at the time of completing the survey (they could select more than one option). The results in Figure 42 show that nearly two thirds (68%, n=4 079) were employed in the higher education sector at the time of completing the survey, followed by near equal percentages (11%) in the government/public sector (n=697), and business (n=696). The remainder were employed in the private non-profit sector (7%, n=402) or education sector (2%, n=110; predominantly positions in schools).

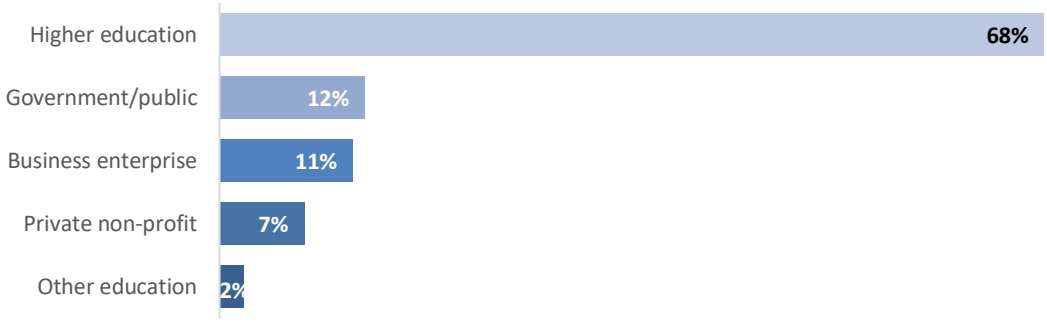


Figure 42 The majority of doctoral graduates are currently employed in the higher education sector (n=5 984)

When we further investigate where doctoral graduates are employed, we see that 59% (n=3 647) of graduates indicated that their employment at the time of the survey was in South Africa. Approximately 4% (n=229) of graduates reported that they were employed at a South African government department or entity. This includes national, provincial and local government departments. When we look at the uptake of doctoral graduates in the South African science councils (including the SAMRC, WRC, Council for Geoscience [CGS], NRF, Agricultural Research Council [ARC], Council for Scientific and Industrial Research [CSIR] and HSRC) we find that 2,5% (158) of graduates were employed at a South African science council. In Figure 43 below we see that of graduates working at South African science councils, 30% were employed at the CSIR (n=48), followed by 15% at the ARC (n=23), 13% at the NRF (n=20) and 12% (n=19) at the HSRC. We see smaller number of graduates working at the SAMRC, CGS and WRC.

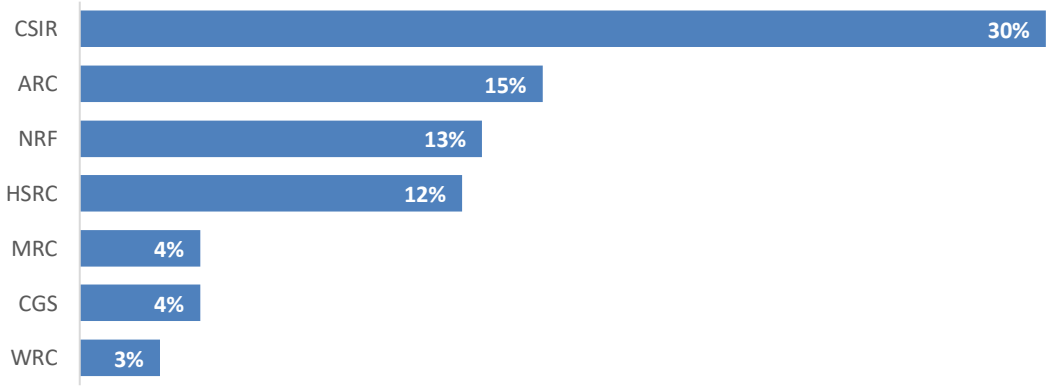


Figure 43 Doctoral graduates employed at South African science councils

Nearly half of all graduates who held employment at a South African science council received their

doctoral qualification in the natural sciences (49%). In Figure 44 below we see that graduates who received their doctoral qualification in the natural sciences, including the biological and environmental sciences and the physical, chemical and mathematical sciences, were more likely to work at a South African science council than graduates in other fields. We find that the lowest numbers of graduates employed at a South African science council were graduates in education, the economic and management sciences, and the humanities and arts.

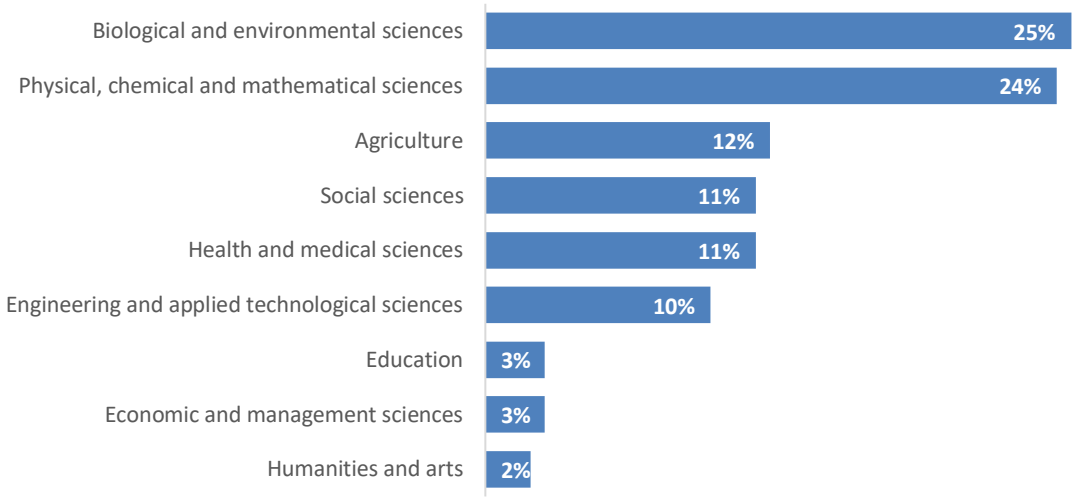


Figure 44 Graduates who work at South African science councils by scientific domain

Given that our survey asked graduates to indicate their sector of employment during their doctoral studies as well as their current (or most recent) sector of employment, we were able to estimate the mobility of our graduates between sectors over the past 19 years. Figure 45 below illustrates the intersectoral mobility of respondents.

The general trends are the following:

- Those who were already employed in academia (light green band) during their doctoral studies remained in the sector. Small percentages moved to the government/public sector, business and the other sectors. However, these "losses" were offset by "gains" from the public sector (which includes science councils) and business. The end result is a net gain for the higher education sector (66% currently employed in the sector compared to 61% of graduates in the sector during their studies).
- The government or public sector (orange band) witnessed an overall net loss, mostly through the migration of staff to universities. At the time of their studies, 15% of all graduates were employed in this sector; by the time of the survey, this percentage had decreased to 12%.
- No other significant changes in terms of the big picture occurred.

In the final analysis, the Sankey diagram shows a very "stable" system with minimal intersectoral mobility.

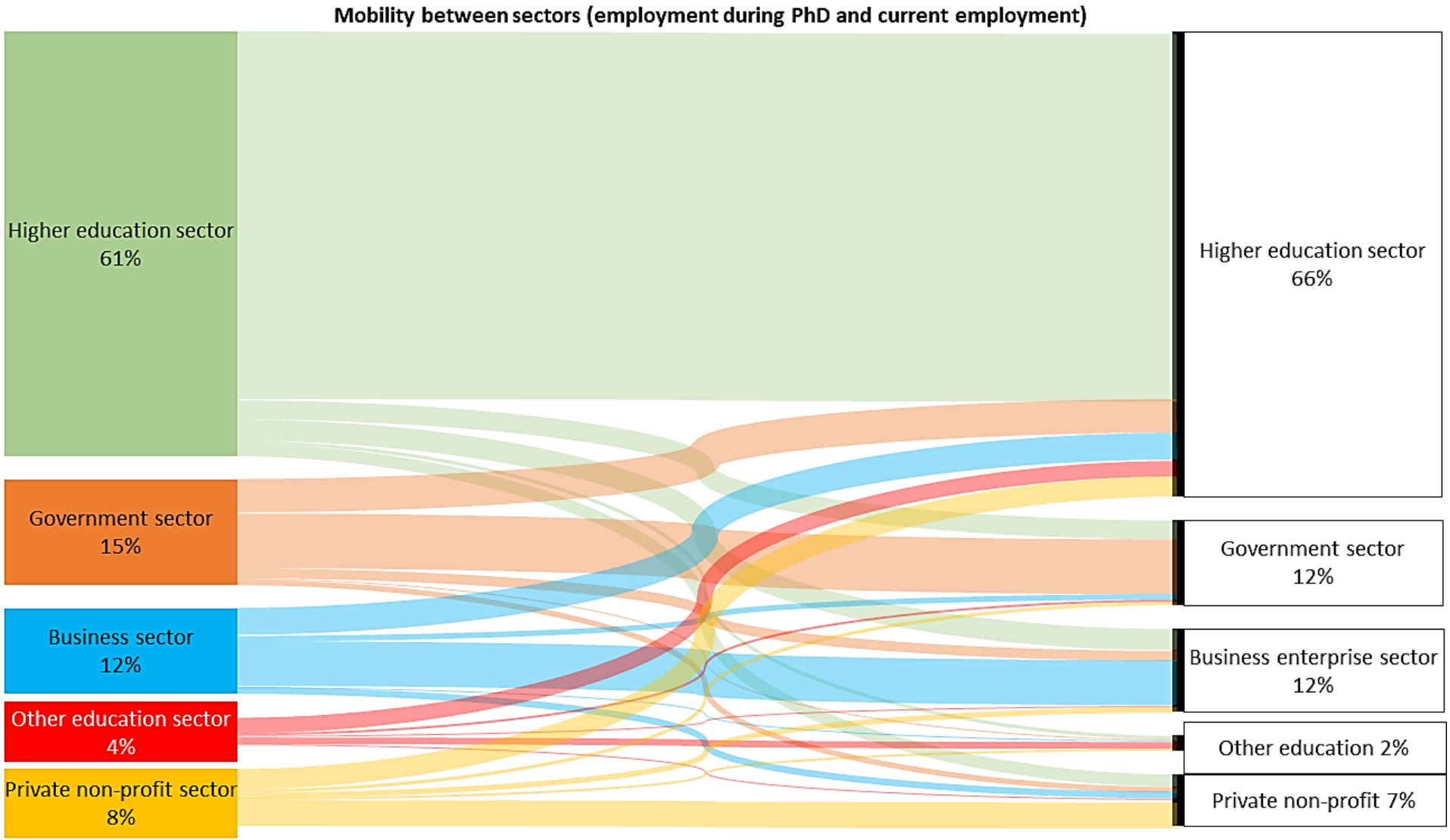


Figure 45 Mobility between sectors (employment during PhD and current employment

Table 31 provides more detail on the relative volumes of flow between each sector. For example, if we focus on outward mobility from the higher education sector, we see that the majority 86,3% (n=2 185) of respondents who were employed in the higher education sector during their doctoral studies were still employed in the higher education sector at the time of the survey. Small percentages moved to the business sector (5,1%), government sector (4%) and non-profit sector (2,9%).

Larger shifts are evident within the government sector (which includes the science councils, such as the CSIR, ARC and HSRC). More than half of graduates (54,7%) who were who were employed in the government sector during their doctoral studies remained in the sector. But a third (33,5%) moved to the higher education sector, followed by 10,4% who went to the business sector.

Looking at the third largest sector of employment of doctoral graduates – the business sector – over half of graduates (57,9%) remained in the sector. More than a third (35%) accepted a position in the higher education sector. Near equal percentages (8%) moved to government or went into the private non-profit sector.

In Table 32 we inspect whether there are differences in the sectoral mobility of black and white graduates. The results show that for respondents who were employed in the higher education sector during their doctoral studies there were no differences in intersectoral mobility. We see, however, that white respondents (26%) who were employed in the government sector while enrolled for their doctoral studies were more likely to change sectors than black respondents (19%) after completion of their qualifications. However, these differences are not statistically significant.

Table 31 Mobility between sectors of employment (from time of doing doctoral studies to current employment)

	Sector of current employment									
	Higher education		Government/Public		Business enterprise		Other education		Private non-profit	
Sector of employment during PhD	n	%	N	%	n	%	n	%	n	%
Higher education	2185	86,3%	113	4,0%	129	5,1%	20	0,8%	74	2,9%
Government/public	199	33,5%	325	54,7%	62	10,4%	6	1,0%	35	5,9%
Business	162	35,0%	36	7,8%	268	57,9%	8	1,7%	37	8,0%
Other education	94	54,0%	12	6,9%	9	5,2%	43	24,7%	8	4,6%
Private non-profit	122	39,0%	21	6,7%	30	9,6%	13	4,2%	153	48,9%

Table 32 Sectoral mobility of black and white graduates

	Higher education sector				Government sector				Business sector			
	Black		White		Black		White		Black		White	
	n	%	n	%	n	%	n	%	n	%	n	%
Changed sectors	52	9%	86	10%	36	19%	51	26%	15	20%	63	30%
Remained in the same sector	508	87%	763	86%	133	70%	124	63%	34	46%	102	48%
Nature of work is cross-sectoral	22	4%	40	5%	21	11%	22	11%	25	34%	46	22%

When we focus specifically on the migration of graduates from the higher education sector as disaggregated by STEM and SSH (Figure 46), we find small but statistically significant differences. Slightly more respondents in the STEM disciplines reported that they had changed sectors (10% compared to 7% in SSH)[17].

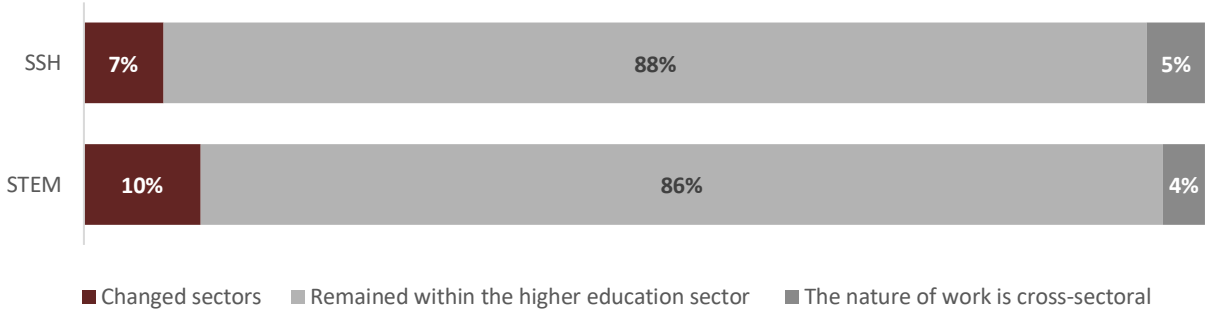


Figure 46 Mobility from the higher education sector

In summary: Those who were already employed in academia during their doctoral studies remained in the sector. Small percentages moved to the public, business and the other sectors. However, these losses were offset by gains from the government sector (which includes science councils) and business. The end result is a net gain for the higher education sector (66% currently employed in the sector compared to 61% of graduates in the sector during their studies). The government sector has witnessed an overall net loss, mostly through the migration of staff to the universities. At the time of their studies, 15% of all graduates were employed the public sector, but by the time of the survey, this had decreased to 12%. There were no other significant changes in the big picture. In the final analysis, the results reveal a very stable system with minimal intersectoral mobility.

5.3.3 Rating of current employment in terms of job security and income

Survey respondents were asked to rate a number of statements related to their current employment position in relation to its sector. The responses were recoded into three categories (agree, neutral and disagree) and the results for respondents who agreed with the following statements are illustrated in Figure 47 below. On the statement "my position offers better job security than positions in another sectors", 70% (n=2 794) of respondents who were employed in the higher education sector agreed. However, only 24% (n=958) of respondents in the higher education sector considered that their position offered higher income than positions in another sector.

[17] Pearson chi-square = 10,035, df = 2, p = 0,007

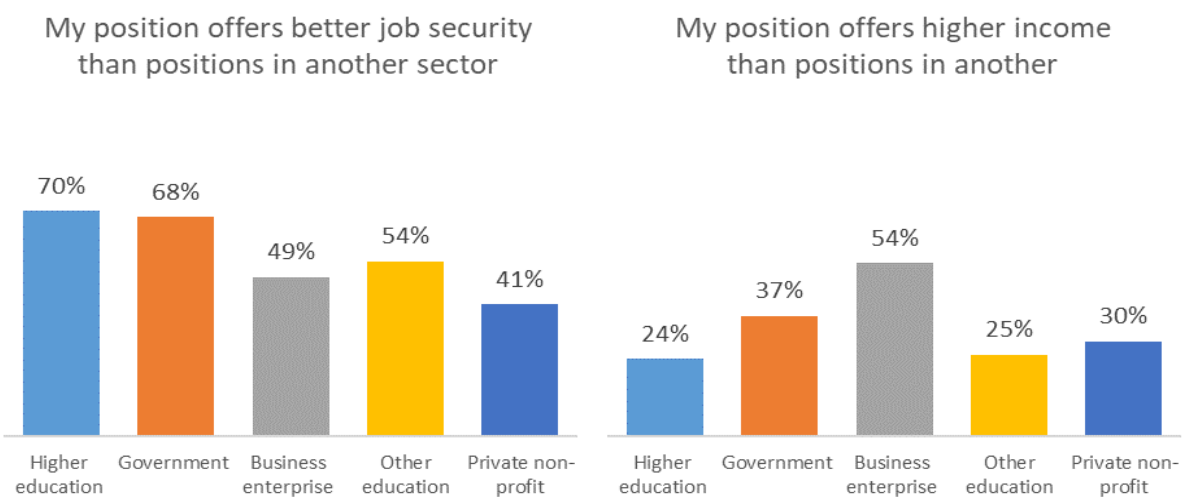


Figure 47 Perceptions of the importance of job security and high income by sector of employment

5.4. Summary of key findings

Salient findings on the employment status of doctoral graduates *within the first year after completing* their doctoral studies:

1. What happens to the doctoral graduate after completion of their studies is clearly a function of whether they are already employed and studying part time, or whether they are studying full time and hence not employed.
2. More than half of graduates remained with the same employer in the first year after completing their doctoral studies. Most of these respondents were employed full time in the higher education sector during their doctoral studies.
3. Graduates in the SSH were more likely to remain with the same employer during the first year following the PhD than their counterparts in the STEM fields.
4. One in five respondents indicated that they accepted a postdoctoral fellowship on completion of their studies. Graduates in the STEM fields were more likely to accept a postdoctoral fellowship.
5. Only 2% (n=138) indicated that they could not find employment within the first year of completing their doctoral degree.
6. Our results show that doctoral graduates were by and large employable, but that graduates in the social sciences were more likely to experience challenges in finding employment directly related to their fields or expertise or technical skills than graduates in the STEM fields.
7. Some of the challenges related to finding employment for respondents on an academic track included limited posts in the higher education sector.
8. Some respondents noted that younger graduates might face challenges in finding employment owing to a lack of work experience.

Salient findings on the *most recent employment status* of doctoral graduates:

1. Nearly two thirds of respondents were employed in the higher education sector at the time of the survey. More than a third of respondents in our sample were employed at a South African university. Nearly one of five respondents was employed at the university from which they received their doctoral qualification.
2. There has been little outward mobility from the higher education sector for respondents employed in the sector during their doctoral studies. In terms of movement into the higher education sector, a third of those who were employed in the government sector during their doctoral studies were most recently employed in the higher education sector. There were smaller inflows from the business, private non-profit and other education sectors.

Chapter 6: Postdoctoral fellowship career path

6.1. Introduction

In this chapter, our aim is to obtain a clear picture of the South African doctoral graduates who accepted a postdoctoral fellowship on completion of their doctoral degree. For the sake of brevity, we refer to these respondents as "postdocs", although it should be kept in mind that the majority are no longer in postdoctoral positions. The questions that this chapter aims to address are as follows:

1. To what extent have South African PhDs accepted postdoctoral fellowships after their graduation, and have there been any changes over time in this regard? How do our observations compare with the South African National Survey on Research and Experimental Development (R&D Survey) statistics on postdocs in South Africa?
2. What is the profile of South African PhDs who accepted a postdoctoral fellowship after their graduation? Here we consider science domain and field (STEM vs SSH), gender, race, age at PhD graduation, nationality and years spent in a postdoctoral position. In some cases, the interaction between two features or changes over time are analysed. Where relevant, comparisons are drawn with respondents who did not accept a postdoctoral fellowship upon completion of their doctoral degree (from here onwards referred to as "non-postdocs"). We also compare the profile of "serial postdocs", i.e. respondents who accepted more than one postdoctoral fellowship, with the profiles of their counterparts who did only one postdoctoral fellowship.
3. What are the main reasons for accepting a postdoc after a PhD, compared to the main reasons for accepting a second or third postdoctoral fellowship?
4. To what extent do postdocs constitute a brain gain for South Africa, considering their nationality and where in the world they accepted postdoctoral positions?
5. In which sectors did postdocs in general, and serial postdocs specifically, secure employment after their postdoc position(s), and to what extent have they changed their employment from one sector to another?

6.2. Size of the sample and changes over time

A relatively large proportion – one in five (20%; n=1 238) – of our sample respondents accepted at least one postdoctoral fellowship upon completion of their doctoral degree over the past 19 years.

In order to determine whether there was any change over the past two decades in the extent to which respondents accepted a postdoctoral fellowship upon completion of their doctoral degree, we disaggregated the sample by the year in which the PhD was attained, and calculated the compound annual growth rate (CAGR) from 2000 to 2018.

The CAGR is 8%. Figure 48 below presents in more detail the growth in the size of the postdoc sample, especially over the past decade.

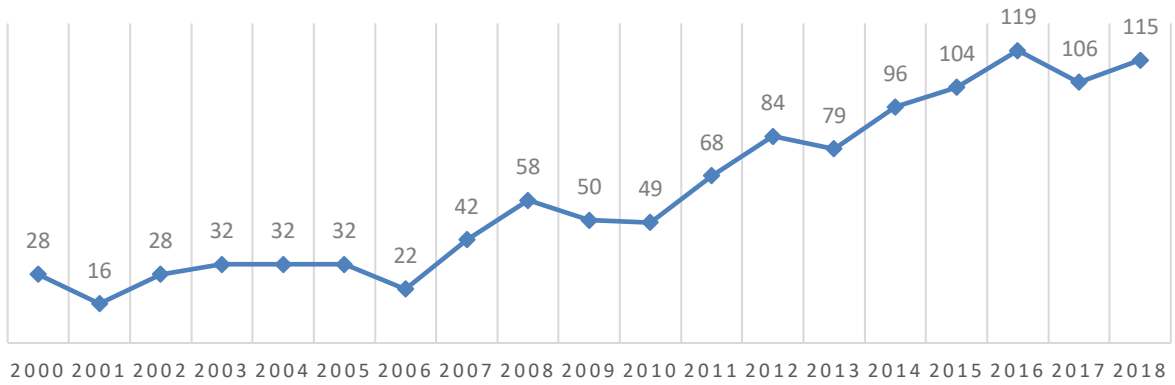


Figure 48 Number of postdocs by year of PhD graduation

The South African R&D Survey provides headcounts of postdocs in South Africa from 2003/2004 (HSRC-CeSTII, 2005) to 2018/2019 (HSRC-CeSTII, 2021). Although the headcounts include postdocs who did not obtain their PhD in South Africa, it is interesting to note that the CAGR for all postdocs over that period is 17% – much higher than the 8% CAGR found for our sample for the same period. Figure 49 below presents the growth in the number of postdocs In South Africa in more detail – according to the R&D Survey figures – from a mere 357 in 2003/2004, to 2 741 in 2017/2018, followed by a slight downturn (to 2 727) in 2018/2019.

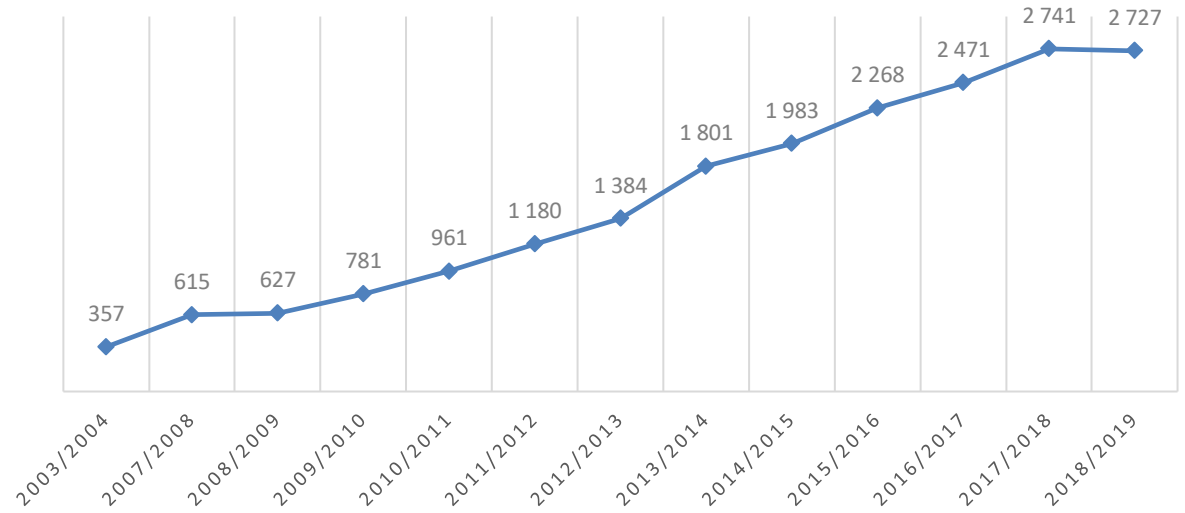


Figure 49 Number of postdocs in South Africa over time, 2003/2004 to 2018/2019

Source: HSRC-CeSTII (2005, 2014, 2019 and 2021)

The R&D Survey disaggregates the headcounts of postdocs by nationality from 2011/2012 to 2016/2017, and we find that the CAGR for the South African nationals in that period to be lower, and the same as the CAGR for our sample for that period, namely 10%. Figure 50 below presents in more detail the more moderate growth in the number of South African postdocs – according to the R&D Survey figures – from 538 in 2011/2012 to 957 in 2016/2017.

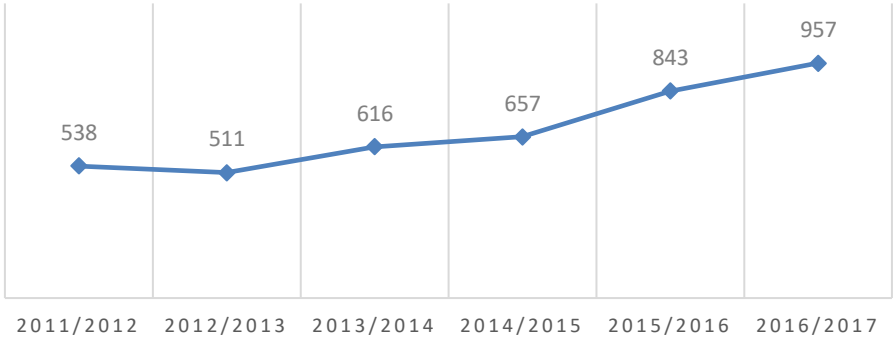


Figure 50 Number of South African-national postdocs over time, 2011/2012 to 2016/2017

Source: HSRC-CeSTII (2014 and 2019)

What we have shown is an increase in the absolute number of postdocs over time, which is to be expected given the increase in the number of PhD graduates every year. Next, we examined whether the proportion of PhD graduates who accepted a postdoc has changed over time (i.e. over the four PhD graduation windows). Figure 51 shows that the percentage of respondents who accepted a postdoc after their PhD increased from 16% in the earliest window (2000 to 2004) to 22% in the 2010-2014 window, whereafter it stabilised.

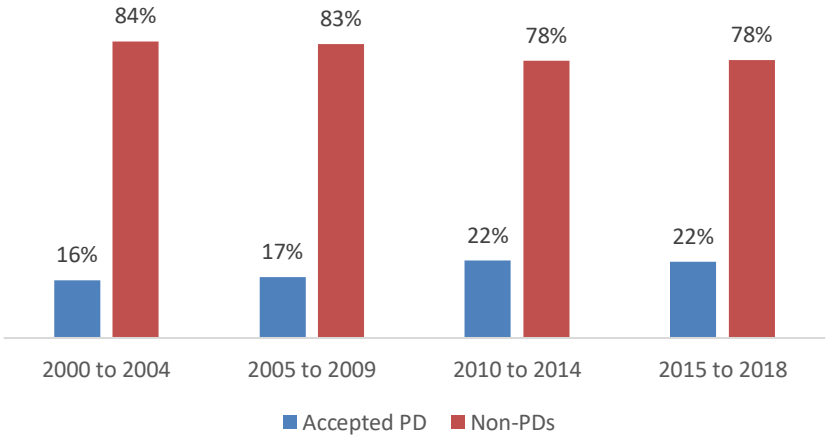


Figure 51 Acceptance of postdoc after PhD, by year of PhD graduation

To determine whether the change over time in the absolute number of our sample of postdocs (Figure 51 above) differed across the scientific domains, we calculated the CAGR separately for each of the nine science domains. In two domains – the economic and management sciences, and education – the first postdocs were only recorded in 2002 and 2003, respectively, and the CAGR was therefore calculated for a slightly shorter period for those domains. The highest CAGR (16%) was found for the economic and management sciences, followed by the humanities (15%), the social sciences (13%) and education (12%). On the other hand, agriculture and the physical, chemical and mathematical sciences (at 6% each) showed lower than average growth. Engineering and applied technological sciences (5% each) are even lower, while the lowest growth (only 4%) was found among the biological and environmental sciences. Table 33 below presents the absolute growth in the number of postdocs per scientific domain in more detail.

Table 33 Number of postdocs by year of PhD graduation and scientific domain

	Science domain									
	Agriculture	Engineering and applied technological sciences	Health and medical sciences	Humanities and arts	Biological and environmental sciences	Social sciences	Economic and management sciences	Physical, chemical and mathematical sciences	Education	**Total**
2000	2	3	6	1	8	2	0	6	0	28
2001	2	1	1	0	8	0	0	4	0	16
2002	1	2	1	3	15	2	1	3	0	28
2003	1	2	2	3	16	0	1	6	1	32
2004	1	2	3	6	13	4	0	3	0	32
2005	1	0	5	3	14	0	0	7	2	32
2006	0	1	5	2	10	2	0	2	0	22
2007	3	3	4	3	17	3	0	8	1	42
2008	4	4	6	6	18	6	1	11	2	58
2009	4	3	4	5	20	4	4	4	2	50
2010	1	1	1	7	17	7	3	11	1	49
2011	1	7	6	8	25	6	0	10	5	68
2012	5	5	8	11	23	8	3	19	2	84
2013	4	5	8	9	20	11	4	15	3	79
2014	3	10	15	10	22	10	3	20	3	96
2015	3	5	10	10	26	15	14	17	4	104
2016	7	10	11	20	21	17	4	22	7	119
2017	8	10	13	10	16	14	11	21	3	106
2018	6	7	15	15	16	21	12	17	6	115
Total	**57**	**81**	**124**	**132**	**325**	**132**	**61**	**206**	**42**	**1 160**
CAGR	6%	5%	5%	15%	4%	13%	16%	6%	12%	8%

Again, it is important not only to consider absolute numbers, but also whether the proportion of PhD graduates who accepted a postdoc has changed over time (i.e. over the four PhD graduation windows) in each of the scientific domains. Figure 52 below shows the changes within the scientific domains over time. We find a significant increase in the share of postdoctoral fellows in education (from 1% in 2000-2004 to 5% in 2015-2018), economic and management sciences (from 2% in 2000-2004 to 9% in 2015-2018) and the social sciences (from 6% in 2000-2004 to 15% in 2015-2018). Conversely, we see that the share of postdocs in the biological and environmental sciences decreased drastically from 44% in 2000-2004 to 18% 2015-2018. For the remainder of the fields the share of postdocs remained fairly consistent over time. This result suggests that doing a postdoc has become more prevalent across all scientific domains and is not limited to the fields in which postdocs were "traditionally" accepted, such as the natural, specifically biological, sciences.

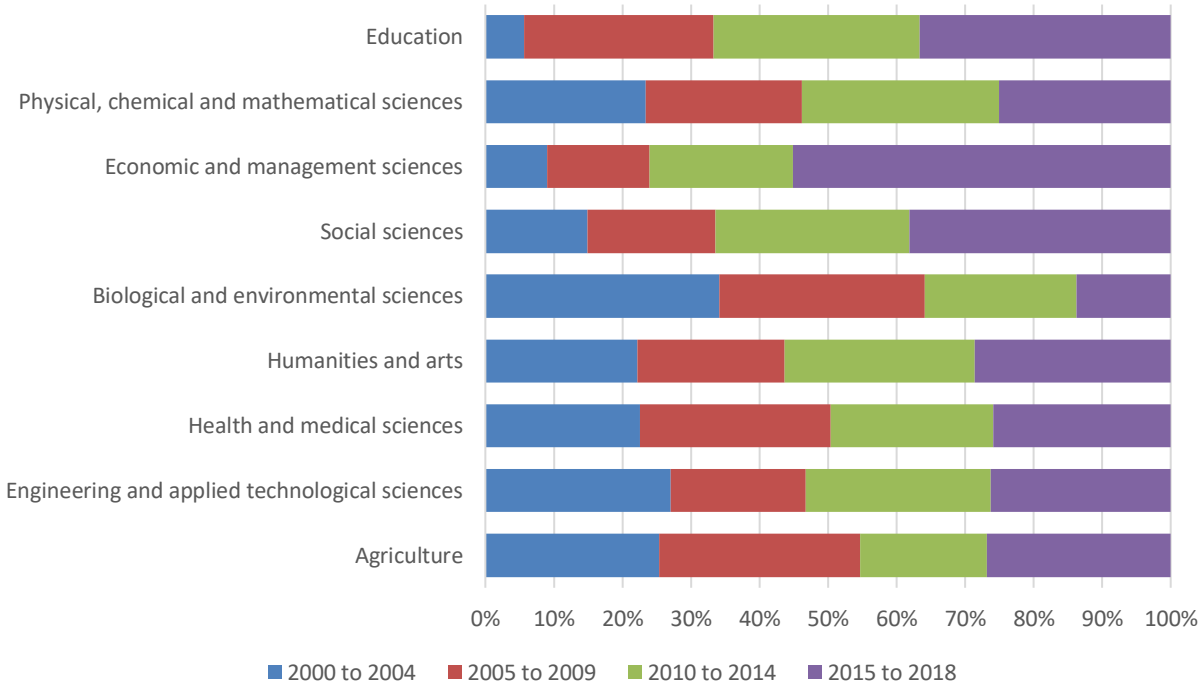


Figure 52 Acceptance of postdoctoral position after PhD, by year of PhD graduation and scientific domain

6.3. Profile of the postdocs

Figure 53 below shows that more than a quarter (28%; n=348) of the postdocs graduated with a PhD in the biological and environmental sciences, followed by the physical, chemical and mathematical sciences at 17% (n=216). Three domains constitute 11% each of the sample of postdocs, namely the humanities and arts (n=139), social sciences (n=137), and health and medical sciences (n=136).

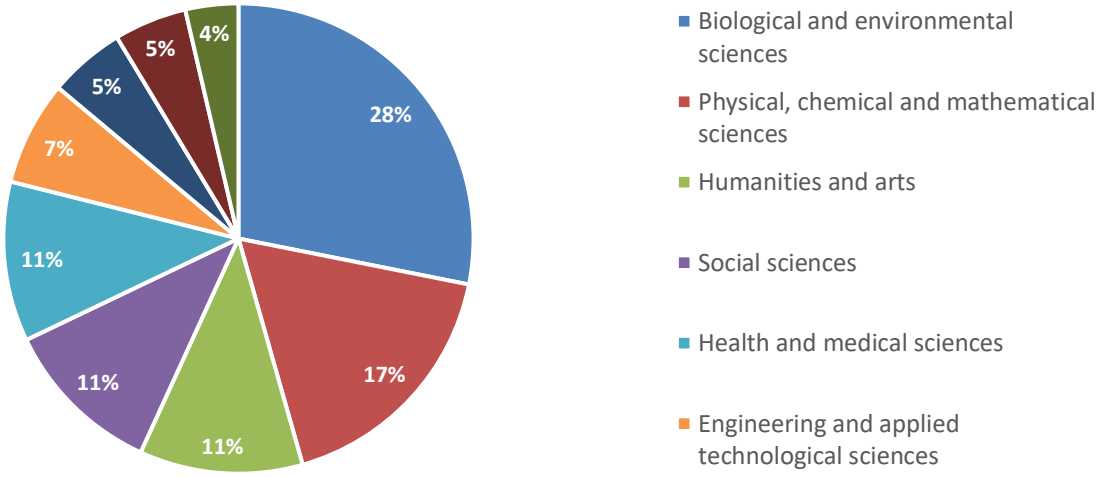


Figure 53 Distribution of postdocs across the science domains

The four domains with the lowest representation of postdocs are engineering and applied technological sciences (7%; n=89), economic and management sciences (5%; n=65), agriculture (5%; n=62) and education (4%; n=45).

As Figure 54 below shows, respondents in the biological and environmental sciences are proportionately most likely (44%) to have pursued a postdoctoral fellowship after their PhD. Those in the physical, chemical and mathematical sciences (28%) and in agriculture (24%) have a relatively high likelihood of becoming postdocs after their PhD. Respondents in the health and medical sciences, and in engineering and applied technological sciences, follow at 19%. On the other hand, respondents who graduated with a PhD in the social sciences (14%) and the humanities and arts (15%), but especially in economic and management sciences (10%) and education (8%), are proportionately less likely to have taken a postdoctoral position after their PhD. These differences are statistically significant.[18]

[18] Pearson chi-square = 463,390484, df = 8, p = 0,000.

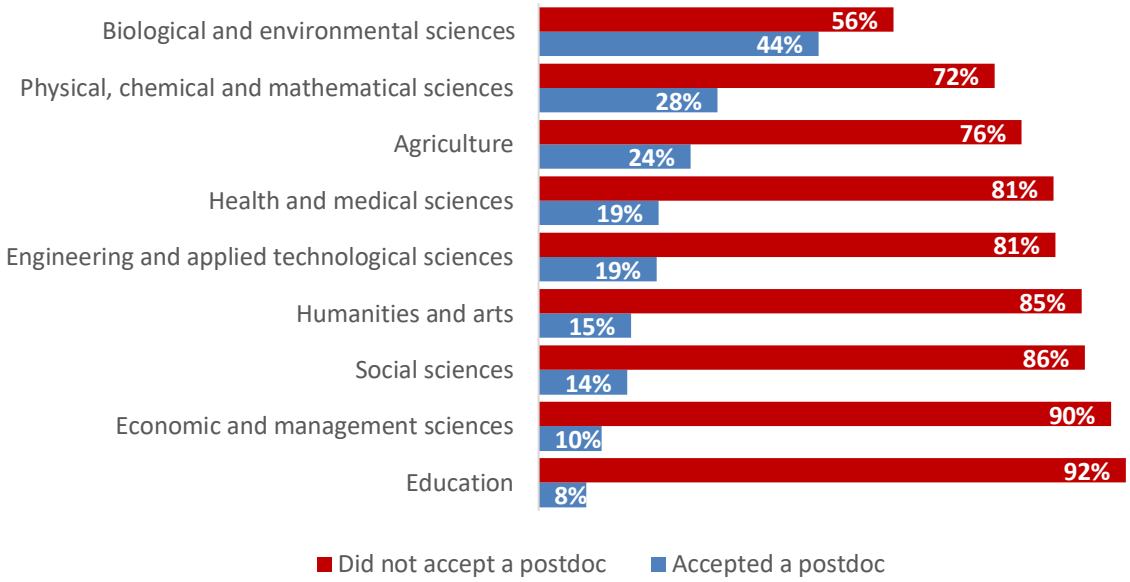


Figure 54 Acceptance of postdoctoral fellowship after PhD, by science domain

The results displayed in Figure 54 were subsequently classified into two major science fields, namely, SSH or STEM, which provides a clearer picture of the distribution of the postdocs in terms of field of specialisation. We find that the majority (69%; n=858) of those who accepted a postdoc after their PhD graduated with a PhD in a STEM field.

In terms of gender, our study shows that slightly more than half (54%) of the postdocs are male. There is no statistically significant difference[19] between the postdocs and non-postdocs in terms of gender distribution. Disaggregating further, by year of PhD graduation (divided into four graduation windows), we find very small (1-2%), non-statistically significant differences[20] between the proportional representation in females and males in each of the four graduation windows, indicating no change over time in the gender composition of postdocs.

We investigated the gender distribution further, by science domain and field (STEM vs SSH). We expected that the male postdocs would be more concentrated in the STEM fields, and found statistically significant differences between males and females in terms of their proportional representation in the nine science domains[21]. As shown in Figure 55 below, male postdocs are proportionately more likely than their female counterparts to have graduated with a PhD in engineering and applied technological science, as well as in the physical, chemical and mathematical sciences (a 7% difference). Men are also more likely to have specialised in the economic and management sciences, but to a slightly lesser extent (a 5% difference), and to a slight extent in agriculture (a 2% difference). On the other hand, female postdocs are proportionately more likely than their male counterparts to be specialised in the health and medical sciences (7% difference), the biological and environmental sciences and in the social sciences (a 6% difference). Female postdocs are slightly better represented, proportionately, in education (a 2% difference), while in the humanities and arts, the genders have equal proportionate representation in our

[19] Pearson chi-square = 0,050803, df = 1, p = 0,821671.

[20] Pearson chi-square = 1,489340, df = 3, p = 0,684733.

[21] Pearson chi-square = 78,907187, df = 8, p = 0,000.

sample of postdocs.

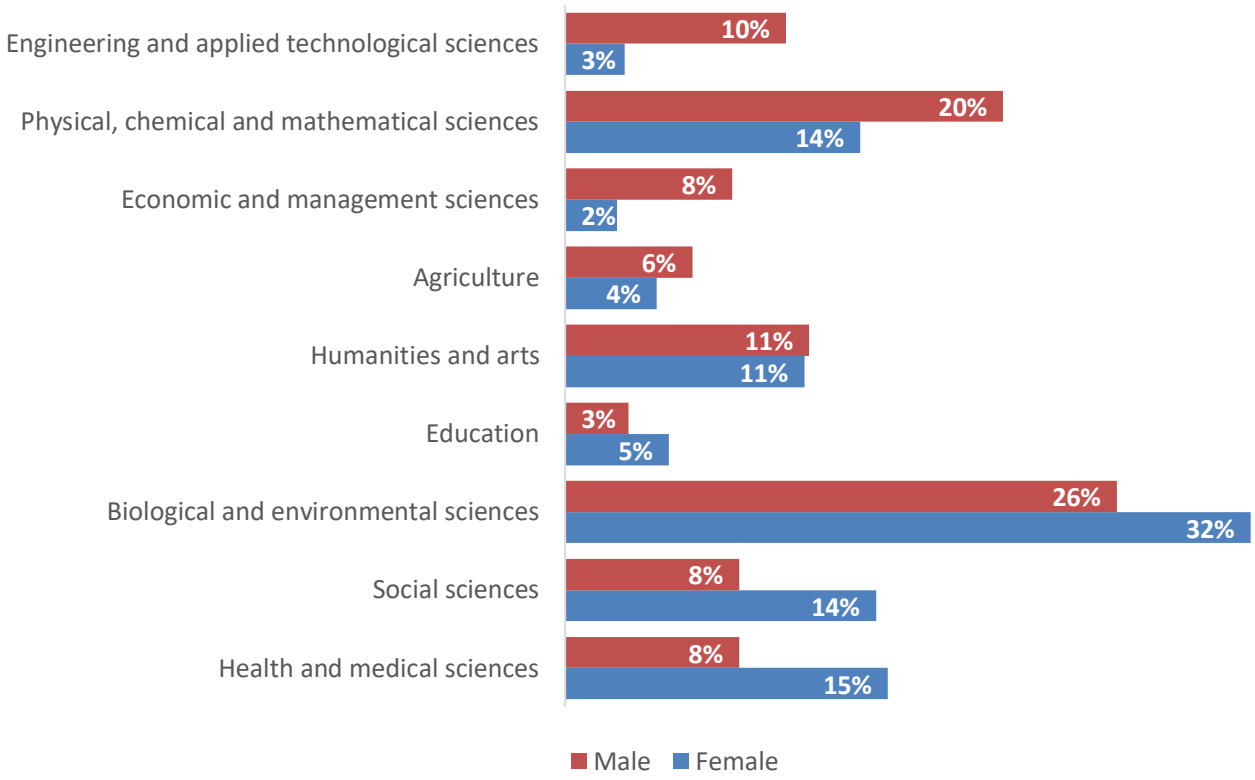


Figure 55 Science domain by gender

When we compare the two fields (STEM and SSH) in terms of gender (Figure 56), we find that 71% of the male postdocs are in the STEM fields, while the percentage in those fields among the female postdocs is slightly lower (68%). However, the difference is not statistically significant.[22]

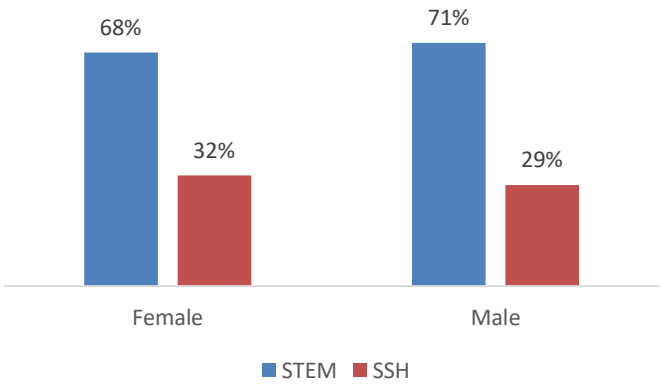


Figure 56 Field by gender

[22] Pearson chi-square = 1,133364, df = 1, p = 0,287059.

The next demographic we consider is race. In this regard, we analyse only those South African nationals who accepted a postdoc fellowship after their PhD graduation, and for whom we have the required data. Among those 612 respondents, 41% are black, while the remaining 59% are white.

Disaggregating further, by year of PhD graduation (divided into four graduation windows), we find that the proportional representation of black and white people among postdocs is very similar. In Figure 57 we see that there have also been no significant changes over time in this regard.

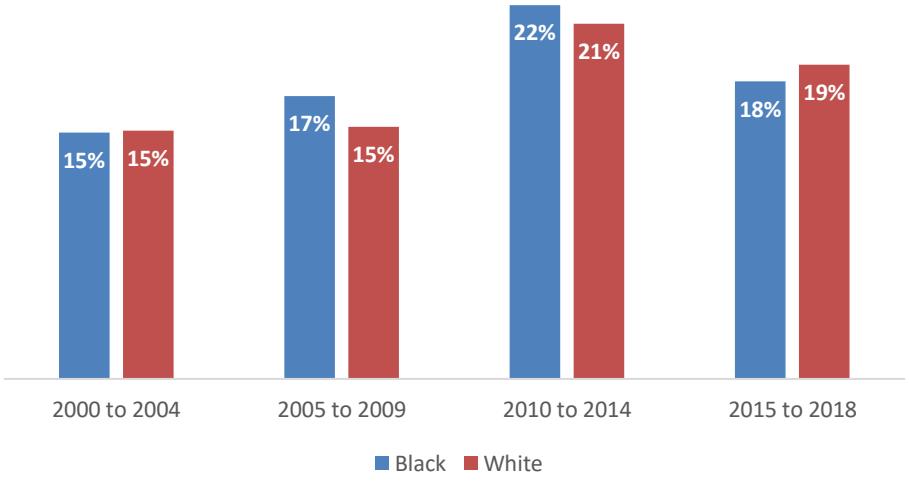


Figure 57 Acceptance of postdoctoral fellowships after PhD by race

As with gender, we investigated the race distribution further, by field (STEM vs SSH). We found that the distribution of postdocs in STEM and SSH by race were generally comparable, with 23% of black postdocs in STEM compared with 28% of white postdocs, as shown in Figure 58 below.

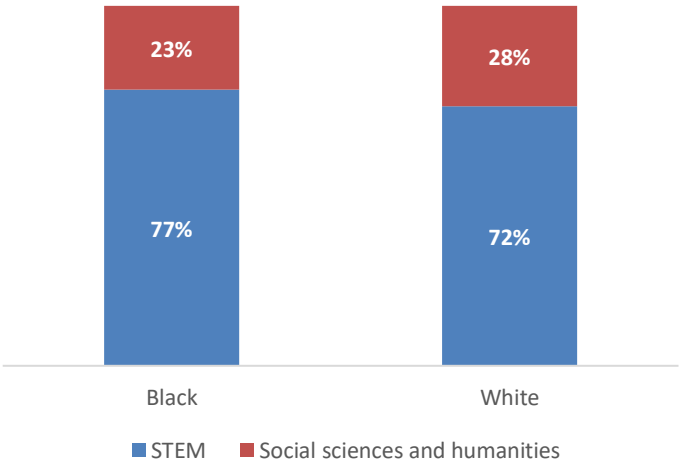


Figure 58 Scientific field by race

In terms of the age distribution of all of the postdocs (irrespective of nationality), the results of our analysis in Table 34 below show that, on average, the postdocs were seven years younger (34) than the non-postdocs (41) when they attained their PhD. The difference is statistically significant.[23]

Table 34 Average PhD graduation age, by acceptance of a postdoc after PhD

	Mean	n	Standard deviation
Accepted a postdoc after PhD	34,2	1 108	6,989
Did not accept a postdoc after PhD	42,1	4 389	8,773

Our results in Table 35 (below) further show that the postdocs who graduated in STEM fields graduated at a lower average age (33) than the SSH postdocs (37). The difference is statistically significant.[24]

Table 35 Average age at which those who accepted a postdoc after PhD graduated with a PhD, by field

Field	Mean	N	Standard deviation
STEM	32,7	765	5,864
SSH	37,4	342	8,124

Postdocs spent an average (median) of three years in a postdoc position, and two thirds (67%) spent between two and four years in such a position (Table 36). Of significant concern is the finding that approximately a quarter of the respondents were in postdoc positions for more than four years, 5% were postdocs for more than six years, and some respondents (2%) reported spending more than nine years as postdocs.

Table 36 The number of years in total that postdocs spent in postdoctoral positions

Number of years	n	%	Cumulative %
1	79	7	7
2	281	24	31
3	288	25	55
4	218	19	74
5	108	9	83
6	94	8	91
7	44	4	95
8	26	2	97
9	13	1	98
>9	19	2	100
Total	1 170	100	

Although fields differ in terms of the duration of postdoc positions, spending more than a few years in one or more such positions does not align with the intention of the postdoc as a temporary position,

[23] Anova results: F = 596.691770, df = 1, p = .000

[24] Anova results: F = 118.350453, df = 1, p = .000

taken primarily for additional training, in particular advanced research apprenticeship under supervision (Gaughan & Bozeman, 2019). This may well indicate difficulties experienced by South African PhD graduates in finding employment after graduation, as supported by the qualitative data presented in later sections of this chapter. Our quantitative data show that, of the respondents who accepted a postdoctoral fellowship after their PhD, a third reported having accepted more than one postdoc. In terms of their profile, the serial postdocs differ statistically significantly from their counterparts who held only one postdoctoral position in that they are:

- On average, two years younger at the time of their PhD graduation (33 vs 35 years).[25]
- Proportionately most likely to be found in the biological and environmental sciences (41%), health and medical sciences (37%), physical, chemical and mathematical sciences, and the humanities and arts (33% each). Conversely, single postdocs are most likely to be found in agriculture (82%), education (80%), engineering and applied technological sciences (79%), and economic and management sciences (78%).[26]
- Proportionately more likely to have been (during their PhD) a national of a country outside of Africa (42%) than a national of South Africa (36%) or of a country on the rest of the African continent (30%).[27]

6.4. Reasons for accepting a postdoc

Respondents were asked to indicate the primary reasons for accepting a postdoctoral research fellowship after their PhD. As respondents could select any number of eight reasons with which they were presented, the reasons are the unit of analysis, as presented in Table 37 below. Of the reasons, the two most frequent ones were to gain additional training in the field of their doctorate (48%) and to carry out research independently (45%). The third and fourth most frequent reasons indicated were to work on a specific project/study (30%), and because other employment was not available (28%).

Table 37 Reasons for accepting a postdoctoral fellowship

Reason	n	%
To gain additional training in the field of doctorate	596	48%
To carry out research independently	560	45%
To work on a specific project/study	372	30%
Other employment was not available	346	28%
This type of position is generally expected for a career in the field	303	24%
To work with a specific person or in a specific place	270	22%
To gain training in an area outside of the field of my doctorate	242	20%
To carry out and support teaching activities	128	10%

The interview data we collected provided rich, contextualised insights into these reasons (and, retrospectively, the value of a postdoctoral fellowship), as well as additional reasons for taking a

[25] Anova results: F = 11,905010, df = 1, p = 0,001

[26] Pearson chi-square = 33,576394, df = 8, p = 0,000.

[27] Pearson chi-square = 6,830421, df = 2, p = 0,033.

postdoctoral fellowship not considered in the questionnaire. In the next subsections, we report the results of our analysis of these data.

6.4.1. The postdoc as a stepping stone to academia

The view that the postdoctoral fellowship would increase the likelihood of highly valued, full-time employment in academia was a theme that emerged strongly from the qualitative data. It therefore resonates throughout the next subsections but is the main focus of this subsection. The view is expressed succinctly by four interviewees:

> *So, one usually does a postdoc if one wants to do … research. If you want to be an academic, you do a postdoc because a postdoc is two years which you dedicate just to research and to publishing papers. And it gives you a great start to your careers in academia. If you don't want to be an academic, you don't need to do a postdoc. So of course, I wanted to be an academic.*

> *Going into academia, yes, [a] postdoc is definitely a good idea. During my postdoc I got opportunities to publish more of my research from [my] PhD and afterwards, also broadening networks, opportunities to travel overseas to other labs, conferences, things like that … so definitely it was worthwhile.*

> *Advantage number one, it makes sure that you are still in the [mainstream] of research. You're not sitting at home. You are not working on your own. You are still involved in organisations. You are still involved in the university.*

> *I suppose it's just been interesting. You know, everything I've done has been super interesting. And I'm also going to conferences; it's really nice. You meet a lot of people and also collaborat[e] with different people around you. And being in the university environment is something I really like as well. I love having the resources, like the library and access to journals, and then just interacting with other people around you and students. Yes, it's a nice environment to work in.*

Linking to the last of the four quotation above, are the words of an interviewee who left academia for one year, when she worked for an NGO. For her, a postdoc is "extremely valuable", because she is –

> *… an academic. And leaving it made me even more aware of the fact that I do love working at universities. I love the diversity of the people you meet. I love the diversity of the work that you can work on. I love that you have a free range, obviously with constraints, but you have free range to investigate something that you're interested in. So, I would like to continue working in a university environment.*

Thus, the value of the postdoctoral fellowship in increasing employability pertains especially to those seeking employment in academia. It does so in two ways, the first of which is that it provides valuable time to publish. Two interviewees (already quoted above) say that "a postdoc is two years which you dedicate just to ... publishing papers", and "during my postdoc I got opportunities to publish more of my research from [my] PhD and afterwards". Another one mentioned that the postdoc was particularly valuable, as he "actually wrote more publications than during [my] PhD time. So, career wise, that's important". For a fourth interviewee, the opportunity to publish relatively unhindered compensated for the poor remuneration of a postdoctoral fellowship:

> *But then on the other hand, you can try even harder to publish more, because in that time you don't have the admin load that the normal lecturer has. I published three papers in that one year. That's a big plus if you actually have time to sit and focus on your research, and that's impossible as a lecturer.*

Two South African universities (the University of Pretoria and Stellenbosch University) were mentioned by interviewees as offering their newly graduated PhDs a one-year postdoctoral fellowship, with the specific purpose of giving them the time to write up publications from their PhD. One interviewee described this as a "very nice scheme", because she "still had a couple of papers that [she] could publish out of [her] PhD", and the fellowship allowed her to keep "working on that". Interestingly, both interviewees used these "internal" postdoctoral fellowships for other purposes as well. One explained that –

> *… by that time, I was still working in parallel, also on a project that was patentable ... and the [university] patented it, so there was also a vested interest for me to keep on doing both [my publications and] the research ... because of the commercialisation value of [the latter].*

The other interviewee used his postdoctoral fellowship to explore further topics with international collaborators (see below). The publications produced during a postdoctoral fellowship are clearly important, but such a fellowship may also provide teaching and supervision experience, which is valuable for advancement in the academic pipeline, as illustrated in the following quotations:

> *I have supervising experience. If there's an opening now, and if the condition is supervision, one of my students is graduating now for a master's degree. So, if the condition is that you should have graduates to get the position of associate professorship, then those conditions are being gradually met. If I have an opportunity, I will be qualified to receive it.*
>
> *To a large extent, also the teaching experience and opportunity to supervise students – to take on honours students, master's students at the same time. And so, you're effectively functioning already at the level of a lecturer or a senior lecture elsewhere, which really helps to build up your CV and get a bit of a stronger chance.*
>
> *So, as a postdoc in this lab, somehow I was overseeing all the students ... and there [were] at the time 14 master's and PhD students. And I actually got trained in supervision as well, because I'm guiding them and telling them to submit monthly progress reports and they come to me for advice.*
>
> *Interacting with undergraduate students and supervising some postgraduates … was a valuable experience in my opinion.*

Another three interviewees found themselves, as postdoctoral fellows, "stepping in" to fill teaching and supervision "gaps", which proved valuable from a career-development perspective:

> *My promoter at that stage ... was nearing the end of his career. And so, there was scope for postdocs to step in and help with the lecturing and the courses that he was teaching at that stage. So, he would keep us in the loop to help him out and teach and supervise students as well.*
>
> *Technically, it wasn't supposed to [include teaching], but it did. Which I didn't mind at the time, because I was starting to look around for permanent positions, and obviously, getting some teaching experience helped. So, I effectively took over some of [my supervisor's] teaching, when he retired. They didn't replace his position immediately. So, there was a teaching gap. And so, I actually taught in two courses over at least three or four of those years.*
>
> *In my first three months, one of the lecturers resigned, and the department was now in a pickle, because there's no one to teach this one first-year class of 200 students. And so, the HoD at the time approached me and asked me, "Would I be willing to just for three months take over this first class until they employ another lecturer?". And I was obviously scared but thinking this was anyways going to be my career as an academic, it will be good practice, I agreed to do it. And I continued lecturing for the rest of my two years of postdoc. And I think that experience has been invaluable, because at the*

end of my postdoc, I had two offers, and that is one at UJ for senior lecturer actually straight up. After the first six months, the HoD said then she wants to give me a position, but I said, let me just finish my postdoc.

6.4.2. Gaining additional training and carrying out research independently

In Table 37 above, gaining additional training in the field of their PhD and carrying out research independently were found to be the first and second most frequent reasons for accepting a postdoctoral fellowship. One interviewee explicitly stated that he "realised that [he] needed to gain some independence from ... working only" on one topic with his PhD supervisor; another "decided" to "progress" herself by means of a postdoctoral fellowship; and a third said that, during her postdoc, "it was an opportunity for me to gain a little bit more independence and explore how to apply the skills I gained during my PhD. So yes, it was a really good experience for me". Three further interviewees explained – in retrospect, and in comparison with their PhD – how the fellowship allowed them to carry out research independently, and the value of this:

I think it was a very positive experience. When you're doing your PhD – I think because it's examined – there's a lot of pressure to just pass and move on. But as a postdoc, we are more independent. And you actually get to do the things that you're really interested in doing. So, I think it was a very positive experience.

It's just the opportunity to focus on a project. It's your own project. And unlike a PhD where you have to write up the thesis.

I'd say it's much better than being a student. At least you have more independence.

The postdoctoral position was described as building their confidence, deepened their knowledge of their field, and led them to acquire new skills. A number of interviewees' quotations illustrate these advantages well:

It was maybe a continuation of the work I've done. Because it was just the [start], the behaviour we were looking at. So, based on my PhD, I've [made] a good contribution in that area ... because we had acquired new equipment, and recruited more PhD and master's students. I was working with these students and the training them in that field.

I'm getting a lot of experience from my host on how to really handle the science team. To be able to coordinate things, like the trip that we made to Cape Town. It was actually a collaboration with a company in Cape Town ... . I think that this postdoctoral is actually positioning me for a strong research and academic career.

I was also involved a lot in research, in meetings for different projects in [my research] area, interacting with master's and PhD students. At a global level, helping with literature, papers, etc., I enjoyed my experience … It also broadened my horizon in the ... research area, because instead of just focusing on my project, I was involved in many other different, but related projects.

I learned how to really translate scientific outputs into easily communicated pieces for the general public.

The postdoc was actually interdisciplinary … I didn't think I had those kinds of skills. I thought science was mainly about doing research with your animals and all that. But then, I didn't know about this aspect whereby you can actually involve citizens [in] science and all that. So that's the main thing that

I really gained through my postdoc.

I also ended up managing a component of the research in Zimbabwe. Because, when I was now the country coordinator, I was basically managing research that was being done by junior researchers and PhD students and master's students.

From that time, I managed to supervise people who are doing kind of diverse type of work. And you had to read to understand that type ... their work and understand the language of the science.

Other benefits of postdoctoral fellowships are dealt with in section 6.7, on geographic mobility, where the experiences of interviewees who took postdoctoral positions in other countries are analysed in more detail.

6.4.3. Choosing existing collaborations, and developing new networks

The survey data (Table 37 above) show that slightly more than one in five postdocs indicated that working with a specific person or in a specific place was a reason for accepting a postdoctoral fellowship after their PhD. One interviewee described his "move to a postdoc" as "following my one supervisor for my PhD". The reason may not always be strictly professional, though:

This was an interesting time. I met and married my wife. She studied in the same department. She actually worked in the ... department. My wife taught [at the department] for seven years. And so, at that point, it seemed logical to look at what opportunities I had".

The same interviewee was also attracted by the work of another member of the department, whom he describes as an "entrepreneur [who] had generated a deal with [another] government". The interviewee spent "one half of what [he] did for the postdoc" on what he describes as the resulting, "amazing undertaking":

We would get a group of some 20 to 25 [of that government's nationals] who would come to [the South African HEI where I was doing my postdoc]. And we would take them from not being able to speak English, not having ... backgrounds [in my field], and we would take them all the way through to PhD. ... The [other] government provided the funding for them all to come. They provided funding for us to build laboratories, they provided funding for us to have some resources available to construct courses for them. We bought fantastic equipment, we bought labs, refitted laboratories, prepared between [me] and [another] gentleman ... . We prepared a training course, literally wrote a book [for] a training course to train them in [my field]. Through the international office lectures were set up to train them to speak English, because none of them could speak English when they arrived … we had great success. Successful people who went all the way through to doing PhDs. And graduating.

At that point, the interviewee was "of course" also "quite into what [he] was doing as an academic career". Thus, he continued to work [on his] research, and "still published quite a lot through that period". But, importantly, "a lot of [his] funding was coming through" the project described above.

The interviews showed how the postdoc broadened existing networks and collaborations, or allowed for the development of new ones, both locally and internationally. For one interviewee, the second of two advantages of a postdoctoral fellowship is that it "gives you a platform to collaborate, to interact with the outside world". Another interviewee described how he used his postdoctoral fellowships to pursue an

international collaboration that flowed from his PhD research and, in the process, secured funding for a project:

> *From the papers from the PhD, we got contacted by some Australians who do similar work. And then they wanted us to try out some new techniques. So, we put together a project proposal, and then I got another NRF postdoc bursary. And then it was more work in line with [the] building of the platform.*

For another interviewee, his postdoctoral fellowship gave him "an opportunity to establish a strong collaboration with" a European institute, which has proved valuable for his research:

> *I attended a workshop and met this team, we discussed, and eventually I went there for two weeks. Now, when I prepare my materials, the characterisations are done in France. So, that makes my work faster.*

As mentioned in a previous sub-section, some South African universities offer newly graduated PhDs a postdoctoral fellowship with the specific purpose of enabling them to publish articles from their PhD work. One interviewee mentioned that he "benefited" from one of these. However, as he "was almost done with all the PhD stuff", he used the postdoc to "carry on" with "lots of other things to explore [through] collaborations that we had, particularly [with] German collaborations".

6.4.4. Unavailability of other employment

As the first sub-section illustrated, the postdoctoral fellowship is viewed as an important stepping stone to a highly valued, full-time position in academia. However, in a context of scarcity of these and other full-time positions, the unavailability of alternative employment opportunities motivated 28% of South African graduates to accept a postdoctoral fellowship after their PhD. The way in which the unavailability of employment leads one to accept a postdoctoral position is explained in detail by one interviewee:

> *When I finished my PhD, I said, "Okay, I wanted to be in academia". But I also knew that it wasn't always going to be easy. So, what I did was, I applied to private companies, and the government. So, I have applied [to a government department] I applied there, filled out all the forms. [At] some of [the] NGOs, I applied. So, I did do a complete application in those places ... The biggest challenge was, even though I had permanent residence, critical skills, it still just didn't seem to help me very much. It didn't help me. And then I even applied to [a South African university for] a temporary post for a semester. I taught for a semester. And even then, there were a few vacancies. I applied for those. I didn't get them. So, it was just not ... it just didn't work out ... At first, I thought it was because maybe I'm not a South African citizen. But when I then saw my friends that I graduated with ... So, if you look at the cohort that I was with, so we graduated, about seven of us, from that lab. Six of us are still doing postdocs today ... Those are not good statistics, because out of the seven of us, only two of us, I think, have some kind of job that's really not a postdoc.*

A second interviewee described her first postdoctoral position as "a saving grace", when she came to the "realisation that reality and expectation are two different things":

> *The expectation was, you know, you study ... [get] your PhD, you get your title, and then immediately you have a job in the research world. The reality is you finish your PhD meaning also you finish the bursary that goes with it. So basically, you get fired. Like, "Congratulations, you're fired." I have no job ...*

She blames herself for coming to that realisation only after her PhD:

> *I've been very focused [on] the work itself and not much into learning that aspect of the work … and never took the time to look into it. So, it's on me. I should have asked probably or find out in advance. But I found out and it was a bit of a shock, you know, you find out that you actually have to seek your own funding if you want to carry on doing the work.*

For a third interviewee, a postdoctoral fellowship was "just the logical next step" after his PhD, because –

> *... there wasn't an immediate option. I guess that I saw [it] was a good alternative. Yeah, that's essentially … it would have been it. So, the postdoc was the thing that most aligned with what I was keen to do at the time, and I didn't have any other alternatives.*

A lack of alternatives to a postdoc is a theme that emerged strongly in other interviewees' narratives as well. In one case, an unexpected turn of events led to acceptance of a postdoc:

> *I was actually employed as a research associate within the institute. But in 2017, our supervisor died and then things changed a bit. So things changed, end of 2017, when I had submitted my PhD, they told me they won't renew my contract. So, it was not expected, it was unexpected. So, the idea of postdoc wasn't in the picture at the time, because I was based there, the project was running, and I was working, and I'd been there for five years. So, it's only 2018 that obviously, like, now, I don't have any income. I don't have any job, other than working on my thesis for resubmission. And so, when I saw the NRF advertisement come up and I decided to apply, but obviously now I had to apply to the department itself, within the same institution. But that was basically, to be honest ... just as a backup, because I had no opportunity at the time. It was really bad. So, I was just applying for [a] postdoc. It was just a backup opportunity in case I [didn't] get employment. So, the issue is, if my contract was not terminated, I don't think I would have done a postdoc.*

A postdoctoral fellowship may therefore not be an individual's first choice, but rather an interim position taken up somewhat reluctantly, instead of a permanent position, as three interviewees explained:

> *It was also kind of a holding job until a lecturer post became available. I knew the one lecturer in the ... unit was three years away from retirement. So, it really was a hold-over to then apply for his job.*

> *We relocated [overseas] about six months after my PhD was completed ... and worked there for almost a year. And then ... we decided to move back to South Africa and the opportunity opened up at [a South African university] to do a postdoc. I was a bit reluctant to resign from work and join a postdoc that was only temporary. I may end [up] without the job of course. So, I made an agreement with my employer that I would do the postdoc and if [the university] couldn't keep me on, then [the employer] would take me back again. It was just informal, but that gave me a bit of a safety net to jump to the university environment and do the postdoc.*

> *Once I finished my PhD, the same friend of mine had gone back to [a South African university], to lecture as well. So, after PhD I was in the process of looking for a job then he said to me while I am busy looking for a job I could go join him at [that university] as a postdoc.*

It is relevant to note that the postdoctoral fellowship at the South African university involved research that "was different to [the interviewee's] PhD background". A lack of options applies not only to employment, but according to two interviewees, to postdoctoral fellowships as well. "[P]ositions are

scarce and competitive and so are postdocs. So, it certainly was an open ended, 'wherever there are opportunities, I'd be willing to consider them,' " one interviewee observed. Another mentioned that her two-year postdoctoral fellowship was coming to an end soon, "and I haven't got any offer after this one ... I've been applying since June last year, but no luck yet". A third interviewee, also a postdoctoral fellow at the time of the interviews, said –

> *I did ask, I did apply. There was another funding opportunity from the university, it was a fellowship for ex-postdoc/postdoc that were working on the commercialisation of IP-protected technology at [the university]. But I didn't get that ... I'm still registered as a postdoc until December. And I will see.*

However, these experiences may be field-specific, as they do not align with those of (1) an interviewee who is trying to fill a postdoctoral fellowship; and (2) a postdoctoral fellow for whom the position was the most attractive option:

> *There are opportunities around. I've got a grant-holder-linked postdoc bursary that I've been trying to fill for two or three years now. I'm just not getting any applicants. No-one suitable. The opportunities are there, but there don't seem to be people willing to take it up. It's not even the grades. It's a very general, broad postdoc ... so, people with a [any] background, it's open to everyone. And the only applicants I'm getting [are] international applicants. Or people who've worked on ... something completely unrelated to what I'm asking for.*
>
> *I wasn't actually looking for other employment at that stage, I think because the work at the [department] and the postdoc was attractive for me. So, the teaching was interesting. The research that I was doing was interesting. So, I wasn't really looking for anything else.*

6.4.5. Other reasons: Raising a family and the role of the supervisor

Two additional reasons for taking a postdoctoral fellowship (not considered in the questionnaire) intersected with gender. Two female interviewees chose a postdoctoral fellowship partly because it provided the flexibility they needed to raise children: The first wanted to better herself, but also "be able to have a home life and not just work. I wouldn't be better off at another institution. So, I took a postdoc". The second stated that, "as a female, it gave me flexibility to have kids. I must admit, I can't really see the research value. It was kind of a flexibility to have kids". Another gender-related reason to accept a postdoctoral fellowship was a woman being a "trailing spouse"[28] to her husband, whose postdoctoral fellowship was created for her:

> *When I finished my PhD... my husband ... got a job and we moved to Grahamstown. It was always going to be harder for him to find something than me. For that interim period, I didn't have anything. And then my supervisors, and his boss, made a postdoc for me. I didn't apply for something that was out there. It was a kind of a joint postdoc between [two South African institutions]. It wasn't really doing research [and] had nothing to do with my PhD.*

The above quotation also points to the role supervisors may play in the decision to take up a postdoctoral fellowship. Another interviewee described his supervisor's role in this regard, and in his decision to return to South Africa:

[28] Harper, E.P., Baldwin, R.G., Gansneder, B.G. & Chronister, J.L. 2001. Full-time women faculty off the tenure track: profile and practice. *The Review of Higher Education*, 24(3):237-57.

After my PhD ... I actually left the country, migrated to Canada. So, while I was still busy trying to find my [feet], I got an email from my supervisor during my PhD time, offering me a position at the institute. And so, I then just packed my bag and came back to South Africa and took up the position – it was a postdoc position at the institute. So, I just came back for it and did a postdoc.

6.5. The drawbacks of a postdoctoral fellowship

A postdoc position also has some disadvantages. The qualitative interviews highlighted the fact that the responsibilities of postdoctoral positions are sometimes poorly defined, and that postdocs occupy a liminal[29] space, in that postdoctoral fellows are neither students nor staff members, which creates what one interviewee referred to as "the major challenge in the postdoctoral". He describes and illustrates this challenge with reference to his own experience:

I think is that the contract says that you are not a student, and you are not staff. And sometimes people want to treat you that way ... I remember there was a time that I was supposed to be in the proposal presentation and then, despite the fact that I ha[d] been a part-time lecturer in the same department, the secretary did not send me a link to join the presentation. And my students were presenting. And then, when I went to ask her, she said that it was only sent to full-time staff. So, I had to go to one of my colleagues to forward the link. I didn't even complain to anybody, but I discovered that it has stopped.

Another interviewee highlighted the discrepancy between status and responsibility:

It's in between, you're not a student, you're finished your PhD, you're supervising students, and you are writing a paper, you're organising grants. So you have the responsibility of staff but with a bursary that still qualifies you as a student.

The "responsibility you get to have", includes sourcing one's own funding, which can be challenging:

I did try to apply for NRF funding and other international funding. But ... either I'm really bad at asking for funding, because I had very little [success], or research [in my field] is particularly challenging when it comes to funding. I got a couple of bursaries from [two foreign funders]. That was just enough to get me through.

The administration that accompanies project management was highlighted as the "only problem" of a postdoctoral fellowship, by an interviewee who "absolutely loved" her fellowship and each project that she worked on during her fellowship:

... with the grant that I got, you suddenly have a project management thing, in a way. So, you're not just working on a project yourself, you're actually managing a project. And I found that was a change. And I will prefer to just basically work on a single project because I love working on a project. But now, I do a lot of project management and the admin that I don't like.

[29] Liminality, a theory from the field of anthropology, refers to a stage of transition. Individuals in a liminal state are defined as being in a somewhat unclear state that is between two clearly defined states.

Another interviewee shared a similar experience. In addition to her own research, she has to "get the funding for covering everything else. You know, the lab and the department, put some funding on two [postdoctoral students] and then teaching". In her view, the responsibilities of a postdoctoral fellow are not sufficiently remunerated, especially "if you compare that with business". Another two interviewees agreed:

> *... the one thing is obviously it's not good pay, so you have to be able to finance that in some way. It's not going to really finance you properly.*
>
> *The salaries are not especially high ... if you compare it with people who are maybe working in companies and private organisations, and who are PhDs, you're probably getting sometimes a third of what they're getting; at best a half. They're not postdocs. So, it's not the best way to make a lot of money.*

However, he highlighted important differences between countries:

> *In Ireland, they definitely pay very well, but the cost of living is pretty high, depending on where you are. In France, I have a decent salary, it's actually very good ... I think each country has its own way. And in Europe, especially, at least compared to the American postdocs, you're definitely above the minimum wage. I mean, you could raise a family on it.*

Social security benefits were mentioned by this interviewee as another factor to consider in cross-national comparisons: "In France, they do have social things. They help you with health care, and things like that. So, I think that also helps". Another interviewee also pointed out that in Italy, where she comes from, "public school is quite good. If I'm sick, I can go to public hospitals; they are quite good". She compares South Africa less favourably, which leads her to question that South African postdoctoral fellows are exempt from paying tax on their salaries:

> *I will be very happy to pay taxes. You know, I don't mind ... My mentality is, if we all pay our taxes, then it is more fair on everyone to have free access to up until you are 18, to education and everyone can have access to the hospital [and] the streets won't have holes [in] it. I'll also [be] paying my taxes if I'm allowed to do so.*

Although postdocs occupy a liminal space between being a student and staff member, one interviewee compared his postdoctoral salary as "definitely better" than what he "was getting in [his] PhD", which was "hardly anything". Another stated, "the money was not as bad". As we reported above, a postdoctoral position also compares more favourably to a PhD in terms of research independence, and some postdoctoral fellows are indeed granted the independence to focus solely on their research. Others are expected to also do administration work, lecture and/or supervise postgraduate students. This one interviewee experienced this quite negatively, as leading to role confusion:

> *The one thing I find difficult about postdocs in general – but it really could just be our school – is that things are so vague about what is expected of you ... That was my ... confusion ... as a postdoc.*

As we highlighted in the previous section, teaching and supervision experience accrued during the postdoctoral fellowship allows postdocs to move up the academic pipeline. One interviewee (already quoted above) mentioned that "technically" his third postdoctoral position "wasn't supposed to" involve teaching, "but it did". He did not "mind at the time", because he thought "some teaching experience"

would assist him in attaining a permanent academic position. Another interviewee was "roped in as co-supervisor" during his postdoctoral fellowship, as a master's student was working on the same project that he was. Two interviewees explained more explicitly the tension, during a postdoctoral fellowship, between conducting one's own research, and accepting other academic responsibilities:

> *I was in a lucky position in that because [the department] didn't ask me to do that aspect of lecturing … because I was extremely busy with [my own research]. So, they were happy for me to do my own thing. So, I can't complain about that part. But ... the other side of the coin is, if I will have to look for a position as lecturer of now, they will ask me, "What is your experience? How many times did you lecture since you finished your PhD?" So, which one of the two?*

> *So, I did help to supervise some students, but only to a small extent. Because in your postdoc, you seem to be evaluated on your paper output. Not always on supervision. It looks good on your CV in the long run, but then you are seen as a failure as a postdoc because you didn't get enough papers out because you were actually helping students all the time. So, I found that a bit difficult as a postdoc. I probably would have helped more in the school with students and projects, but I was trying to guard my time for research.*

Important from a gender perspective is that this interviewee was, at the same time, also "trying to guard" her time for her baby.

As we report in more detail in section 6.7, 17% of the postdocs accepted their first fellowship in countries outside of Africa. The short-term nature of these positions in a foreign country brings its own challenges, as one interviewee explained:

> *The only problem that it is usually very short. So, it's hard, coupled with a social settling and you also have to do the work. It's a bit hard in France, especially in Brittany, where people speak French. And I hardly knew any French when I came. So, it's the social integration most of the time.*

6.6. Reasons for serial postdoctoral positions

The percentages of respondents who indicated each of eight reasons for accepting one or more additional postdoctoral fellowships are presented in Table 38 below. The distribution is somewhat different from that found for the same eight reasons for accepting a (first) postdoc after the PhD (Table 37). Most notably, whereas the lack of other employment options was only the fourth most frequent reason (cited by 28% of respondents) for taking a postdoctoral fellowship after the PhD, it is the most frequently cited reason for taking one or more postdocs after the first (41%), followed by the need to carry out research independently (36%), still in second place, but cited by a lower percentage of respondents.

Table 38 Lack of employment positions cited as the primary reason for doing multiple postdocs

Reason	n	%
Other employment was not available	172	41%
To carry out research independently	149	36%
To work on a specific project/study	125	30%
To gain additional training in the field of my doctorate	119	29%
To gain training in an area outside of the field of my doctorate	107	26%
To work with a specific person or in a specific place	100	24%
This type of position is generally expected for a career in my field	71	17%

Reason	n	%
To carry out and support teaching activities	28	7%

This is an important finding, in that the rationale for multiple postdoctoral fellowships is rooted in a lack of other employment opportunities. This is supported by the qualitative data. As an interviewee explained, the reason for "sticking with" long-term postdoctoral positions in the academic environment is the potential for growth, and for getting a [permanent] position. But [in] 90% [it] doesn't seem to be the case, because the university doesn't want to hire". Another interviewee agreed that, currently, the "common opportunity that we get is the postdoc. So, it's postdoc after postdoc. There's no permanent job at the moment." When asked whether the interviewee would accept another postdoc, her answer was affirmative, "because if I can find work, rather than sitting at home, I will take another postdoc". As his postdoctoral contract was coming to an end, another interviewee "was also busy on the lookout for other positions. I was applying for jobs. I had applied for another postdoc ... in Washington. Luckily, I got the postdoc fellowship, so I'm on it now".

In another case, an interviewee moved from a first postdoctoral position at a South African higher education institution to a second one at a South African science council, because at the science council, "there were more chances that I was going end up being employed internally". In addition, the second postdoctoral position was more aligned with the interviewee's background: "I was going to continue along the same lines" as "my PhD background," he said.

An interviewee who accepted multiple one-year postdocs at different universities in South Africa explained, "I ha[d] a few interviews, but I was still unable to land a job. That was the biggest challenge: I was just not able to land a job. So, [I got] another postdoc". The same interviewee provided an additional reason for taking more than one postdoctoral fellowship, namely securing funding for more than one year. After moving from Grahamstown to Cape Town, he spent one year in a fellowship at UCT, until "the funding [ran] out", which led him to take another postdoc position back in Grahamstown. After this, he "ended up taking a postdoc in the US". He took that position, "because they had assured me that there was enough money for three years ... a pot of money for three years".

Moving geographically from one short-term postdoctoral position to another, even within one country, creates financial and other difficulties, as he explained:

> *The sad thing is you're having to move; there's a cost of moving from Makhanda/Grahamstown to Cape Town, only for a year. And now you have to move your family again and move back. It's very difficult ... [it's] so uncertain, such a high level of uncertainty, for someone that has a family ... It's unfair on the researcher, because then, I was under a lot of pressure. You're also trying to publish in that year; you're trying to make sure that it's worthwhile. So, you spend a lot of time just trying to publish, but there's so little time.*

The qualitative data provided insights into other disadvantages of being in long-term or multiple postdoc positions, namely, that one stagnates professionally, and specifically that one cannot be promoted or receive a salary increase. But here again, the qualitative data highlight a tension between the advantages and disadvantages of long-term postdoctoral positions, which two interviewees expressed as follows:

> *There are a lot of postdocs that are frustrated – just talking to my friends within my cohort, I know the frustration. I have a friend: he's been doing the same postdoc, which is great, because he's in his fifth year, the same postdoc. It's kind of good, because it gives him some level of permanence, I think.*

People can say that when you continue only on postdoctoral, you're growing in your personal development, but you are not growing in status. So that's the disadvantage. We are growing in personal development, which may eventually help you to grow your status. But really, your status is not changing. You can't be promoted. I mean, you can't be given any salary increment.

A third interviewee pointed out only the disadvantages, for example, "if you keep on living [on] a bursary, you also can't really go to a bank and get a loan if you want to buy a house or a car".

Serial postdocs voiced some criticism. One person expressed the view that "these one-year postdocs" should not "be allowed". Another described how she "had extensive discussion with colleagues", about the issue that "the postdoc position was created to get a lot of cheap labour from highly qualified people". She explains how the universities that host postdoctoral fellows benefit financially from the fellows' non-permanent positions, by saving "some money" on salaries. "[T]he university gets a lot of work and publication from people that are qualified for probably a more secure position ... They think that they are going to save money by doing that."

However, by not employing postdocs permanently after their first postdoctoral fellowship (which she also ascribes to universities' lack of "long-term planning") the universities are losing "loyalty and the energy of someone that is 30 years old, has a lot of idea[s], a lot of ... [vision] and energy and [wants] to grow that". This issue is important from a gender perspective, as she explains:

Mostly for woman … it's complicated, because as you know, if you want to have kids, whether it's biology or society, [it] becomes difficult to wait so long. And then a lot of us decided now, stuff it, I'm going to rather have kids and I cannot put as much effort into research for the small salary. So, they ... stay at home, or they look for a job outside the academic environment.

And for those who remain, "there is this feeling of, 'well, I could build something here but what's the point, if in five years, I'm not going to be hired, I have to move away and go [to] another university' ". Thus, she concludes that, among her postdoc colleagues,

The feeling is the university is going to lose out if that's going to carry on that way. A lot more than the money that they're saving. It's like having a very fast turnaround of new people in a business, then you train them, and then you let them go to get someone [cheaply] again. The business is going to eventually suffer, because you're not building up and training your next generation.

Her suggestion is that the "lot of potential" that exists in the form of postdoctoral fellows "should be rewarded better or maybe ... more filtered, so you get less position but then there is a sort of progression so that you can ... have the two options available." Options are important, she argues, "because we're not all the same". Some postdocs,

Eventually stay and some [..] know that this is a short time and then they have to move ... Some people love the idea of having one year here and another year in another university and two years overseas. By all means, live that freedom.

Some postdocs do, however, choose a permanent position, rather than accepting a second or third postdoctoral fellowship, even the fellowship is abroad and relatively well-remunerated:

I saw these adverts, then I put in an application in Korea. And the professor immediately wrote me that

they want me to come in two or three-months' time, for two or three years at R600 000. It is 45 million [in] Korean money. So, I've got another postdoc there for three to four years. At the same time, again, I've got another one [at a South African university]. So [I was] about to go to Korea. Then [another South African university] said, 'Come for an interview'. It's better to get a permanent position.

6.7. Geographic mobility of postdocs

In this section, we provide some insights on the extent to which postdocs constitute a brain gain for South Africa. First, we consider the extent to which South Africa has benefited from the influx of PhDs from the rest of Africa, who remained in the country as postdocs. We therefore determined postdocs' region of nationality during their PhD studies. As Figure 59 below shows, a total of 40% (n=473) of postdocs were not South Africa nationals at the time when they graduated with a PhD. They were either nationals of countries in the rest of Africa (31%; n=369) or in the rest of the world (9%; n=104).

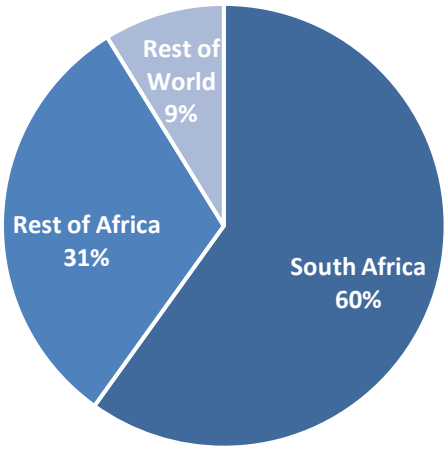


Figure 59 Postdocs' region of nationality at the time of PhD graduation (n=1 180)

Figure 60 below shows that, among the PhD graduates who were South African nationals at the time of their PhD, a lower percentage (18%) took a postdoc position after their PhD than those with nationalities in the rest of Africa or the rest of the world (25% each). The difference is statistically significant[30].

[30] Pearson chi-square = 35,649614, df = 2, p = 0,000

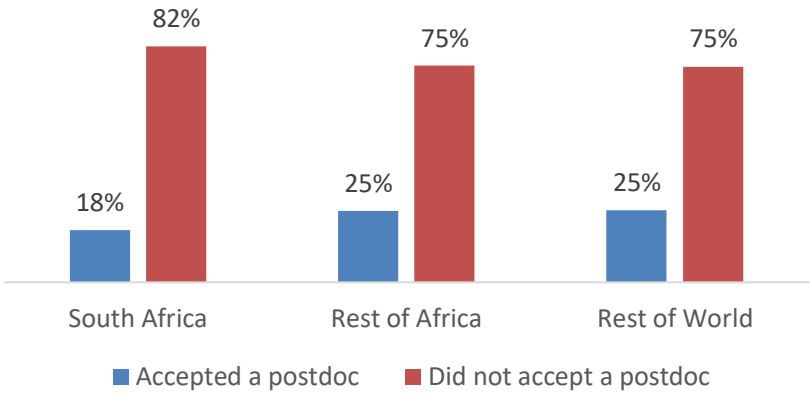


Figure 60 Acceptance of postdoctoral position after PhD, by region of nationality during PhD

The second aspect of the brain gain component of the science system that we investigate involves the geographic location of the postdoc positions that were accepted. We compare the geographic locations of the first (n=1 198), second (n=397) and third postdocs (n=114) that were accepted (Figure 61).

Among those respondents who accepted a postdoctoral fellowship upon completion of their doctoral degree, by far the majority (82%; n=978) accepted such a fellowship in South Africa; only 1% (n=11) moved to the rest of Africa, while the remaining 17% (n=209) accepted their first postdoc in the rest of the world. The average duration of the 978 postdocs located in South Africa was two to three years.

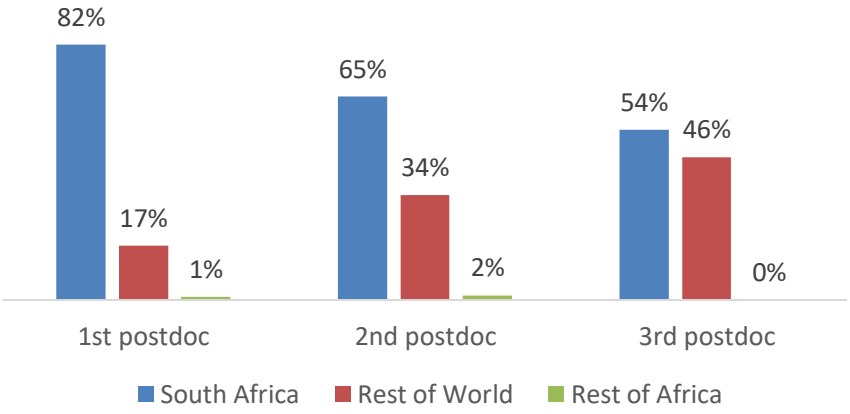


Figure 61 Geographic location of first, second and third postdoctoral fellowships

Among the respondents who accepted a second postdoc, the percentage that remained in South Africa was much lower (65%) than among those in their first postdoctoral position after the PhD. We see a notable, twofold increase (to 34%) among those who accepted a postdoctoral position in the rest of the world. Although the percentage of respondents who accepted their second fellowship in the rest of Africa increased slightly, it remains very low (at 2%). Among the 144 respondents who provided data on the location of their third postdoctoral position, those who did so in South Africa dropped even further, to 54%, and those who accepted a third position in the rest of the world comprised the remaining 46%, as none of those third postdoctoral positions were located in the rest of Africa.

As already mentioned previously, one interviewee who had been in three short-term postdoctoral positions in South Africa took a fourth one abroad, because the funding was more secure, for a longer period (three years). He added that his decision was also informed by the possibility that "maybe getting some international exposure would be beneficial". Another interviewee was, in retrospect, sceptical about the advantages of an overseas postdoctoral fellowship: "[T]he time in Germany was useful, but not necessarily so much more. I think, in the end, a lot of what I did there, I could have just done in South Africa," he said. He conceded that, "certainly, you make some new acquaintances,", and that –

> *There was certainly one collaboration that we struck up while I was there, which did help, which is specifically with a guy ... in Germany. So, he ended up, later on, running this big ... programme ... and pulled me in.*

However, the interviewee ascribes this collaboration more to serendipity than a postdoctoral fellowship in another country, and downplays its significance somewhat:

> *That was time and place. It was basically because I was sitting one floor down from him in the same building. And he was looking for an early-career researcher who was interested in [my field of specialisation], and so, it was just being in the right place. And that then, in the end, also contributed to just little collaborations on that programme, specifically. It wasn't, for my own research career, a major thing. But it did help to have a name on one or two bigger papers and things down the line, where I contributed just a little bit. So, I wasn't lead on any of these programmes, but it did help.*

On the other hand, for another interviewee, his postdoctoral position abroad was very valuable from what he refers to as "a technical point of view":

> *Because working in a different environment itself is something you can't teach on paper. And also, observing how people work. And just knowing what people do ... I think we kind of underestimate the social aspects you learn from actually being in an environment. And that's something you can't get from anywhere else. Even if you can't get it from a conference or a lecture, just learning the ways of how people do things and meeting new people, honestly. So, it has been very valuable for me.*

In particular, his postdoctoral fellowship overseas assisted him in developing a broader view of research:

> *It's helped me to have a life outside academia, because in Europe, I guess also in North America and Asia, there is a very big ... interrelatedness between academia and industry, private industry. And I imagine also government and policy. So, there are different aspects, there are different ways the university, or you as a student, would interact with people in maybe non-profits. But ... in the sector [I work], with industry, which is a very, very big part of research in any case, because that's where new ideas come, that's where they're tested. And in the smaller economies, we missed that because you always think, okay, when I do a PhD, I'm going to go and become a lecturer, who just teaches, but then you forget that there's also this whole different industry, very big industry, much bigger maybe than the academia itself, where there's scientists working with companies and working as consultants. And so, that has been very important from my side. To actually see PhDs working at companies and solving*

problems and creating new products, basically in the whole R&D industry. So, it has definitely been very valuable from an awareness point of view.

In addition, for this interviewee, the postdoctoral position abroad was valuable from a "skills point of view". He explains, "I've built up a lot of skills, which I definitely couldn't in South Africa, because our group was small and we didn't have a lot of money. So, it's just hard to do all this fancy science." The same interviewee spent six months in Ireland at an organisation that "is very keen on" the postdoctoral fellows "going to conferences and building up networks," he said. "As a postdoc, you were evaluated on these things, and they'll pay for them ... In those six months, I did attend training and things like that. So, they were really up on that".

Another interviewee's postdoctoral advisor at a university abroad played an important role in securing his current employment (albeit temporary) in the same country. The advisor "connected me with some people he knew from here that needed someone to teach biology for a semester," the interviewee explained.

The postdoctoral positions taken in South Africa have been further disaggregated by the South African higher education institution that hosted the positions (Figure 62 below). Some trends from first to second and third postdoc position are highlighted (some caution is recommended in interpreting these figures, as the number of postdocs is quite small, especially in the case of the third postdoctoral fellowship). Among the 926 respondents who took a first postdoc position at one of 23 South African higher education institutions, 59% were at just five institutions, which are (in descending order) UCT (17%), SU (16%), UKZN (10%), and UP and Wits (at approximately 8% each).

When the second postdoc positions (n=241) at 20 South African higher education institutions are considered, 62% were hosted at six institutions, and the pattern changes from the first postdoc position. Most notably, SU (19%) moves to first place, and UCT (12%) to second. UP, in third place, now takes a larger share (11%). UKZN (7%) moves to fourth place, which it shares with Unisa (previously in 11th place, at 2%) and RU (previously 7th place at 6%). Wits moves down to fifth place, at 6%. Among the small number (n=59) of respondents who took a third postdoc position at one of 16 South African higher education institutions, we find an increase in concentration (69% at six institutions), but the pattern is similar to the one found for second postdocs, with SU first (at 17%), UCT second (at 15%), UP third (at 14%), Wits fourth (at 10%), and UKZN and RU sharing fifth place, both at 7% each. At the third postdoc, Unisa drops back to seventh place, at 3%.

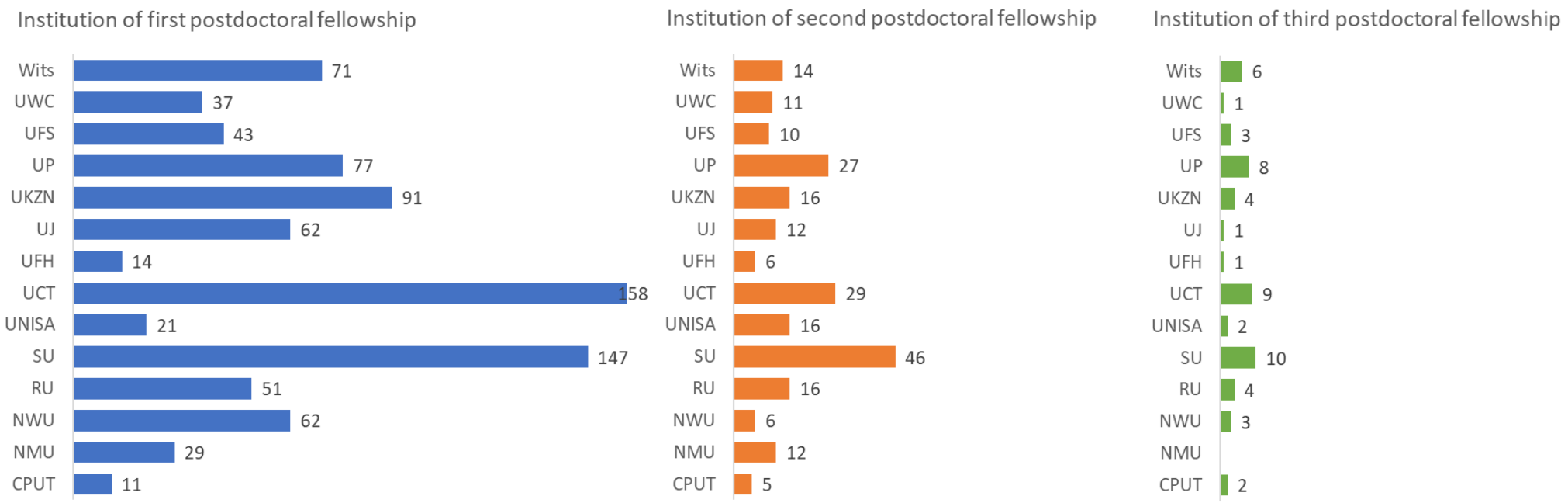


Figure 62 South African higher-education institutions hosting respondents in their first, second and third postdoctoral positions

6.8. Employment after the postdoc

In Section 6.6, the qualitative data showed that an additional reason for accepting a postdoctoral fellowship after their PhD is as a stepping stone to employment in academia, and the postdoc is valued for enhancing employability in academia. In this section, we analyse the current employment status of all the respondents who accepted a postdoc position after their PhD. We caution that current employment status does not take into account that some respondents were postdocs as far back as 2001, and have in the meantime developed their careers, while other respondents only recently concluded their postdoc positions, or are even currently in postdoctoral positions.

Figure 63 shows that 69% of respondents who accepted a postdoc after their PhD are currently employed, while 21% are still in a postdoctoral position. Only 5% are self-employed, while the remaining 4% are not economically active.

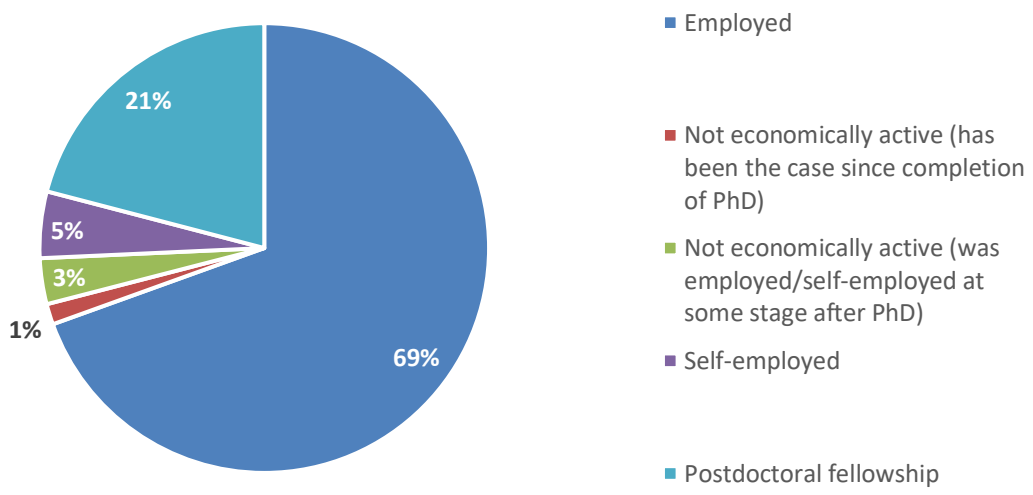


Figure 63 Current employment status of respondents who accepted a postdoctoral position after their PhD

If we compare the postdocs and non-postdocs in terms of their current employment (Figure 64), we find that the postdocs are proportionately less likely to employed, or to be self-employed, than those respondents who did not accept a postdoc after their PhD.

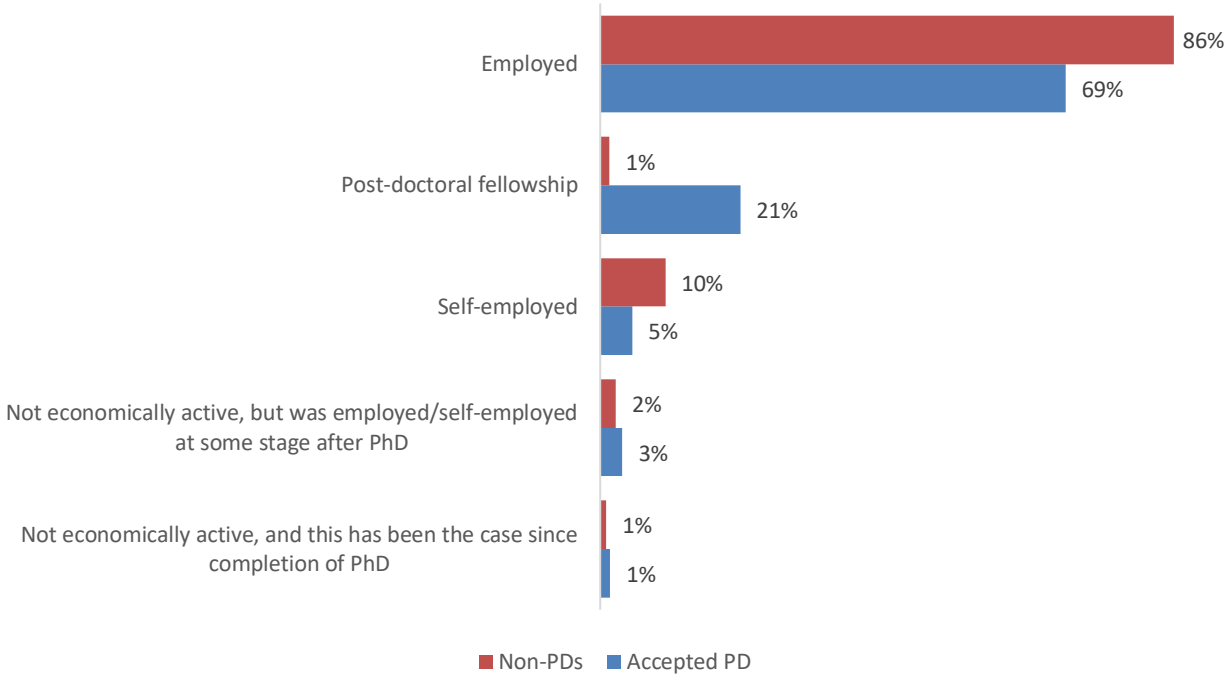


Figure 64 Current employment status, by acceptance of postdoc after PhD

Figure 65 shows that, of the 843 previous postdocs who were employed, the majority (80%) were working in the higher education sector, 12% in the government sector, 6% in the business enterprise sector, 4% in the private non-profit sector, and less than 1% in the "other" education sector, such as schools.

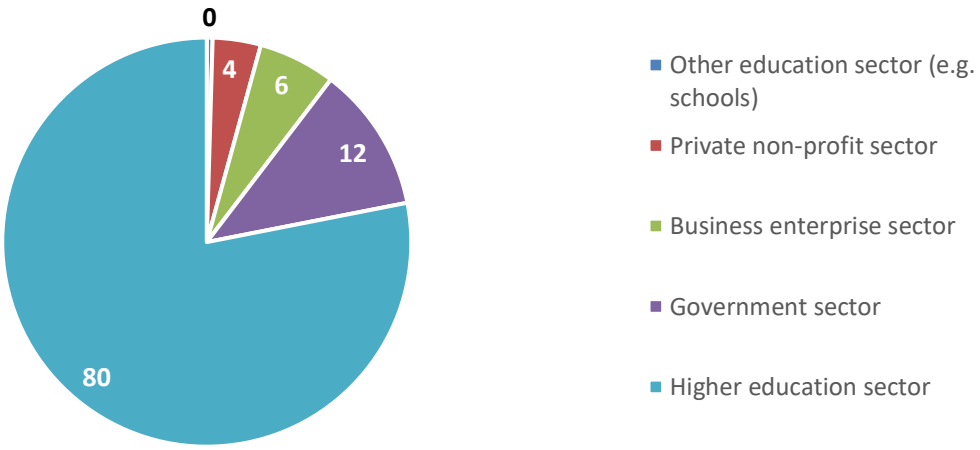


Figure 65 Sector of employment of currently employed respondents who accepted a postdoctoral position after their PhD

Of the previous postdocs who are employed, 38 reported that the nature of their work is cross-sectoral. Of the 796 whose work is not cross-sectoral, and who provided the relevant data, 81% (n=646) remained in the same sector they were in before graduating with a PhD, while the remaining 19% (n=150) changed their sector of employment after graduation.

Although only 14% of the postdocs are currently employed at the same institution that hosted them as postdoctoral fellows, the interview data seem to indicate that postdoctoral fellows tend to apply, or are invited to apply, for permanent positions at the same university where they are fellows:

> *They gave me the opportunity to do a postdoc for two years. Whilst I was doing the postdoc, that's where the opportunity for a lecturer opposition came up and then I applied for it. Yes, that's currently what I'm doing now.*
>
> *And then, while I was busy with [the postdoc], they actually advertised the position at the university and I was the only applicant. That's how I landed my first academic job.*
>
> *So they moved me from a postdoc or I applied for that subject specialist position with the aim of, if I do get it, to run the [taught master's]. So, ... long story short, after a few years, they changed the subject specialist position to a senior lecturer from August, October last year. Because most of my work was academic and not technical as the position sort of dictates.*
>
> *I think it helped me get the foot in the door, initially...*
>
> *... based on my contribution and my experience, which acquired, I was invited to join the teaching staff.*

Of the 473 postdocs who were not South Africa nationals at the time when they graduated with a PhD, 77% (n=365) are currently employed, and 41% of those (n=151) are currently employed in South Africa.

Our final analysis in this chapter (Figure 66) considers the employment trajectories of the approximately 400 respondents who accepted more than one postdoctoral fellowship after their PhD. Of these "serial postdocs", the majority (61%; n=247) are currently employed, while a further 30% (n=119) are still in postdoctoral positions. The remainder are either not economically active (5%; n=20), or self-employed (4%; n=16).

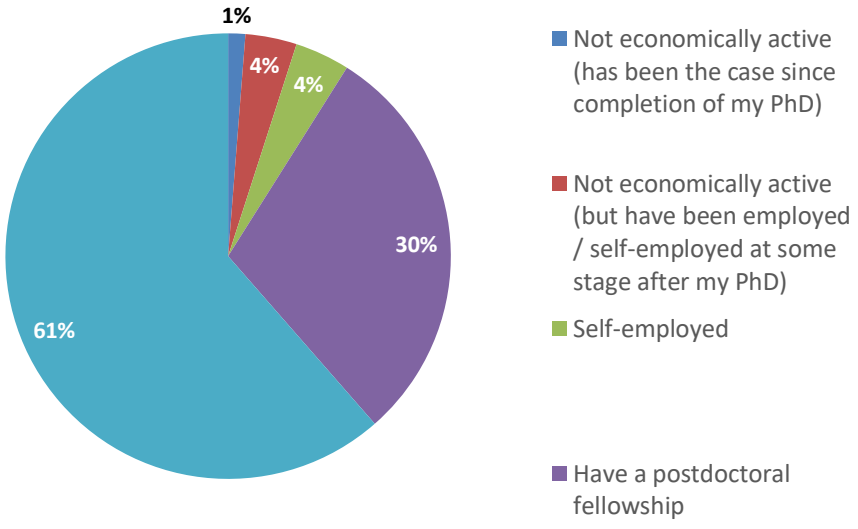


Figure 66 Current employment status of respondents who accepted more than one postdoctoral fellowship after their PhD

To determine whether different employment patterns emerged for those who were appointed in only one postdoc and those who reported multiple postdocs (especially considering the main reason for serial postdocs reported in Section 6.6), we compare these two subgroups proportionately. Table 39 below shows that respondents who indicated that they had done more than one postdoctoral fellowship were most likely to be in a postdoctoral position at the time of the survey (30%) than respondents who only completed one postdoctoral fellowship (21%). This difference is made up by graduates who only completed one fellowship and who were employed at the time of the survey (69%), compared to a smaller share of employed multiple postdocs (61%). In terms of self-employment and not economically active graduates, we find no differences between postdocs' employment trajectories.

Table 39 Comparison of postdoc and multiple postdocs' employment status at time of the survey

	One postdoc	Multiple postdocs
Employed	69%	61%
Self-employed	5%	4%
Postdoctoral fellowship	21%	30%
Not economically active	4%	5%

Figure 67 presents a disaggregation by sector of employment of the 247 serial postdocs who are employed. By far the majority (84%; n=207) indicated the higher education sector as a sector of employment. A further 13% (n=32) have found employment in the government/public sector, and 6% (n=16) in the business enterprise sector. The private non-profit sector is currently employing only 2% (n=6) of the previous "serial postdocs", and none of those postdocs are currently employed in "other" education sector (e.g. schools).

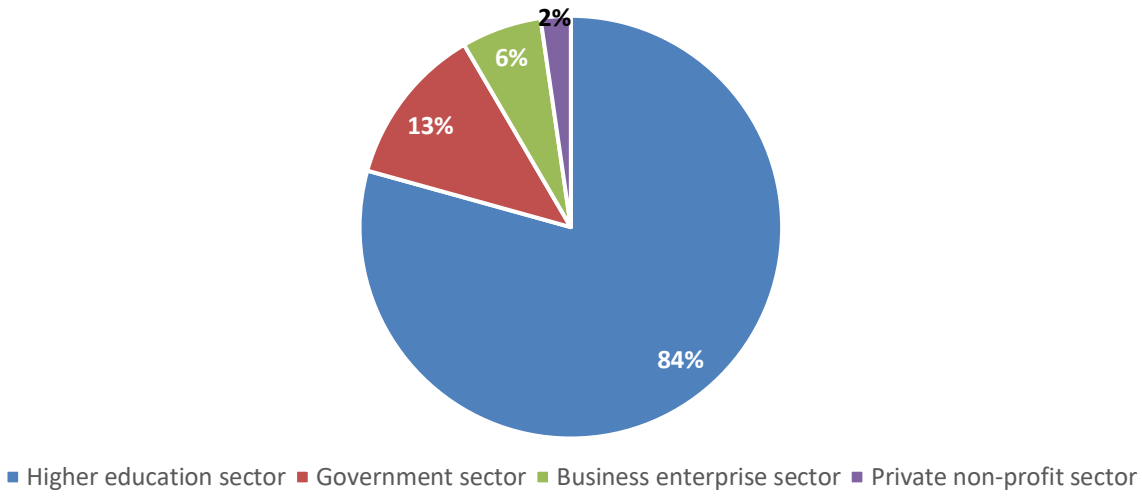


Figure 67 Sector of employment of currently employed respondents who accepted more than one postdoc after their PhD

6.9. Summary of key findings

A fifth of the SA doctoral graduates that we surveyed accepted a postdoctoral fellowship after completing their doctoral degree at some time over the past 19 years. Over the past two decades, the relative shares of these postdocs has grown significantly. The growth has been particularly steep since 2011, and most pronounced among the economic and management sciences, especially when compared to the biological and environmental sciences, where the postdoctoral system seems to have become saturated. Across the two decades, the postdocs have been best represented among the biological and environmental sciences, and in general in the STEM fields, while they are least likely to be found in the SSH fields, especially in the domain of education.

Although slightly more than half of the postdocs are male, the genders have been equally likely to accept a postdoctoral fellowship after their PhD over the period studied, and irrespective of the field (STEM or SSH) in which they had graduated. Thus, where postdoctoral fellowships in general are concerned, gender representation does not seem to require urgent intervention. However, at the level of science domain, the comparatively low representation of female postdocs in the engineering and applied technological science, as well as in the physical, chemical and mathematical sciences, remains a matter of concern, much less so than in the health and medical sciences, the biological and environmental sciences, or the social sciences.

On average, postdocs obtained their PhD at a much younger age than non-postdocs did, especially if they graduated with a PhD in the STEM fields. While the majority of postdocs spent an average of three years in a fellowship position, approximately a quarter were in postdoctoral positions for more than four years, and one in three may be termed "serial postdocs", who accepted one or more postdoctoral positions after their first fellowship. Our data – both quantitative and qualitative – indicate that the majority do so not out of choice, but rather because of a lack of employment opportunities, especially in the academic sector, where they prefer to find permanent positions. Importantly, these serial postdocs are even younger when they graduate with their PhD than their single-postdoc counterparts.

These results, together with the slow growth of postdoctoral fellows in some fields, are important from a policy perspective. The NRF's latest funding policy is to support only PhDs who are 32 years or younger at the time of commencing with their doctoral studies. Such a policy may lead to a reduction in the average age of doctoral graduates, which is likely to further increase the proportion of graduates seeking postdoctoral fellowships, especially in the STEM fields. Although our results show that such fellowships have benefits, other results lead us to conclude that the South African science system is reaching capacity it its ability to absorb increasingly younger graduates, whose lack of full-time employment options leads them to apply, often repeatedly, for a finite number of fellowship positions. The biological and environmental sciences are of particular concern, based upon their slow growth rate in postdoctoral fellowships (the slowest in all domains), and highest likelihood to host serial postdocs.

The reasons for taking postdoctoral positions are mainly to gain additional training in the field of one's PhD and to carry out research independently, but the ultimate goal is to secure a permanent position, especially in academia. Our qualitative data show how these and other expected benefits of the postdoctoral fellowship were mostly realised in the cases we interviewed, while the quantitative data show that the majority of postdocs, and especially serial postdocs, have indeed found employment in the

higher education sector. The qualitative data do, however, alert us to many negative features of postdoctoral fellowships, and the lack of full-time employment opportunities that most likely have fuelled the dramatic increase in postdoctoral positions since 2011. In Mertonian terms (Merton, 1968), we observe a social pattern that is functional for the science system as a whole, while being dysfunctional for certain individuals within that system.

A social pattern that is working for the South African science system is the tendency for PhD graduates who were nationals of other countries during their PhD studies in South Africa to remain as postdocs in South Africa, at least for three years. Of these, a substantial proportion gained full-time employment in South Africa afterwards. We combine three sets of results to support our conclusion that these PhD graduates constitute a brain gain for the country. First, by far the majority of postdoctoral positions were taken up in South Africa. Secondly, a relatively large proportion (40%) of the postdocs were not South Africa nationals at the time when they graduated with a PhD in South Africa. In fact, South African nationals were proportionately (and significantly) less likely to take a postdoctoral position after their PhD than nationals from other countries. Lastly, of the postdocs who were not South Africa nationals at the time when they graduated with a PhD, more than two thirds are currently employed, and 41% of those are currently employed in South Africa.

Chapter 7: Geographic mobility of doctoral graduates

In this chapter we explore the geographic mobility of doctoral graduates throughout their careers. Geographic mobility is defined as the movement of graduates between countries. We explore both the inbound and outbound mobility flows of South African and non-South African graduates. In the previous chapter we discussed the geographic mobility of postdoctoral research fellows. Determining the mobility of doctoral graduates provides evidence for the "brain gain", "brain drain" and "brain circulation" discourse in the knowledge system.

7.1. Introduction

A small number of mobility studies have been conducted in South Africa, including Meyer and Brown (1999), Kahn et al. (2004), Kaplan (2008), Erasmus and Breier (2009), Höppli (2014), and Kaplan & Höppli (2017). (As can be seen from the dates of these reports, we do not have recent statistics on the mobility trends of South African graduates. All of these studies function at the macro level, especially through the use of foreign recipient country immigration databases and other secondary data. In 2013, close to 750 000 South African-born individuals (the majority of whom are classified as highly skilled) resided in 23 major destination countries (Höppli, 2014; Kaplan & Höppli, 2017).

One of the main objectives of our study was to determine the flow of doctoral graduates into and out of South Africa. Survey respondents were asked about their geographic mobility during two stages of their careers. Firstly, respondents were asked to describe their original plans upon completion of the PhD and then to indicate what had actually happened in the first year following completion of their studies; secondly, respondents were asked to indicate in which country their most recent employment position was primarily located. As discussed previously in the report, respondents' nationality during the PhD was taken as a proxy for the country of birth of respondents and this provides the basis for our analysis of geographic mobility.

In this chapter we thus report on the general trends in the mobility of graduates. We explore the mobility of graduates within the first year of completing their doctoral studies as well as the reasons underpinning their mobility choices. We then determine the mobility of graduates leading up to their most recent employment.

7.2. General trends in the geographic mobility of graduates from South African universities

In Figure 68 below we show survey respondents' geographic mobility within the first year after completing their doctoral studies, by respondents' nationality during the PhD. The results are summarised in Table 40.

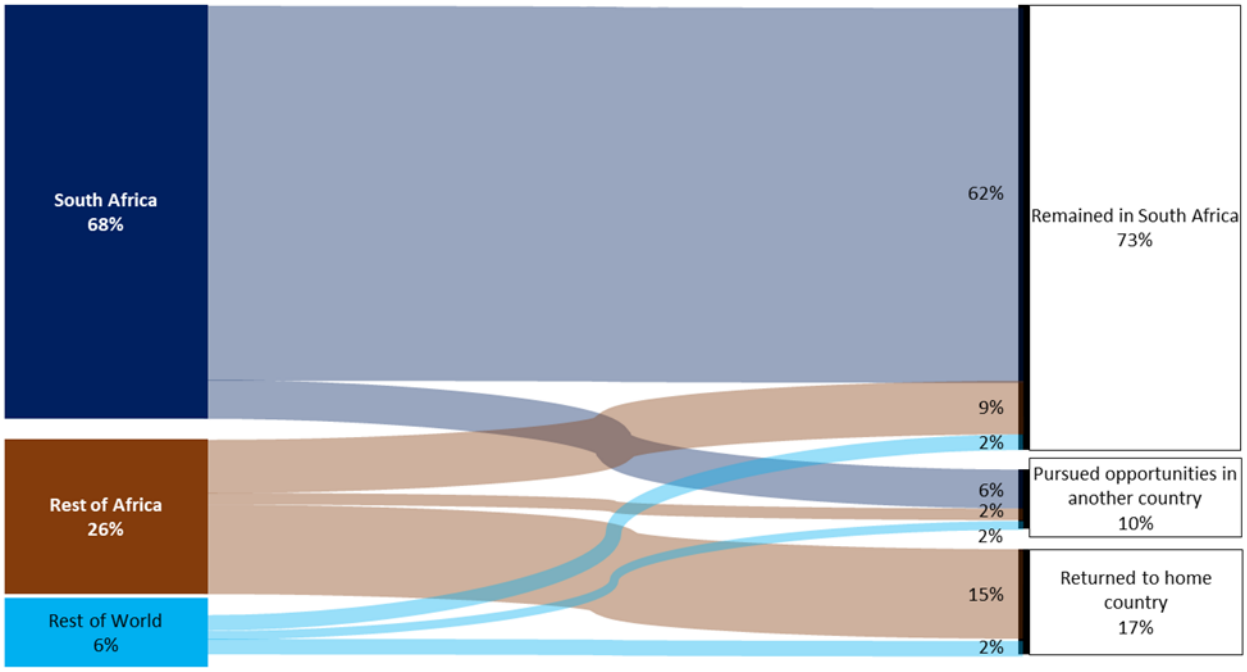


Figure 68 Geographic mobility within first year of obtaining the doctorate by nationality of graduates

The Sankey diagram above shows that:

- The majority of South African nationals remained in South Africa after completion of their studies. A relatively small percentage (6%) pursued opportunities elsewhere in the world.
- The second largest group (26%) in our study were doctoral students from the rest of Africa. The majority of these returned to their home country, but nearly one in three remained in South Africa after graduation. A small percentage pursued opportunities elsewhere in the world.
- Of our total sample, 6% were students from outside Africa. About half of them remained in South Africa, while a third returned to their home country after graduation.

Note: The percentages reported in the Sankey diagram refer to the percentages of subgroups of the *total sample*, while the percentages reported in the table below refer to the share of observations per subgroup reported. In other words, the 352 South African respondents who pursued opportunities in another country make up 6% of *all respondents*, but 9% of *South African respondents*.

Table 40 Geographic mobility of doctoral graduates within the first year after completing PhD

During the first year after completing your PhD, what actually transpired?								
Nationality during PhD in three categories of regions	I remained in South Africa		I returned to my home country		I pursued opportunities in another country		Other (please specify)	
	n	%	n	%	n	%	n	%
South Africa	3 418	89,9%	-	-	352	9,2%	31	0,8%
Rest of Africa	490	34,0%	817	56,7%	108	7,5%	27	1,9%
Rest of the world	143	38,6%	138	37,3%	79	21,4%	10	2,7%

The figures below show the geographic mobility of black and white graduates. We find that a larger percentage of white graduates 11% (n=1 781) went abroad immediately after completing their doctoral studies compared to 7% (n=1 174) of black graduates[31].

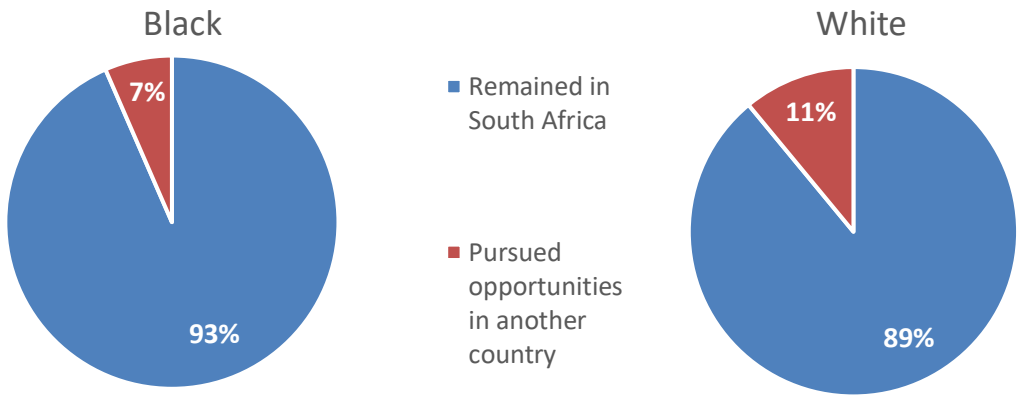


Figure 69 Mobility of black and white graduates within the first year of completing their doctoral studies

In Figure 70 below we look at the in and outbound mobility of doctoral graduates after the first year of obtaining their doctoral qualification by scientific domain. The results show that graduates in the health sciences (78%), education (77%), and social sciences (76%) were most likely to remain in South Africa upon completion of their doctorates.

We see that international graduates, mainly those from Africa who return to their home countries upon completion of their doctoral studies, studied for doctorates in agriculture (30%), physical, chemical and mathematical sciences (22%), and humanities and arts (20%). When we look at the outbound mobility of graduates by field, we see that the largest share of graduates who pursued opportunities abroad upon completion of their doctoral studies were in the biological and environmental sciences (14%), physical, chemical and mathematical sciences (12%), and engineering and applied technical sciences (11%).

[31] Pearson chi-square = 86.794, df = 4, p = 0,000.

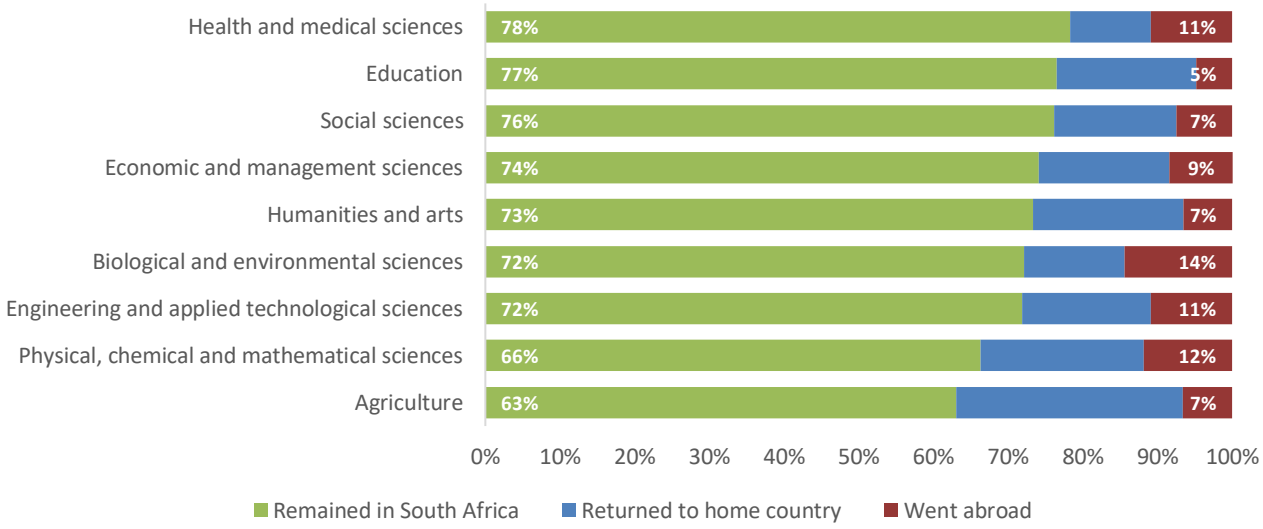


Figure 70 Geographic mobility during first year after PhD per scientific domain

These findings suggest that we are more likely to retain graduates in the social sciences (including education, management and economic sciences, humanities and arts) in South Africa, while graduates in the STEM sciences are more likely to be geographically mobile. This is an important finding given the policy imperatives to expand the STEM skills base in the country. We have shown throughout this report that STEM graduates, especially in the biological and environmental sciences, are more likely to take up a postdoctoral position, and these positions often give graduates important international exposure. The question is however, do these postdocs return to South Africa?

In Figure 71 below we illustrate the country in which graduates' employment at the time of the survey, was primarily located. We see, once again, that graduates in the social sciences and health sciences remain in, or return to South Africa, where graduates in the biological and environmental sciences, humanities and arts, and physical, chemical and mathematical sciences, are more likely to work outside South Africa.

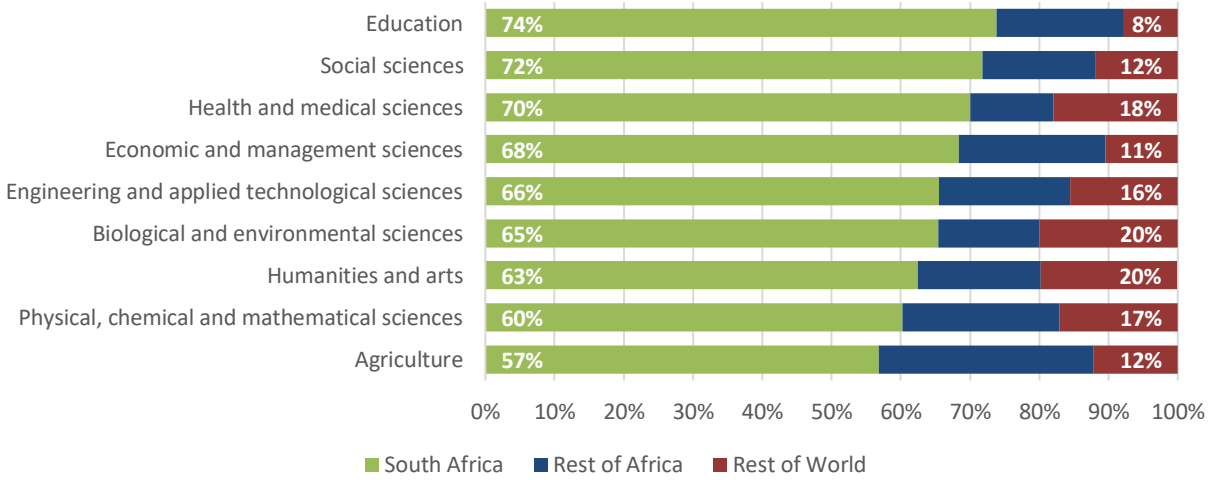


Figure 71 Country of employment by scientific field

7.3. Motivations underlying graduates' mobility choices

Respondents who indicated that they had remained in South Africa during the first year after completion of their studies were asked about their reasons for remaining in South Africa (respondents could choose more than one option). The most frequently reasons for staying in South Africa after graduation were family or personal reasons (n=2 476), followed by academic factors such as a position at a South African university, postdoctoral studies, and being a member of a research team (n=1 483). Seven percent (n=239) of South African respondents listed factors associated with the social, political or economic environment of South Africa as a reason for staying in the country.

Table 41 shows that for non-South African citizens, academic factors (RoA, n=362; RoW, n=85) were the most cited reason for staying in South Africa within the first year of completing their doctoral studies. One out of five (21%, n=105) African graduates (RoA) considered the socio-political context in their home countries as motivations for remaining in South Africa upon completion of their doctoral studies.

Table 41 Reasons cited for remaining in South Africa within first year after graduation[32]

	South Africa		Rest of Africa		Rest of the world	
	n	%	n	%	n	%
Family or personal reasons	2 476	72%	130	27%	76	53%
Academic factors	1 483	43%	362	74%	85	59%
Economic factors	558	16%	90	18%	24	17%
Issues related to the social, political or economic environment in my home country	239	7%	105	21%	1	1%

Among respondents who left South Africa upon completion of their studies, the top reasons for South African citizens included academic factors (n=198) and economic factors (n=125). For non-South African citizens, the most cited reason for leaving South Africa included family or personal reasons (RoA, n=381; RoW, n=99) followed by academic factors (RoA, n=247; RoW, n=70) as shown in Table 42.

Table 42 Reasons cited for leaving South Africa upon completion of doctoral studies

	South Africa	Rest of Africa	Rest of the world
Academic factors (e.g. position at a university, postdoctoral studies, academic opportunity in a field)	198	247	70
Economic factors (e.g. non-academic job offer, job search)	125	124	45
Family or personal reasons	111	381	99
Issues related to personal safety (e.g. xenophobia)	80	105	24
Issues related to visa or residency in South Africa	24	159	35

Table 41 and Table 42 thus show that the primary motivations for mobility into (or remaining within) graduates' home countries are family or personal reasons. When we look at the reasons given for leaving South Africa immediately after completion of the PhD between black and white graduates we see no substantive differences. The only difference is observed among graduates who cited issues related to

[32] Note that respondents could choose more than one option and the percentages therefore do not add up to 100%.

personal safety, where 16% of white respondents were concerned about their safety compared to 7% of black graduates.

7.4. Brain drain, brain gain or brain circulation

In the following section we explore the mobility of graduates between the first year after graduation to their most recent employment position held at the time of the survey. At the time of the survey, more than two thirds (n=3 649) of doctoral graduates' most recent employment was primarily located in South Africa. This compared to 18% (n=993) who were employed in an African country, and 15% (n=834) who were employed elsewhere in the world, as shown in Figure 72.

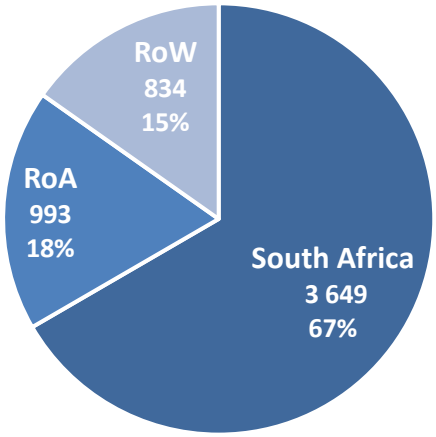


Figure 72 Graduates employed in South Africa at the time of the survey

In Figure 734 and Table 43 below we look at the mobility of South African doctoral graduates between the first year after completing their doctoral studies and the time of the survey. We note the following:

- The largest group in our sample, as illustrated by the dark blue band in the left-hand column, shows that the majority of respondents who remained in South Africa after completing their studies were still employed in South Africa at the time of the survey.
- In terms of outward mobility of South African graduates, 7% of South African graduates who initially remained in South Africa after completing their doctoral studies were, at the time of the survey, employed outside of South Africa. One percent (n=31) were employed in an African country, while 6% (n=211) held employment in a country outside the African continent.
- When we look at South African graduates who left South Africa after the completion of their doctorate degrees (n=352), 10 respondents were currently employed in Africa, while the majority were employed elsewhere in the world. In total this constitutes 7% of our total sample.

Note: The percentages reported in the Sankey diagram refer to the percentages of subgroups of the *total sample*, while the percentages reported in the table below refer to the share of observations per subgroup reported. In other words, the 352 South African respondents who pursued opportunities in another country is 6% of *all respondents*, but 9% of *South African respondents*.

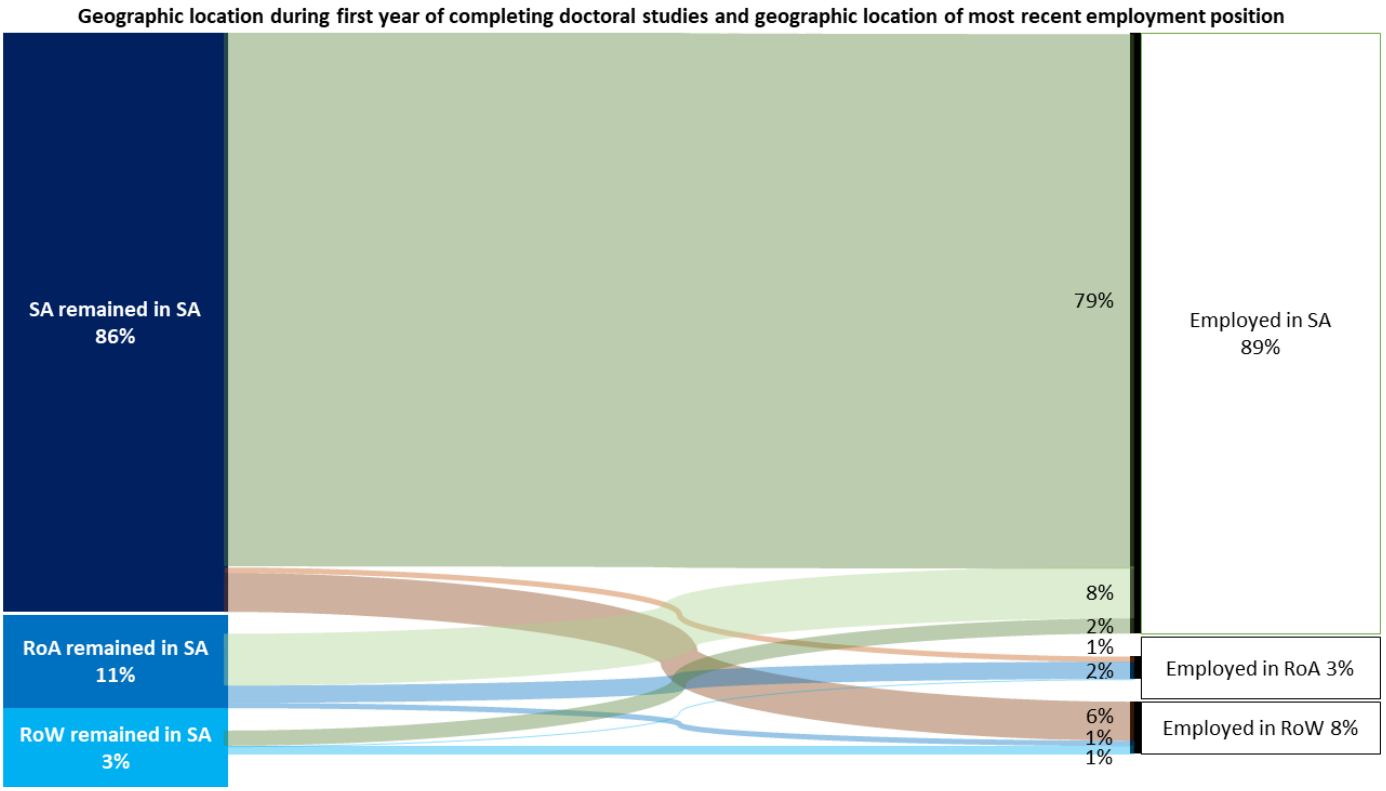


Figure 73 Inbound and outbound mobility of South African citizens

Table 43 Inbound and outbound mobility of South African citizens

	Total	Currently employed in South Africa		Currently employed in rest of Africa		Currently employed in rest of world	
SA citizens who remained in South Africa	3 418	2 884	84%	31	1%	211	6%
SA citizens who pursued opportunities in another country	352	117	33%	10	3%	199	57%

In Table 44 below we explore whether there are differences in the inbound and outbound mobility of black and white citizens. In each case we show the number and percentage of graduates who either remained in South Africa or pursued opportunities abroad within the first year of the completion of their doctoral degrees, with the country or region (South Africa, the rest of Africa and the rest of the world) in which they were employed at the time of the survey. We find that black graduates who initially left South Africa after obtaining their doctorates were more likely to return to South Africa (57%, compared to only 30% of white graduates). Conversely, nearly two thirds of white graduates who went abroad within the first year after graduation were employed in the rest of the world at the time of the survey, compared to nearly one third of black graduates. This shows that in terms of brain circulation, black respondents are more likely to return to South Africa, while the outbound mobility of white graduates is contributing to the loss of the highly skilled from South Africa.

Table 44 Inbound and outbound mobility of black and white South African nationals

		Total	Currently employed in South Africa		Currently employed in rest of Africa		Currently employed in rest of world	
SA nationals who remained in South Africa	Black	1 174	1 001	85%	26	2%	25	2%
	White	1 781	1 491	84%	10	0,5%	150	8%
SA nationals who pursued opportunities in another country	Black	87	50	57%	5	6%	27	31%
	White	210	62	30%	5	2%	128	61%

While Table 43 described the geographic mobility of *South African* doctoral graduates, Table 45 below shows the mobility of *non-South African* graduates who remained in South Africa following the completion of their doctoral studies. The table below shows that, of the African graduates who remained in South Africa (n=490), 57% (n=278) were still employed in South Africa at the time of the survey compared to a quarter (25%, n=121) who were employed elsewhere. Of the 143 respondents who had citizenship from a country outside of South Africa, 57% (n=82) were still employed in South Africa at the time of the survey compared to 32% (n=45) who were not.

Table 45 Inward and outward mobility of non-South African doctoral graduates who remained in South Africa upon completion of their doctoral studies

	Total remained in South Africa within first year	Current employment in South Africa		Current employment in rest of Africa		Current employment in rest of world	
RoA nationals who remained in South Africa	490	278	57%	91	19%	30	6%
RoW nationals who remained in South Africa	143	82	57%	1	1%	44	31%

Of the 360 non-South African respondents who initially remained in South Africa at completion of their doctoral studies and who were employed in South Africa at the time of the survey (RoA, n=278, RoW, n=82), nearly two thirds (64%, n=229) were employed at a South African university at the time of the survey (RoA, n=185; RoW, n=44).

7.5. Summary of key findings

1. The majority of South African nationals (90%) had remained in South Africa during the first year after completing their doctoral studies.
2. The primary motivations for mobility into (or remaining within) graduates' home countries are family or personal reasons.
3. Nearly 60% of graduates from African countries returned home within the first year of completing their studies, while 9% of graduates remained in South Africa. One out of five African graduates (RoA) considered the socio-political context in their home countries as motivations for remaining in South Africa upon completion of their doctoral studies.
4. Nearly two thirds of African respondents who accepted a postdoctoral fellowship in the first year following their doctoral studies remained in South Africa, which suggests that they accepted postdoctoral fellowships at South African universities or institutions.
5. White graduates are more likely to be geographically mobile than black graduates.
6. Graduates in the STEM sciences have greater outbound mobility than graduates in the social sciences, health sciences, and arts.
7. At the time of the survey, more than two thirds (n=3 649) of doctoral graduates' most recent employment was primarily located in South Africa.
8. Overall, there is little evidence of a brain drain of South African doctoral graduates. On the contrary, there is strong evidence of a net brain gain for South Africa.

Chapter 8: Use and value of the doctorate

In this chapter we reflect on the results from the survey and insights from the interviews about the different ways in which respondents have applied and used their PhDs in their jobs and, more broadly, the value they attribute to their PhD in terms of their professional and personal development and advancement. In general terms, we sought to answer the question as to whether the PhD degree is perceived to have been a good return on investment for doctoral graduates.

We begin by exploring which aspects of their PhDs respondents have drawn on in their day-to-day work. This ranges from skills, knowledge, methods and findings specific to the PhD, to more general skills, knowledge and competencies acquired in the process of undertaking the degree. We focus specifically on some of these aspects, namely, research skills, transferable skills, and the extent to which managerial tasks are core aspects of respondents' current employment positions.

We then turn to respondents' reflections on the more general value of their PhDs. This includes survey responses on whether or not doctorate holders' expectations of doing a PhD had been met and whether they believed the PhD was a good return on investment. We also used the interview data to look in greater depth at respondents' motivations for doing a PhD in the first place and their retrospective reflections on the value of the PhD.

8.1 Utilisation of the PhD

The survey asked respondents to consider the extent to which they utilise their PhDs in their **current** employment. In particular, they were asked to rank the application and utilisation of five different aspects of their doctoral studies. In Figure 74 and Table 46 we show the percentages of respondents who indicated in each case whether a particular knowledge or skill contributed to a large extent to their current employment. The results show that the general knowledge acquired during the doctoral studies was ranked highest (85% of respondents). The categories that followed, in descending order, were research skills and expertise (79,7%, n=4 440), and field-specific or subject/technical knowledge (63,7%, n=3 554). The methods used (57,5%, n=3 186) and findings produced (35,7%, n=1 991) in their PhD research were ranked fourth and fifth, respectively.

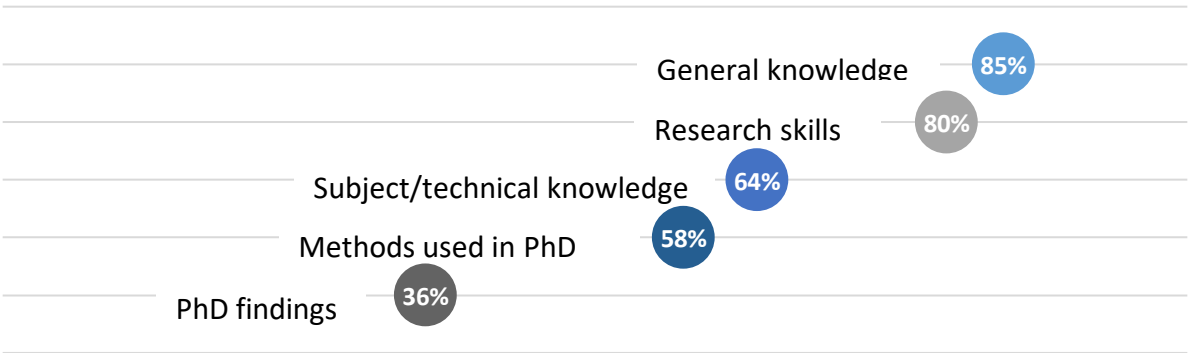


Figure 74 Utilisation of aspects of the PhD in day-to-day tasks of current employment

Table 46 Utilisation of aspects of the PhD in day-to-day tasks of current employment

	Rank order	n	%
General knowledge acquired during doctoral studies (such as critical thinking, academic writing, etc.)	1	4 708	84,5
Research skills and expertise	2	4 440	79,7
Field-specific or subject/technical knowledge	3	3 554	63,7
Methods used in PhD research	4	3 186	57,5
Findings produced by doctoral research	5	1 991	35,7

It is not surprising that recent graduates (i.e. those who received their PhDs between 2015 and 2018) were more likely to use the findings produced by their doctoral research than the other groups (see Figure 75 below). The findings of doctoral studies conducted 10 to 19 years ago are more likely to be deemed redundant by respondents at the time of completing the survey.

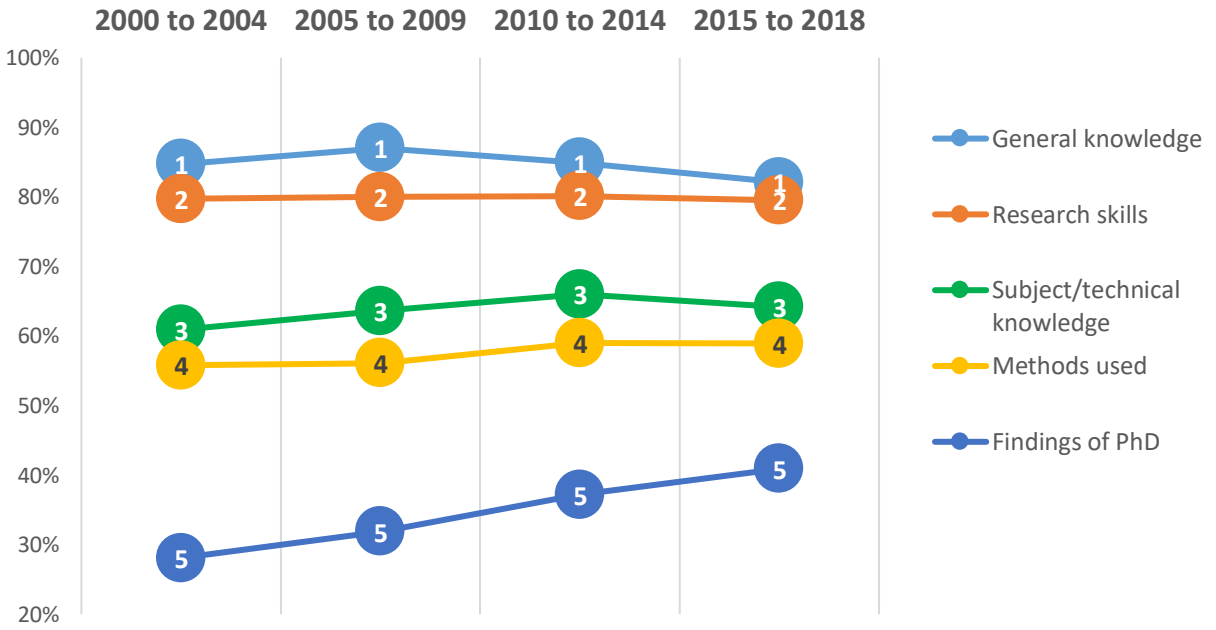


Figure 75 Use of skills acquired during doctoral studies by graduation window

Persistence and general use of high-level knowledge and research skills are ranked first and second. This is followed by subject/methods. The lowest ranked was the findings of the PhD, but we see that there are changes over time with recent graduates considering the findings of their PhD more useful in their current employment compared to respondents who graduated 10 to 19 years ago.

8.1.1. Knowledge acquired during doctoral studies

In the section below we explore the application and utilisation of knowledge acquired during the doctoral studies by graduates' nine scientific domains. Figure 76 below shows respondents across the disciplinary fields use general knowledge, such as critical thinking or academic writing, in their daily tasks. The application of transferable skills learnt during the doctorate is therefore of value to doctoral graduate irrespective of disciplinary field.

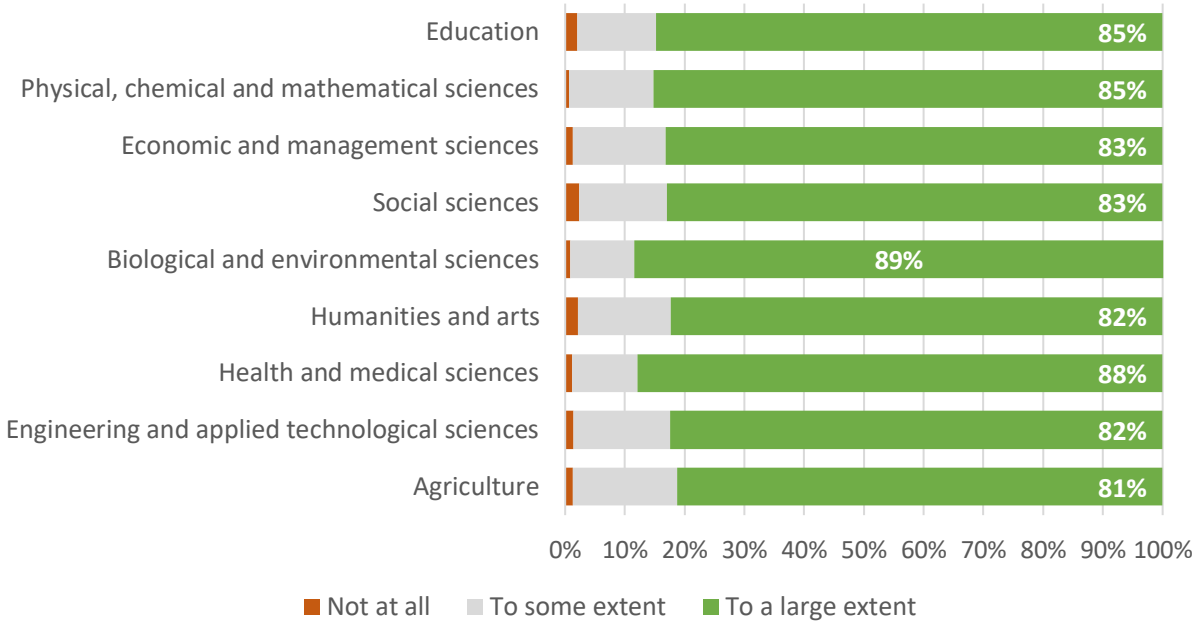


Figure 76 Extent to which general knowledge gained through doctoral studies was used in current employment

Mirroring the survey results, and aside from research skills, interview respondents most often highlighted what might be termed "transferable" and "soft" skills as the most valuable learnings from their PhD experience. These relate to the ability to think critically and conceptually, to solve problems, to communicate effectively (both verbally and in writing) and to manage projects or large amounts of information or time. Many of these skills form part of the broader set of research skills acquired. The quotations below from interviewees – most of whom were working in non-academic positions – articulate the kind of wide range of transferable or soft skills that we heard from many respondents:

> *Something that I've realised [subsequent] to actually being in the throes of the moment of doing the PhD, what you gain from a PhD is not expert level, phytoplankton knowledge. It's time management, it's perseverance, it's being able to understand the research process. It's writing, it's problem-solving. It's all that peripheral stuff that you have to manage to get through a PhD. And I actually think the subject matter part of it is the smallest component for me. [Also] being able to read widely across any scientific field, and actually across the university, because sometimes we support people in the other colleges – arts, law, medical. So being able to actually just pick up any kind of grant and read it, you've got the skills to just set yourself up.* (Research administration officer at a university)
>
> *I sometimes get pulled in for other ad hoc stuff, and it's often around contributing more to the critical thinking and that side of it, rather than the actual core knowledge from the PhD.* (Project executive at a municipality)
>
> *The biggest thing that I learned from my PhD is developing the art of critical thinking, of not being afraid to be wrong and make mistakes.* (Manager at a science council)
>
> *My PhD taught me how to think, like your master's does to some extent, but your PhD really forces you to think quite critically about things and look at it from different angles.* (Founder and consultant in a business enterprise)
>
> *You very seldom use the actual things that you've done for your postgraduate studies, but through the process you learn how to problem-solve and to obtain the literature, to sort of see through literature*

and find the things that [are] relevant and what's not. You learn to distinguish between good and bad information and data. I think that's the main thing, because when we do environmental impact assessments, it's a wide field and it's nothing that I've learned in university. Everything that I do is basically new and you have to go and research various aspects of the industries, and to determine the different potential impacts and how to solve [them], and if you don't have the skills to basically see through the vast expanse of information available nowadays on the Internet and wherever, it can be quite difficult. So that I think, is the number one skill. And then obviously scientific writing, how to properly write a report is definitely one of the skills that I use. (Environmental impact assessment consultant)

I think for me, [the PhD] taught me two things. It taught me critical thinking and it taught me how to really document and write well. So for me, it was following a research methodology, but then being able to communicate and write well in the written form. That was something that my master's has helped with, but particularly my PhD, being able to write well, and communicate and be able to substantiate all the various positions and be clear in terms of where one is building on the work of others, versus bringing in one's own views, or novelty and the difference between them. And that is something that has really stood me in good stead. I use that on a daily basis. I mean, not the technical work that I did. I'm not doing that kind of stuff anymore, day to day, but the critical thinking and the documentation really stayed with me. (Head of an R&D centre at a science council)

I think the most important thing were the research skills with the editing. So I'm still applying my research skills. Now what I do is I read articles and edit articles. I check for structure and readability, because we've got lots of second language and third language writers. My role is to help streamline their writing so that it's legible and readable and structured. (Scientific editor at a university)

In terms of soft skills, in some instances the context of the PhD project enabled the acquisition of "people skills" such as how to manage competing viewpoints or negotiate with a range of stakeholders. For example, one interviewee, who now works in a high position at an international NGO, said the following:

The way I did my studies in terms of setting up the interaction at the level of government, I think it also gave me a bit of experience in terms of negotiating with government people, communities, you know, working with diverse people. I think that is one of the aspects, apart from the technical knowledge, which now I also used in the end. (Regional programme director of an international NGO)

People also reflected on how the PhD had helped them grow on a personal-professional level. Perseverance, working independently, being more resilient to criticism, and generally having greater confidence in themselves and their abilities were mentioned. One interviewee reflected on how the PhD taught her to have a long-term purpose and vision, and how to navigate daily stresses:

But most of all, I think that art of having long-term vision and purpose. So, my day-to-day work is all over the place. Like I said, besides the technical part of the work, there's also just the general aspects of dealing with people. But I think because of the PhD training, before I even get to the specific PhD, it really has given me that long-term vision focus. And you don't sweat the small stuff when you do a PhD, because so many things go wrong along the way. (Manager at a science council)

Figure 77 and Figure 78 below show that the application of field specific or technical knowledge does not vary significantly between disciplinary fields

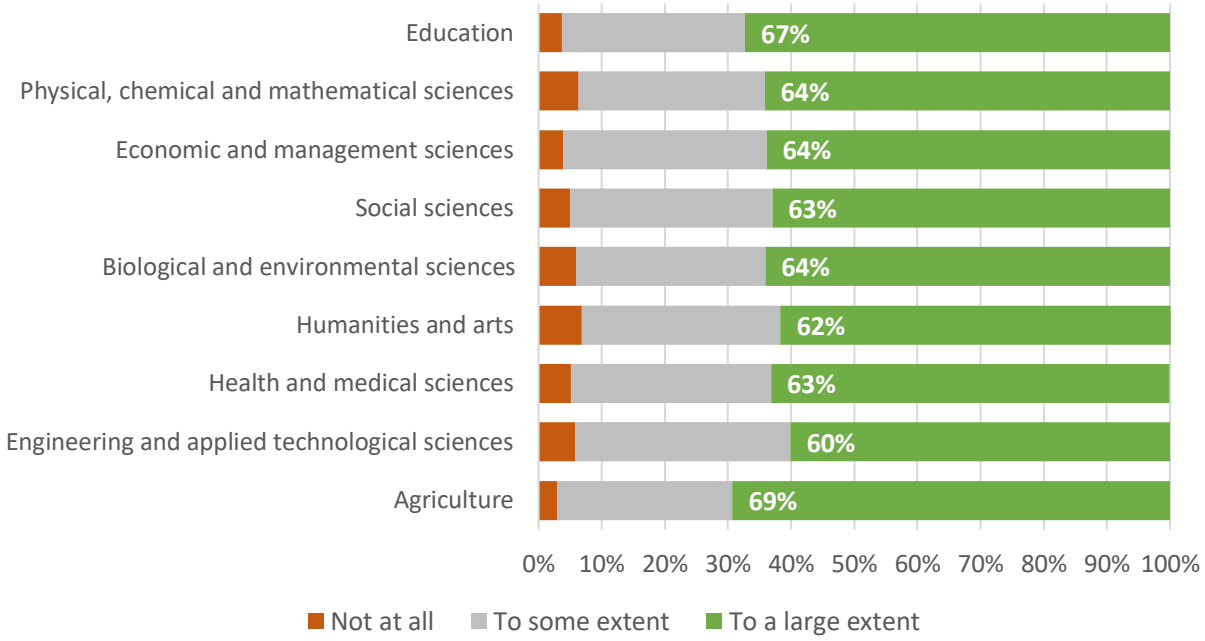


Figure 77 Extent to which subject specific or technical knowledge gained through doctoral studies was used in current employment

In the previous section, we found that the findings of the PhD are considered to be the least relevant to graduates' employment tasks. Figure 78 below shows that graduates in the biological and environmental sciences were the least likely to use the findings of their PhDs in their current employment (35%), followed by respondents in the physical, chemical and mathematical sciences (27%), and engineering and technological sciences (25%).

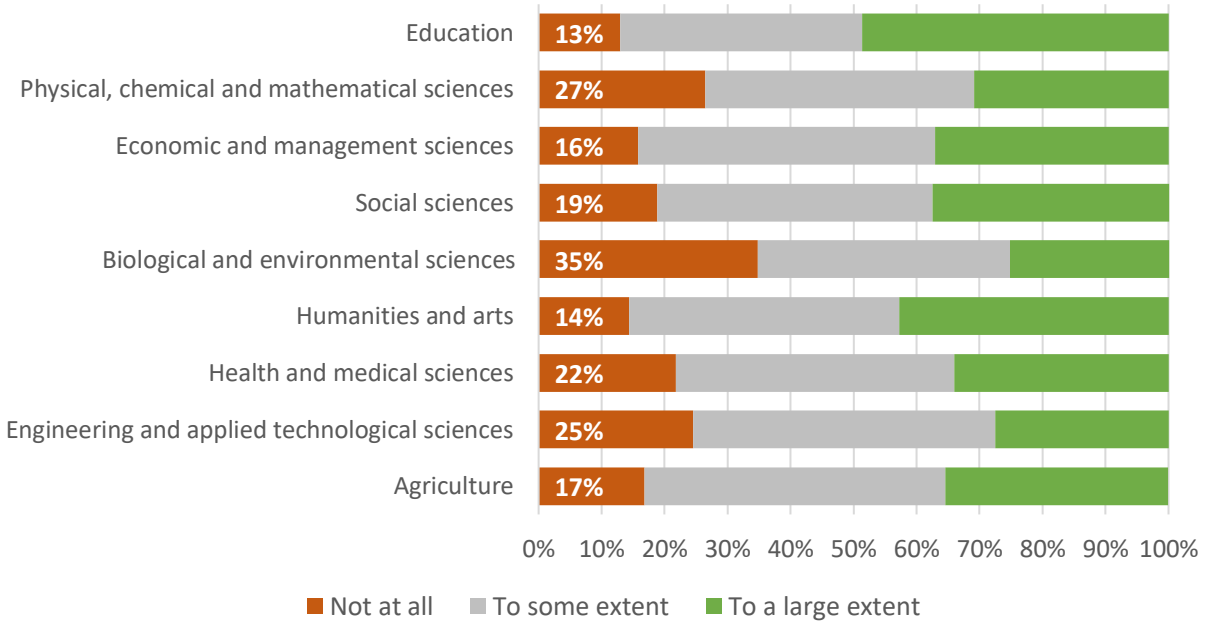


Figure 78 Extent to which the findings produced during doctoral studies are utilised in current employment

We found that respondents in the biological and environmental sciences were also less likely to use the methodological skills and expertise gained through their doctoral studies (15%) in their current employment, as shown in Figure 79.

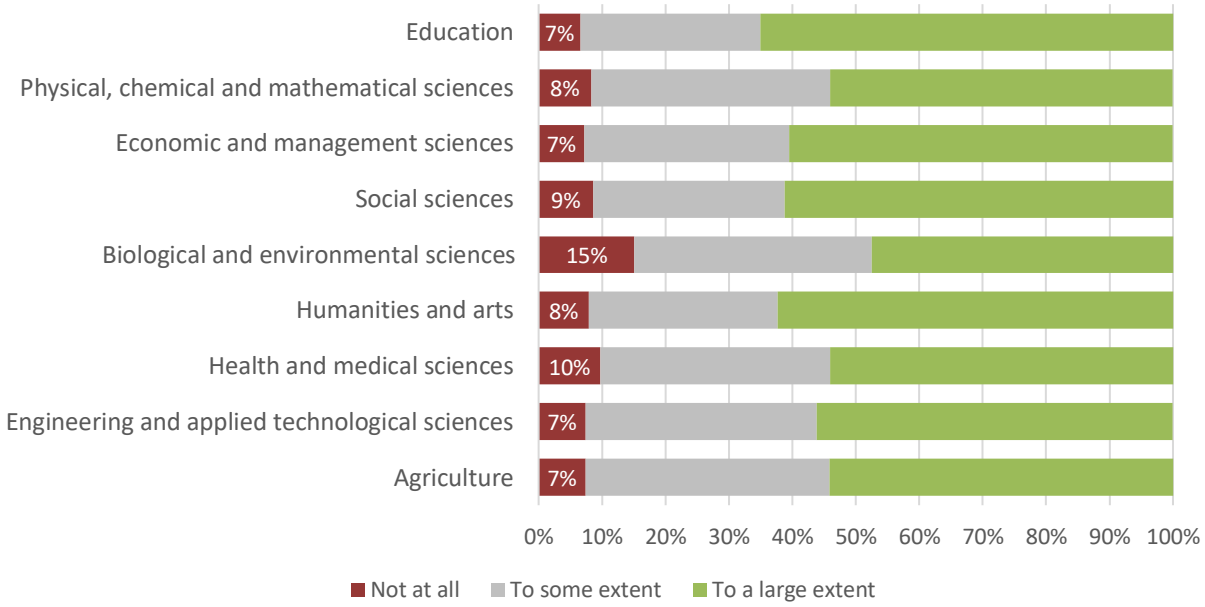


Figure 79 Extent to which the methodological skills and expertise gained through doctoral studies are utilised in current employment

In terms of research skills, we see that there was little difference between the scientific domains as far as the use of research skills gained through doctoral studies was concerned, with graduates rating the extent to which they used research skills similarly across fields, as shown in Figure 80.

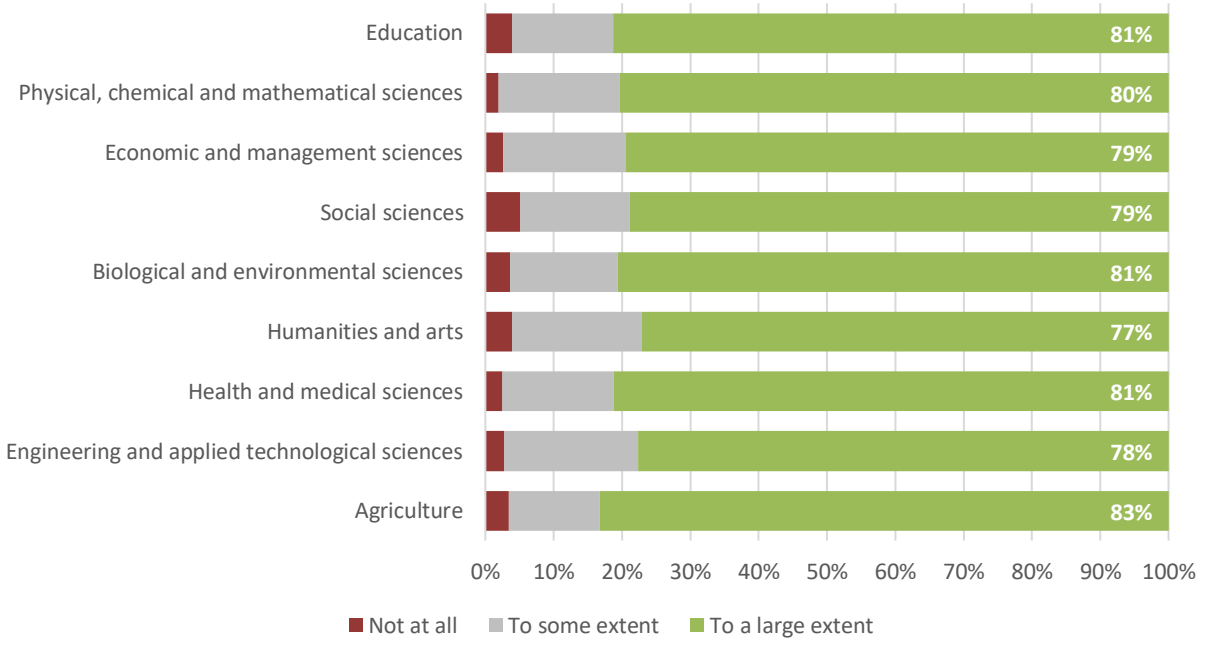


Figure 80 Extent to which research skills gained through doctoral studies are used in current employment

8.1.2. Utilisation of research skills in current employment

Doctoral degrees in South Africa are typically research-based and doctoral students are required to make an original contribution to the body of scholarship and knowledge in their respective fields. More than two thirds (70,5%, n=3 875) of respondents indicated that a *doctoral degree is a requirement* for their current employment position.

Not surprisingly, most graduates who are currently employed in the higher education sector (83%, n=3 324) indicated that a PhD was a requirement for their work, compared to only 53% (n=354) in the government/public sector (as shown in Figure 81). Fewer respondents in the private non-profit sector (39%, n=149), business enterprise sector (33%, n=221) and the "other" education sector (23%, n=24) considered the doctorate to be a requirement for their current employment position.

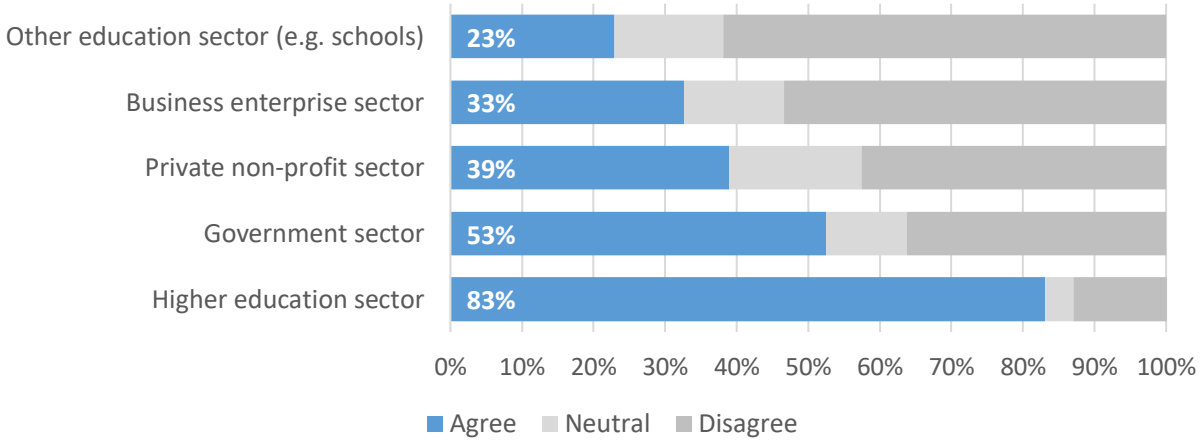


Figure 81 Doctorate as a requirement for current employment in higher education sector

Our survey asked respondents to indicate to what extent *research activities were a component* of their current employment position. Overall, our results show (Figure 82 that 70,4%, n=3 930) reported that research activities are a large part of their most recent employment responsibilities.

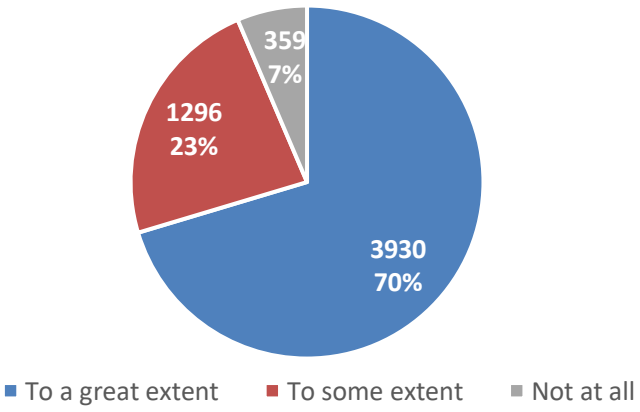


Figure 82 Research activities as a component of most recent employment position

When we look at the survey responses by sector as illustrated in Figure 83 and Table 47 below, we see that 81% (n=3 271) of respondents in the higher education sector reported that research formed part of their day-to-day work activities. The second highest sector was the government sector (60%, n=415), followed by the non-profit sector (44%, n=176), the business enterprise sector (36%, n=246), and finally the "other" education sector (22%, n=24).

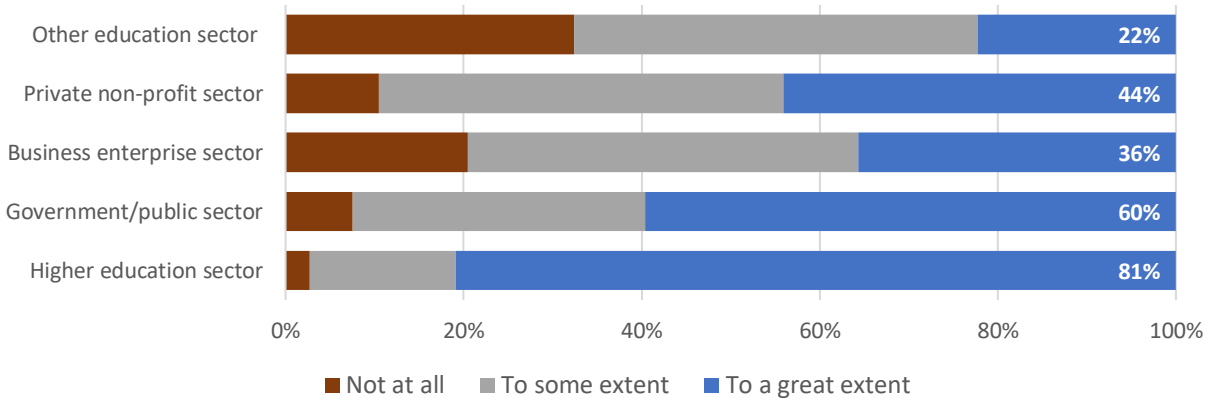


Figure 83 Research as a component of current employment position by sector

Table 47 Research job requirement or component of current employment position by sector

In which one of the following sectors are you currently employed?										
	Higher education sector		Government/ public sector		Business enterprise sector		Other education sector		Private non-profit sector	
	n	%	n	%	n	%	n	%	n	%
Not at all	108	2,7%	52	7,5%	141	20,5%	35	32,4%	42	10,5%
To some extent	663	16,4%	229	32,9%	302	43,8%	49	45,4%	181	45,4%
To a great extent	3 271	80,9%	415	59,6%	246	35,7%	24	22,2%	176	44,1%
Total	4 042	100%	696	100%	689	100%	108	100%	399	100%

When we look at field differences, as illustrated Figure 84, we see that respondents in agricultural sciences were more likely to do research in their current employment (79%, n=184). Surprisingly, a large percentage of respondents in the health and medical sciences reported doing research as a significant component of their current employment position (72,6%, n=466). Respondents who completed their doctoral studies in the social sciences (68,2%, n=604), humanities and arts (68,6%, n=588), and engineering and the applied technological sciences (68,8%, n=297) reported less involvement in research tasks.

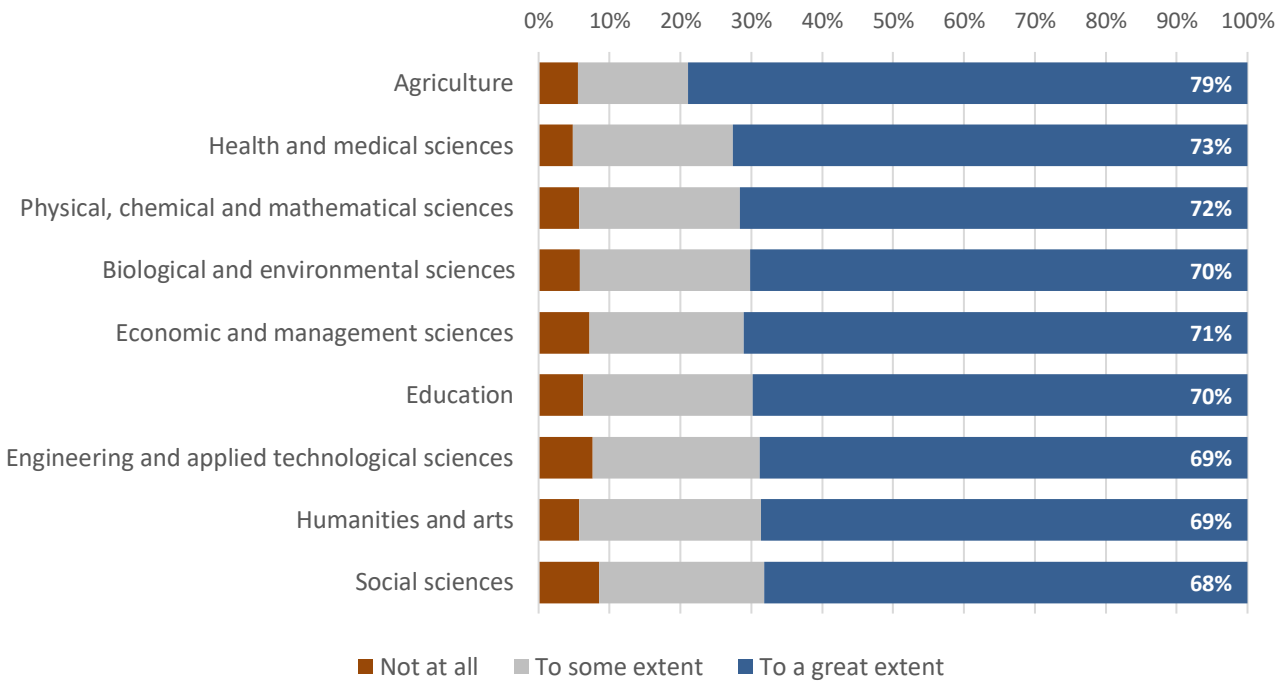


Figure 84 Research a component of current employment position by scientific domain

8.1.3. Involvement in technology development, innovation and entrepreneurship

In addition to asking our respondents to comment on the utility and application of research and knowledge-related skills in their current employment, we decided also to ask them to indicate to what extent they were involved in technology development, innovation and entrepreneurial activities after completion of their degrees.

The results in Figure 85 below show that 11% (n=696) reported very active involvement followed by 15% (n=928) who indicated active involvement. Respondents who had moderate or little involvement constitute 34% of our sample, while 40% (n=2 391) reported no involvement in technology development, innovation or entrepreneurial activities.

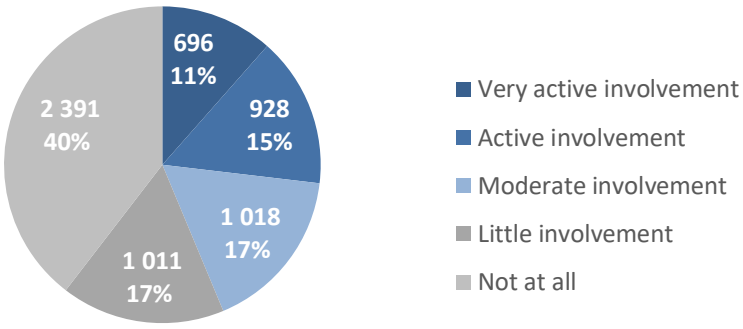


Figure 85 Involvement in technology development, innovation or entrepreneurial activities (n=2 391)

Figure 86 and Table 48 show that doctoral graduates who are employed in the business enterprise sector were more involved (28%, n=192 very active involvement and 23%, n=162 active involvement) in technology development, innovation and entrepreneurial activities. Respondents in the higher education sector reported the least involvement in activities related to innovation and entrepreneurship (8%, n=340 very active involvement and 15%, n= 110 active involvement).

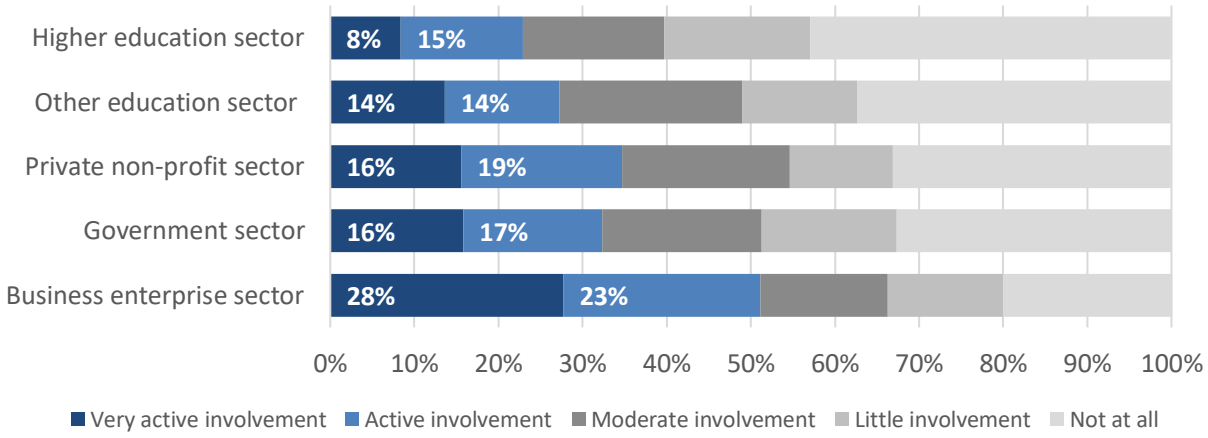


Figure 86 Active involvement in technological development, innovation and entrepreneurial activities by sector

Table 48 Involvement in technological development, innovation and entrepreneurial activities by sector of current employment

	Higher education sector		Government/ Public sector		Business enterprise sector		Other education sector		Private non-profit sector	
Very active involvement	340	8,4%	110	15,8%	192	27,7%	15	13,6%	62	15,6%
Active involvement	585	14,5%	115	16,5%	162	23,4%	15	13,6%	76	19,1%
Moderate involvement	677	16,8%	132	19,0%	105	15,2%	24	21,8%	79	19,9%
Little involvement	703	17,4%	111	16,0%	95	13,7%	15	13,6%	49	12,3%
Not at all	1 725	42,8%	227	32,7%	139	20,1%	41	37,3%	131	33,0%

In Figure 87 and Table 49 below we find that respondents who completed their doctoral studies in engineering and applied technological sciences (49%, n=230 active involvement) and agriculture (46%, n=116 active involvement) indicated that they were more actively involved in innovation and entrepreneurial activities than respondents in the natural and social sciences.

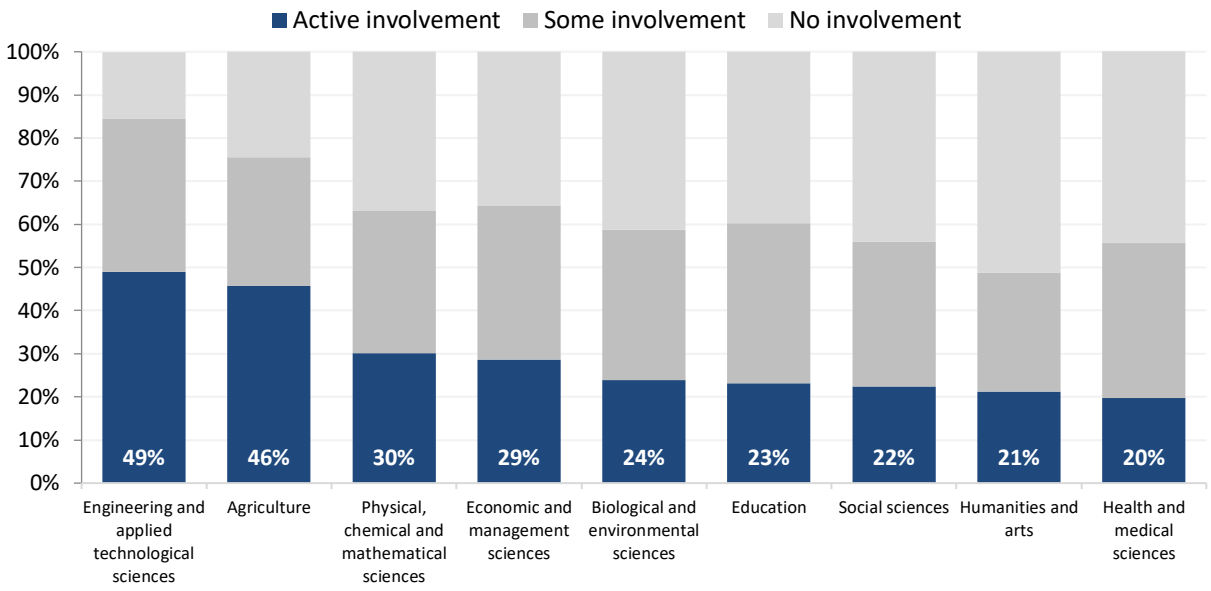


Figure 87 Involvement of doctoral graduates in technological development, innovation and entrepreneurial activities by field

Table 49 Involvement in technological development, innovation and entrepreneurial activities by scientific domain

		Active involvement	Some involvement	No involvement
Agriculture	n	116	76	62
	%	45,7%	29,9%	24,4%
Engineering and applied technological sciences	n	230	167	73
	%	48,9%	35,5%	15,5%
Health and medical sciences	n	137	250	310
	%	19,7%	35,9%	44,5%
Humanities and arts	n	194	252	468
	%	21,2%	27,6%	51,2%
Biological and environmental sciences	n	186	272	321
	%	23,9%	34,9%	41,2%
Social sciences	n	214	322	421
	%	22,4%	33,6%	44,0%
Economic and management sciences	n	185	229	230
	%	28,7%	35,6%	35,7%
Physical, chemical and mathematical sciences	n	225	247	275
	%	30,1%	33,1%	36,8%
Education	n	133	213	228
	%	23,2%	37,1%	39,7%

In terms of gender differences, notably fewer female graduates reported having been involved in technological development, innovation and entrepreneurial activities. Table 50 and Figure 88 below show that 20,6% (n=547) of female graduates reported active involvement in technology development,

innovation and entrepreneurial activities compared to 31,7% (n=1 013) of male respondents[33].

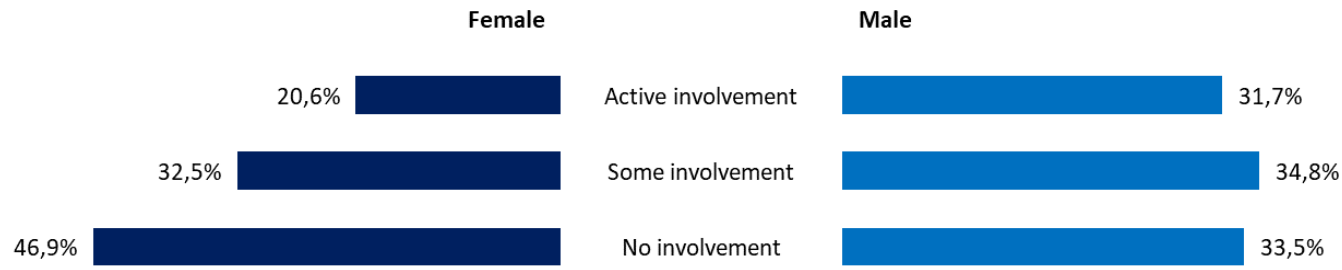


Figure 88 Active involvement in technology development, innovation and entrepreneurial activities by gender

Table 50 Active involvement in technology development, innovation and entrepreneurial activities (n=547)

	Female		Male	
	n	%	n	%
Active involvement	547	20,6%	1 013	31,7%
Some involvement	864	32,5%	1 114	34,8%
No involvement	1 247	46,9%	1 072	33,5%

When we disaggregate our results by race, we find that there are no differences between black and white graduates' involvement in development, innovation and entrepreneurial activities as shown in the table below.

Table 51 Differences between black and white graduates' involvement in technology development, innovation and entrepreneurial activities

	Black		White	
	n	%	n	%
Active involvement	331	24,8%	510	25,2%
No involvement	575	43,1%	869	42,8%
Some involvement	428	32,1%	649	32,0%

In Table 49 we found that graduates in the STEM fields reported more active involvement in technological development, innovation and entrepreneurial activities. Subsequently, we therefore explore if there are gender differences between respondents in STEM and SSH fields in terms of involvement in innovation activities. In Figure 89 and Table 52 below we find that in the STEM disciplines female graduates (20,8%, n=258) are also less likely to be actively involved in technological development, innovation and entrepreneurial activities than their male counterparts (37,2%, n=630)[34].

[33] Pearson chi-square = 139,913, df = 4, p = 0,000
The differences in column percentages between male and female respondents who indicated "active involvement" are statistically significant at 0,05. Results are based on two-sided tests.
The differences in column percentages between male and female respondents who indicated "no involvement" are statistically significant at 0,05. Results are based on two-sided tests.

[34] STEM disciplines: Pearson chi-square = 151,200, df = 4, p = 0,000
SSH: Pearson chi-square = 16,799, df = 4, p = 0,002

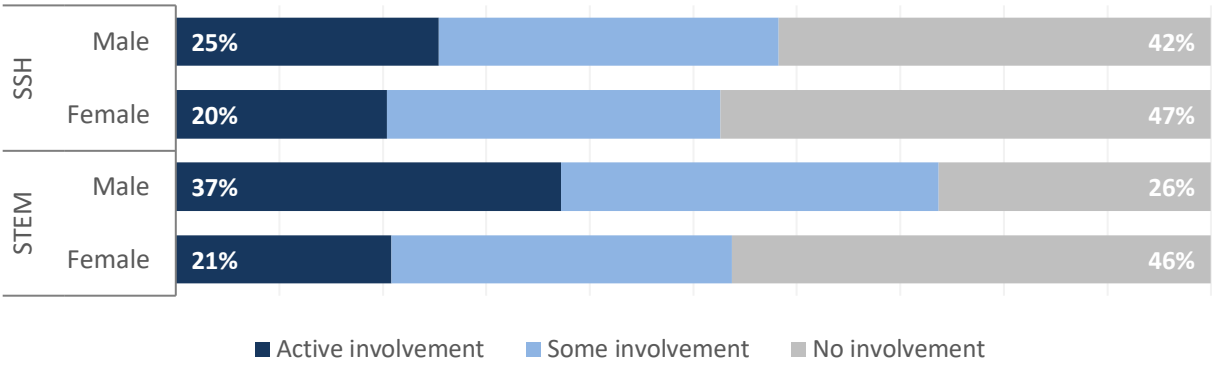


Figure 89 Active involvement of STEM graduates in technology development, innovation and entrepreneurial activities by gender (20,8%)

Table 52 Active involvement of STEM graduates in technology development, innovation or entrepreneurial activities by gender

	STEM				Social sciences and humanities			
	Female		Male		Female		Male	
	n	%	%	n	n	%	n	%
Active involvement	258	20,8%	630	37,2%	288	20,4%	382	25,4%
Some involvement	408	32,9%	619	36,5%	456	32,2%	493	32,8%
No involvement	575	46,3%	445	26,3%	671	47,4%	626	41,7%

8.1.4. Managerial responsibilities

While the acquisition of managerial skills is not necessarily an expected outcome of doctoral studies, we were interested to see to what extent the respondents' current employment positions involved managerial responsibilities and to what extent this differed across sectors. Survey respondents were asked to indicate whether managerial tasks/responsibilities were a requirement or component of their current employment position. Overall, just over half (53,8%, n=3 004) of respondents indicated that managerial responsibilities formed part of their current employment responsibilities to a great extent, compared to 6,5% (n=364) who indicated not at all (Figure 90).

For both STEM and SSH fields the differences in the percentages of male respondents and female respondents who reported "active involvement" are statistically significant at the 0,05 level. Results are based on two-sided tests.
For both STEM and SSH fields the differences in the percentages of male respondents and female respondents who reported "no involvement" are statistically significant at the 0,05 level. Results are based on two-sided tests.

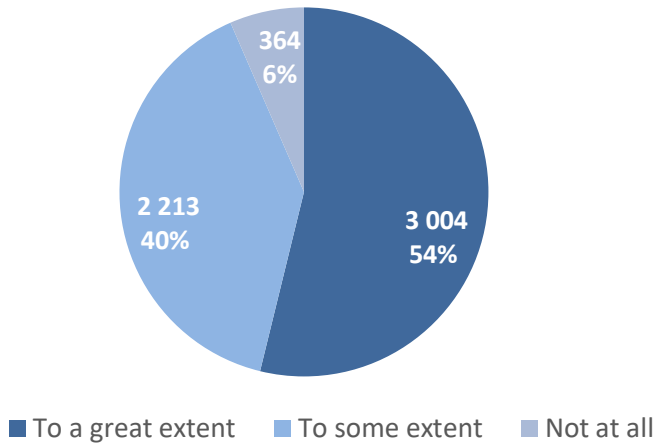


Figure 90 Managerial tasks and responsibilities part of graduates' most recent employment position (n=3 004)

Figure 91 below shows that a higher percentage of black graduates (61%, n=768) reported active involvement in managerial activities in their employment at the time of the survey than white respondents (53%, n=1 007). When we further disaggregate these results by year after graduation we find no significant differences between white and black graduates.

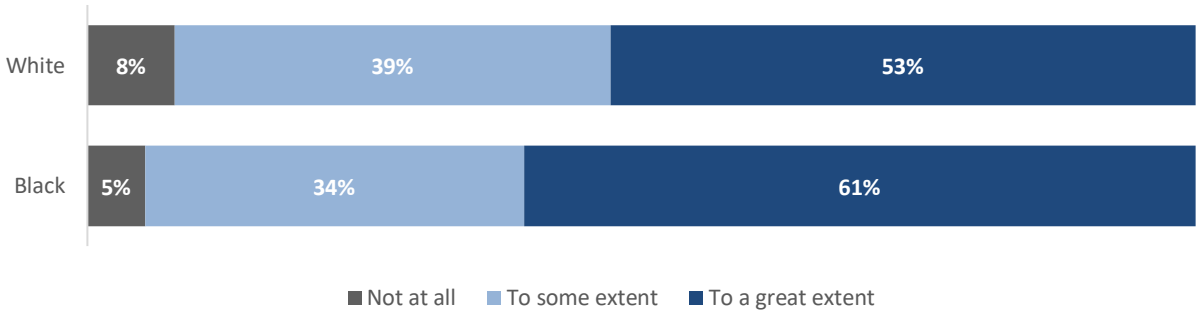


Figure 91 Involvement in managerial responsibilities in most recent employment for black and white graduates

Figure 92 below shows the distribution of respondents with managerial responsibilities by sector of employment. Generally, the differences between the sectors are small where the lowest proportion of doctorate holders with managerial responsibilities were in the higher education sector (52,1%, n=2 103), with the highest proportions in the non-profit (60,7%, n=242) and government/public sectors (60,4%, n=420).

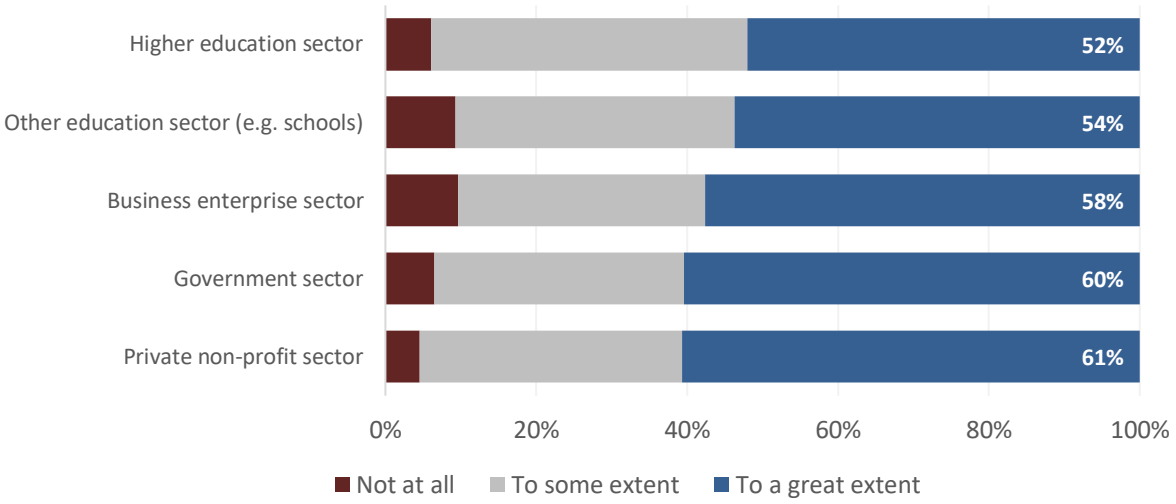


Figure 92 Involvement in managerial responsibilities in most recent employment by sector

8.2 Reflections on the value of the PhD degree

Individuals decide to undertake PhD degrees for a variety of reasons. Very often these are related to efforts to advance graduates' careers, whether for the purposes of promotion, increased income, improved employment prospects, and generally to open doors on the career front. As such, doing a PhD can be seen as an entrance to a particular career, a ladder to upward mobility, or a bridge from one career and/or sector to another. For lovers of knowledge and intellectual challenges, the value of doing a PhD can also have personal dimensions.

In this section we consider respondents' perceptions and reflections on the value of having undertaken a PhD degree. From the survey perspective, we consider respondents' responses to questions about whether their expectations of having a done a PhD had been met, whether they felt that the PhD was a good return on investment, and whether they think they would have been better off not having done a PhD or, at the very least, have done a PhD in another field. As will be seen, for the most part doctorate holders are very satisfied with their choice to pursue a PhD degree.

We then turn to the interview data to obtain further insights into doctorate holders' motivations and expectations for doing a PhD as well as the different ways in which they reported they had benefited – professionally and personally – from having a doctorate.

8.2.1 Overall levels of satisfaction

The survey asked respondents to rate, on a five-point Likert scale (strongly agree to strongly disagree), four statements which would give an indication of their overall satisfaction with having undertaken a doctoral degree and thus the value they have derived from it. The results are illustrated in Figure 93 and

Table 53 below.

As can be seen from the figure below, the vast majority of respondents expressed satisfaction with their choice to do a PhD:

- 91,8% (n=5 244) disagreed with the statement that in hindsight they should not have pursued a doctorate.
- 82,6% (n=4 704) disagreed with the statement that in hindsight they should have pursued a PhD in another field.
- 79,5% (n=4 550) agreed that, overall, doing a doctorate had been a good return on investment.
- 76,5% (n=4 385) agreed that their expectations of obtaining a doctorate had been met.

Figure 93 Survey respondents' satisfaction with their decision to do a PhD

Table 53 Survey respondents expressed satisfaction with the pursuit of a PhD

		n	%
In hindsight, I should not have pursued a doctorate	Agree	261	4,6
	Neutral	206	3,6
	Disagree	5 244	91,8
	Total	5 711	100
In hindsight, I should have pursued a doctorate in another field	Agree	478	8,4
	Neutral	511	9
	Disagree	4 704	82,6
	Total	5 693	100
Overall, doing a doctorate has been a good return on investment	Agree	4 550	79,5
	Neutral	532	9,3
	Disagree	640	11,2
	Total	5 722	100
My expectations of obtaining a doctorate have been met	Agree	4 385	76,5
	Neutral	576	10
	Disagree	774	13,5
	Total	5 735	100

In the table below we disaggregate the findings by race. We find that generally black and white graduates expressed similar sentiments about the value associated with the pursuit of their doctoral qualifications. The exception is, however, where a smaller percentage of black graduates felt that their expectations of doing a PhD were met (73% selected "agree" and 18% selected "disagree"). The differences in the responses of black and white graduates about their expectations of obtaining a PhD were statistically significant[35].

Table 54 Black and white graduates' satisfaction with the pursuit of a PhD

		Black		White	
		n	%	n	%
In hindsight I should not have done a PhD	Agree	66	5,2%	80	4,1%
	Neutral	37	2,9%	75	3,8%
	Disagree	1 182	91,9%	1 815	92,1%
In hindsight I should have done a PhD in another field	Agree	124	9,7%	144	7,3%
	Neutral	122	9,5%	185	9,4%
	Disagree	1 034	80,8%	1 635	83,3%
PhD a good return on investment	Agree	1 011	78,4%	1 568	79,5%
	Neutral	112	8,7%	201	10,2%
	Disagree	166	12,9%	204	10,3%
My expectations of doing a PhD met	Agree	941	72,7%	1 522	77,2%
	Neutral	121	9,3%	222	11,2%
	Disagree	232	17,9%	228	11,6%

[35] Person chi-square = 27,254, df = 2, p = 0,000.

In Figure 94 below we explore whether perceptions about the value of the doctorate differ across the four graduation windows. The results support the general findings presented above. However, a slightly smaller percentage of recent graduates rated their doctoral degree to have produced a good return on investment than the earlier graduates[36]. These results could suggest that the perceived value of the doctorate has diminished in recent years. The changing nature of employment and the fact that there has been little growth in positions at public higher education institutions may point to the changes in the perceived utility of the doctorate. Alternatively, the fact that a smaller share of recent graduates perceive the doctorate as a good return on investment could be because insufficient time had passed since graduation for the value of the doctorate to be gauged. It is too early to say which of these interpretations is correct.

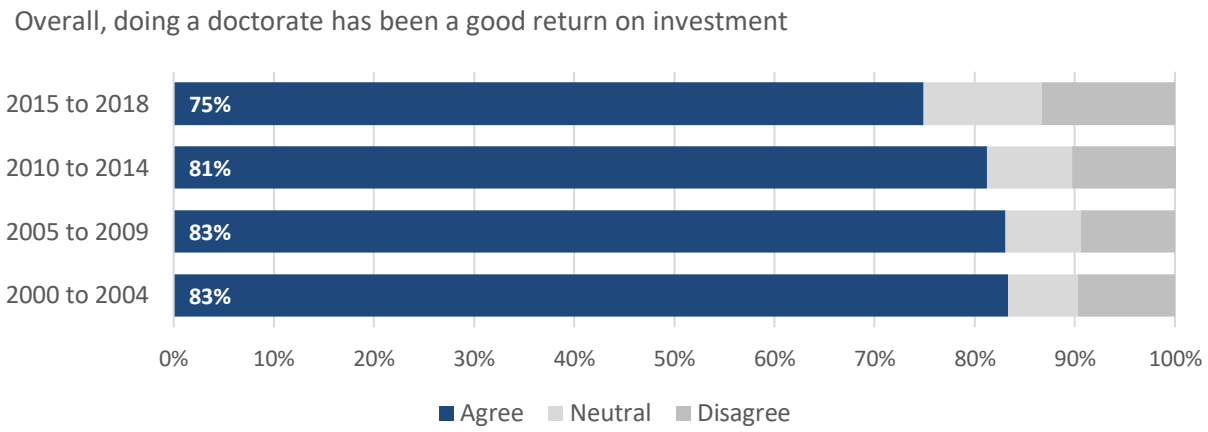


Figure 94 Perception of graduates on the return on investment of their PhD

In Figure 95 below we explore whether doctorate holders' expectations of doing a PhD have been met, and how this might differ between recent graduates and those who completed their studies more than 10 years ago. Once again we see that 82% (n=659 and n=923) of respondents who completed their doctoral studies in 2000 to 2004 and 2005 to 2009 agreed that their expectations of the doctorate had been met. This compares to 71% (n=1 288) of recent graduates.[37]

[36] The differences in the percentages between respondents who agree that the PhD is a good return on investment and graduated in 2015 to 2018 is statistically different to graduates who obtained their degrees in 2000 to 2004 and 2005 to 2009 (95% confidence interval). Results are based on two-sided tests.

[37] The differences in the percentages between respondents who agree that their expectations of doing the doctorate had been met who graduated in 2015 to 2018 is statistically different to graduates who obtained their degrees in 2000 to 2004, and 2005 to 2009 (95% confidence interval). Results are based on two-sided tests.

The differences in the percentages between respondents who agree that their expectations around doing the doctorate had been met who graduated in 2010 to 2014 is statistically different to graduates who obtained their degrees in 2000 to 2004 and 2005 to 2009 (95% confidence interval). Results are based on two-sided tests.

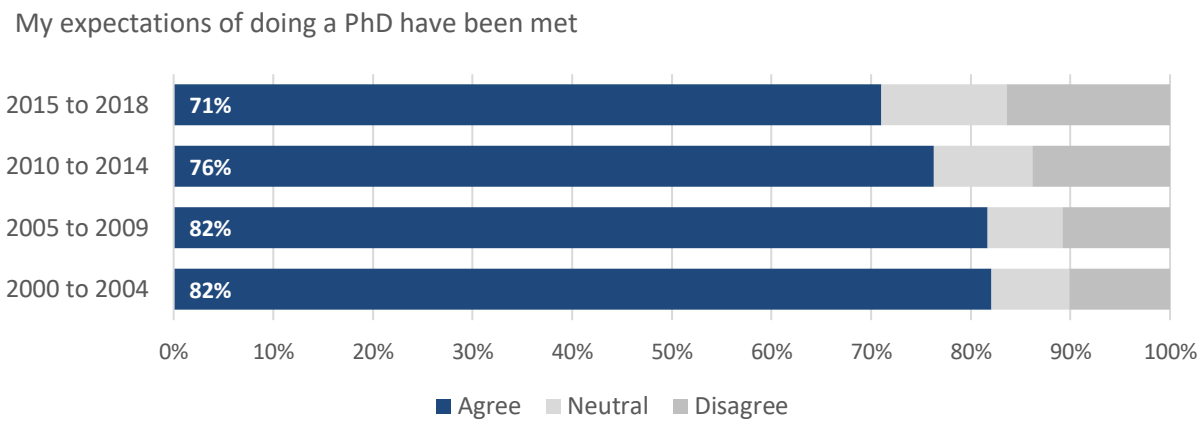


Figure 95 Survey respondents assessment on their expectations of doing a PhD

In Figure 96 below we look at the survey respondents who indicated (agree and strongly agree) that they would have liked to pursue their doctoral studies across scientific domains. The overall picture does not suggest major differences. With the exception of respondents in education (13%), the differences are small and range from 6% of respondents in the engineering and technological sciences to 9% in the social, and biological and environmental sciences.

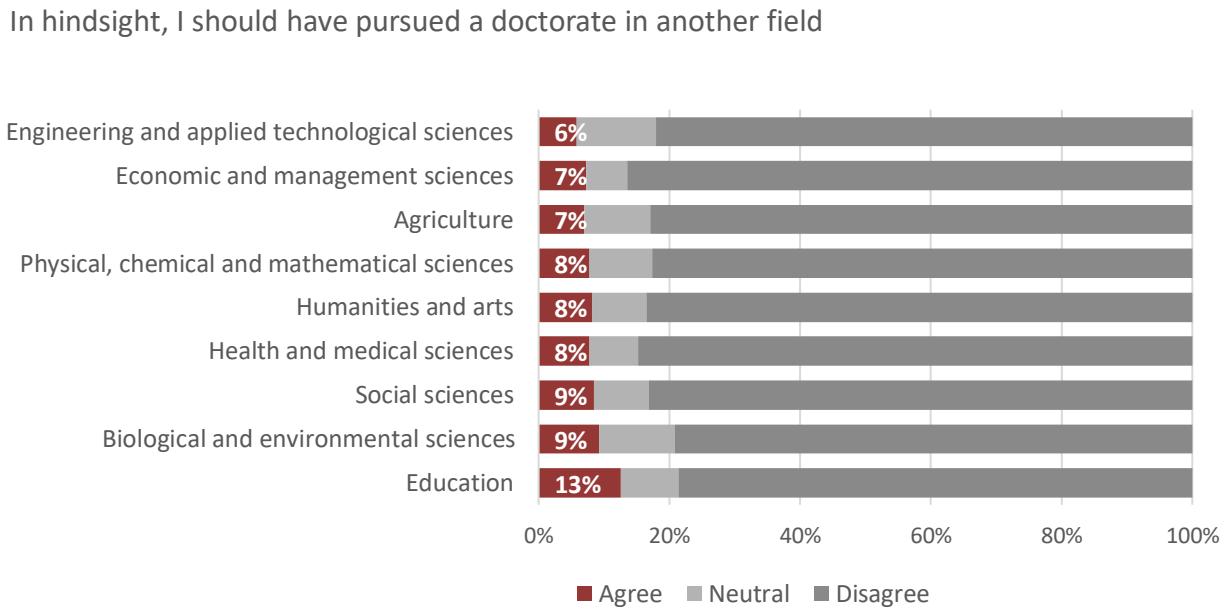


Figure 96 Respondents' opinion on the field they chose in which the doctorate was completed

8.2.2 Motivations and expectations

In the interviews we asked respondents why they had decided to embark on a PhD degree and how this would benefit them.

Many of the respondents referred to career-related motivations. Of course, for those on the academic

track who wished to progress up the career ladder, obtaining a PhD was a requirement. Some of these were already employed as academics at a university, while others wished to make the move into academia. Some respondents made this decision early on in their careers, while others decided to move into academia at a later stage. In these latter cases, there was often a time lag between the master's and enrolment for a PhD.

A related reason for doing a PhD was as a way of becoming a researcher or scientist – whether in academia or in other sectors – and acquiring the requisite skills. Again, in some cases, the PhD was intended to facilitate a major career change.

> *In the long term, I knew I wanted to be in academia, but focusing on applied research. So at the time I was doing my PhD, I was working at a consulting firm. But my goal for the PhD was specifically to go into academia. But I knew that if I didn't end up in academia, it would count in the consulting industry as well – for proposals or whatever, if you've got a title in front of it. So it would have [worked] both ways. But my primary goal was to get into university.* (Lecturer, academic track)

> *Well, I'm a lecturer at CPUT. And when one is in the academic field, it's always beneficial to do a PhD. If you want to apply for a senior lecturer position, you need a PhD. So obviously, it's for those reasons, for promotion reasons, and also to enhance yourself as an academic for research opportunities.* (Lecturer, academic track)

> *Because I wanted to work as a researcher and a marine biologist. So in my view, the way to actively doing research was to do a PhD. That was like the next stepping stone to then specifically do that career.* (Entrepreneur, academic track)

> *I've been having a lot of interest in a research career, and advancing my research ability and competencies. So I knew a PhD [was] really my best way to enhance my research ability. But also, I knew that a PhD would be one way to enhance my networks in the field of research and the science.* (Dean, academic track)

> *I was hoping to be able to move into an academic position. My job was quite technical, although I was involved in a lot of research, but it was basically a technical job. I wanted to move into an academic position and be able to have my own research projects.* (Scientist, academic track)

Interview respondents also referred to a range of intrinsic motivations for undertaking a PhD, such as a means to personal growth, fulfilling a personal aspiration, or taking on a significant intellectual challenge. These are referred to again in the next section.

The perceived cost of doing a PhD

From the interview data, it became clear that many graduates pursued a PhD because it came across their path. For many graduates therefore, their expectations of the PhD were not clearly articulated at the beginning of their doctoral studies. Notwithstanding the often seredipitous pursuit of a PhD, very few graduates reflected negatively on their PhD journey, as it generally gave the graduate a sense of personal achievement. Some respondents indicated challenges with gaining meaningful employment, such as a shortage of employment positions in academica, age or Broad-Based Black Economic Empowerment labour policies. But the PhD became vauable to them in other ways that they did not expect. In consulting jobs for example, a PhD did not necessarily increase the repertoire of skills of the graduate but often the title gave prestige that earned their company favour when tendering for contracts.

Perhaps the most notable drawback to getting a PhD was that in some cases graduates were overqualified and experienced challenges with finding satisfactory employment. A small number of interviewees (16) reported difficulties finding work in industry with a PhD because they were considered overqualified. One interviewee felt that industry did not understand what a person with a PhD could offer, while others remarked that industry thinks graduates with a PhD belong in academia, know too much and are untrainable.

> *I embarked on a PhD late in life as a "bucket list" item – something that I did to satisfy myself and I achieved that. What I did not anticipate was that once I became "Dr" I became immediately unemployable. Despite my broad industry experience, academia appears only interested in published articles and teaching experience, while industry appears unwilling to pay the extra dollar for a PhD.* (Qualitative response on survey)

> *One disadvantage that I'll point out is, if you get your PhD, and you're not working, it becomes difficult to get a job, especially out of academic institution. So, a PhD is a disadvantage if you want to go into industry to work. [Because] I think [with] most jobs, they're not willing to take someone [at] a high level. They prefer someone at an entry level and then train you. It's assumed that if you have a PhD, you already know a lot and would expect to be paid more. At least that's my experience.* (Lecturer at a university in Zimbabwe).

> *Industry's not too friendly to people with PhDs. If you've got a doctorate, and you're going to apply for jobs, I think you're at a disadvantage if you have a PhD. Master's, yes, PhD, kind of push[es] you out of the line, from my personal experience, it wasn't really, it wasn't really a good thing for people to see that [you have] a PhD and applying for a job. So it wasn't for me. But if you want to stay within the academic environment, yes, it's good for you if you want to stay within the research. But in … industry, it's not. It's really not, it's a disservice to you, you've got one, the only way you can be part of an industry … with a PhD, from my experience, is that you serve as a consultant, then you are viewed as an associate and the consultant for that company or that industry. And yeah, it was better like that. So with a PhD it would be better for you to actually market yourself as an independent specialist, if you want to be in the industry.* (Independent consultant).

> *The post-PhD, it's quite difficult because, one, there are just so many people doing PhDs now, and therefore there [are] limited openings in … academia, for example. And there's also less, maybe, appreciation in the industry because most of the stuff that they do they just require[s] the basics, someone with just a mere diploma to just go work. You don't necessarily need a PhD or PhD in that industry, for example. In South African industries, there's only Sasol that [has a high] number of PhDs employed. I mean, there [are] a lot, but [in] other industries a PhD is not necessarily a requirement. So I think that is the challenge of post-PhD, especially in the sciences. And also the perception, because if were to say to someone I have a PhD in chemistry, that's what they will think, oh, okay, it's an Einstein. They wouldn't think about what actually you have acquired during the PhD itself. If I was an industry boss with a PhD, I would know obviously what the PhD has, what they bring in. But obviously, if you've got leaders who've never gone through postgraduate [studies], they will not know what to expect from a PhD. And so it is a problem.* (Postdoctoral researcher at a South African University).

> *And so I got to the end of my PhD and I decided it's time to make some money, it's time to get a job. And so let me look for a job. So I started looking for a job in environmental consultan[cy]. So I had a PhD in ecology and I thought environmental consulting, that seems like a very practical kind of area in which I could find a job in and I was horrified to discover that in environmental consulting, all they wanted was environmental lawyers, or accountants or engineers. Anyone who's a PhD in ecology was considered overqualified. So then I started looking around a bit more and I kind of stumbled on to general management consulting. And they*

didn't really care what qualifications you had. (Senior lecturer at a South African University

It's difficult to get to work when you graduate. It's not easy to get employment. Because you find that other companies, like private companies that deal with water, they rarely hire people who have reached the level of PhD. You see, they rather hire people who have attained their diplomas or plus degrees. And then they train them at your job. But somebody who has a PhD, you just have to go into maybe … university academic institutions, unless you can come up with your own consultancy firm. (Senior lecturer at a Lesotho University).

The ramification of not finding work, either in industry or academia, is doing one postdoctoral fellowship after another.

What's happening now, it's like after a PhD, that common opportunity that we get is the postdoc. So it's postdoc after postdoc. There's no permanent job at the moment. If I cannot find work, rather than sitting at home, I will take another postdoc. (Postdoctoral researcher at science council)

One interviewee noted that his PhD had not benefited him in his place of employment because his industry did not recognise its value.

My own organisation that I'm working in, does not actually recognise that formally. There were a lot of instances where I could have made some other contribution based on my experience. And then you find that you're excluded from it. So they give it to people that they know, or people that [have] done it for the last 10 years or something like [that]. And they are not exposed to the latest technology, or the latest studies out there. But because I've done it five years ago, or 10 years ago, and you weren't even consulted and you weren't even given a choice. Even when I asked to make contributions, they weren't interested. So maybe it's different at the factory itself, but in mining there's no need to have a PhD. You can say I've got a PhD, this is doctor so and so, but it doesn't mean anything to them. (Divisional head at Sasol).

Several individuals expressed disappointment at how their PhD has not been used in their employment or had affected their current employment.

My employer actually discouraged me from doing a PhD. They didn't want to fund me because it didn't add any value. They would rather have me spend the time at work. They were prepared to pay me for the extra work, but not doing a PhD. (Divisional head at a municipality)

But it does depend on the person. If a young consultant who is flying in their career, for example, said to me I'm thinking of stopping to do a PhD, [I] probably wouldn't advise it because I think it does take a chunk out of your focus. I felt that happened to me. I felt like I got left behind a little bit in consultancy and I had to play catch-up a little bit. That was a bit stressful for me. (Environmental impact assessment consultancy)

[Is a PhD useful in your current position?] No. Not at all. I realised that I was just too old to be able to make a move to [an] academic career. I'm just about to retire now. In fact, in one year I [will] be retiring. And so from that point of view, the PhD actually didn't fulfil what I had in mind. I've been involved in research all along, but always as a co-author. I do a lot of data analysis. And that's how I got my entry point into a wide range of papers, different topics. But the PhD didn't make much difference with that, actually. It is an advantage, but I was not able to really get the most out of it because I was just too late. (Researcher at a South African university)

[Was doing a PhD worth your while?] For personal development, yes But not for my career, which is [a]

crying shame, actually. And quite a bit of disappointment for me. It was because of the political challenges in South Africa. Particularly because I was a white male. At the same time, coming to another country [moved to NZ] and coming up against people with local knowledge, especially in ecology, it's quite powerful to have local knowledge, as opposed to just general knowledge. (Science writer)

This survey response suggests that this individual expected a PhD to increase his salary, but found that it did not. In fact, a PhD has cost him financially.

While the value and relevance to my personal and professional knowledge and growth has been immense, I am uncertain regarding the economic value of a PhD degree. My salary since graduating has not significantly increased or improved compared to what I was earning before. In fact, I had to take a significant income cut for the two years of postdoc in the hope of securing more permanent employment at a public university, which never happened. So financially, I am not sure that my PhD was an investment as I put … a lot of my personal finances into completing it, took a pay cut to pave a career for myself afterwards, and yet five years later I am not earning any differently even though I have a PhD. (Qualitative response in survey)

Two interviewees explained that their PhDs had come at a high personal cost, especially with regard to maintaining the family-work balance.

To be honest, I don't think so [a good investment of his time]. It came a very high price. I missed five years of my children's lives. Obviously, if I didn't work, I worked on my PhD. So I neglected my family, I neglected my marriage. In that regard, it's not really worth it. In terms of my goal to just close the loop, I think that's positive, because that's probably something I would have wondered throughout my life if I shouldn't have pursued it. So that I think is a positive, but in terms of life in general, and life as a whole, I'm not convinced it was worthwhile. I am starting a new position in July at another company. So just moving from animal health to human health to medical writing. So that has now happened in the last two months. That was after I completed the survey. I asked them why I could get this job and they said they feel that doing a PhD develops critical thinking and so forth. I have specialised myself in the field of animal health to a degree where I couldn't get out. I was overqualified for anything else, and I didn't have any other relevant experience. So I think, in this case, the PhD helped me now to move career paths and try something else. So I must say that was a positive. (Science writer for private company)

Look, I mean, the actual PhD, I'm glad I have it. If you're going to ask me if it's worth the sacrifice to my personal life, I'd say no. And if someone tells me that they want a PhD, and I'd be like, do you really want one? Is it really useful? And if you do it, just remember that sacrificing all the time with loved ones, you are going to regret that so you know, rather keep having your weekends and take breaks, don't just work all the time because you will regret it later. (Senior researcher in national government department)

8.2.3 Value of the PhD in terms of professional advancement and personal fulfilment

We have already noted that for those on the academic track, obtaining a PhD degree is a necessity for advancement up the academic ladder. This was most succinctly summed up by one respondent who said:

Once I got back into academia, of course the PhD is like a basic passport. Without a PhD you can get to the position of a lecturer and that's it, you hit a glass ceiling. So with a PhD, you then are able to enter the ranks.

(Associate professor at a university*).*

In addition, pursuing a PhD is an obvious route for those who wish to pursue careers as scientists or researchers. Beyond this, interview respondents offered numerous examples of how obtaining a PhD improved their career prospects, with many referring to how it "opened doors" for them.

From the perspective that the PhD broadens individuals' existing stock of knowledge, skills and networks, having a doctoral degree can markedly increase and open up one's employment prospects. Put another way, positions become available that would not otherwise have been accessible.

> *It's opened … new doors. I would not have had the job opportunities that I've had, and the learning experiences that I've had, if I hadn't done it. It's definitely been a gateway for me.* (Senior research fellow at a university)

> *A PhD is like a key that can unlock a lot of doors, be it in the private sector, be it in the public sector. When I did my PhD, I didn't realise this. But afterwards, in hindsight, I always tell people who want to do a PhD, they ask, why should I do a PhD, I don't want to become a professor? I say, well, take me for example. The opportunities that it can unlock within all sorts of environments is legion. So the CSIR is, as you know, a research institution that values, that attracts PhDs and master's students. So if they get an application from somebody with a PhD, that has published extensively, and comes from a research environment, they would grab that person.* (Professor at a university)

> *The reason why I count it as a good return on investment is that one thing that it has managed to do for me is that it has allowed me to at least use my skills in different areas. So, my skills set, I've entered into collaborations where I wouldn't even have thought about it, but they would have contacted me and said, hey, we noticed you do this kind of work, do you think you could give us some ideas on this? It kind of opened doors in that area.* (Assistant professor at a university)

> *It worked out well because now, even when I'm here in Malawi, even in South Africa, people contact me for biomonitoring work. They need my services in water. Then I have to link them, even if I'm not in South Africa, have to link them to someone in consulting firms. Now, I'm making my name here and people are starting to know me. There are lots of World Bank projects here and everybody wants me involved in terms of water resources monitoring, water quality, because there are few experts.* (Entrepreneur)

Insofar as there is a level playing field, meaning that having a PhD is not a requirement per se but that the job is in what one might refer to as a "knowledge sector", having a PhD seems to make people more competitive and give them an edge.

> *My thinking was on a whole new level. Concepts that were difficult for others were quite simple and easier for me. I simply have no competition*. (Senior scientist at a parastatal)

> *Another thing is that I don't have to work hard to get what I want. It's linked to less competition and stuff like that. When people think about water they just look at maybe the quantities of their water. But in terms of the pollution issues, it's a huge problem here. So there are lots of opportunities for me here. Competition is less because everybody is coming to me. Whatever I do, I'm getting it.* (Entrepreneur)

> *Also to be competitive internationally. I think the PhD was not really to get me a job. Because if I really wanted to make money off the bat, probably the PhD is not the best place to start. But it enabled me to get a career which is internationally competitive. I can actually get a job anywhere in the world. I think a PhD does help you do that. Because if you do great work, regardless of where you're from,*

people will give you a chance. (Postdoctoral fellow)

One way in which this kind of value in a PhD degree can be articulated is in terms of it having symbolic value to prospective employers. In other words, it signals a certain level of competence or potential set of skills – including transferable skills such as those highlighted earlier in this section, like the ability to work independently, manage large amounts of information, think conceptually and solve problems. A related dimension is that a certain amount of prestige is attached to the PhD – and often specifically to the title that comes with it – which gives doctorate holders credibility in the eyes of others. Interview respondents provided examples of how this is leveraged and the following quotations are some examples:

> *Remember that I'm working in a specialist field of wastewater and water treatment and, obviously, to have a PhD, I think just on paper, puts you ahead of other people. What happens in our industry is, if you tender for work, there are some requirements, and many of these international projects nowadays require at least the minimum of a master's degree. And then many times they will on … functionality, they will mark and give you points in terms of your qualification. So obviously to have a PhD, you can score full marks.* (Principal at a private enterprise)

> *You get taken seriously in a professional perspective. I also think that when we're looking for funding, applying for funding opportunities and stuff, I think having a PhD is a good thing. I think it gives you some academic status, over maybe somebody with a master's or honours study. I think by the time you've got your PhD people presume that you more or less know what you're talking about.* (Regional programme director for an international NGO)

> *If people ask for quotes and they have different quotes in front of them and they have more qualified versus less qualified persons but the price is the same, then I would expect them to, or rather hope they go for the more qualified persons … It gives us a little bit of an advantage over the competition.* (Environmental scientist in a private enterprise)

> *There's something about when you introduce yourself and they check your CV and they see that you [are] a "doctor". It makes things a lot easier. People tend to feel you've got the knowledge to provide a solution.* (Managing director of a consulting firm)

However, as one respondent pointed out, of course having a PhD is not guarantee of expertise or competence!

> *I think, similar to the Eskom environment, [the PhD] wasn't a requirement. But certainly from a stature perspective, people do put a lot of value [on] it. Sometimes I think mistakenly. And I give that within a context that I mean I have staff in the business that have PhDs that absolutely struggle and I've got staff without PhDs that fly. So getting a PhD is no guarantee or indication of ability or capability or aptitude or hard work associated with those things. So certainly, as you know, engaging externally, the fact that I'm a "doctor", people give a lot of credibility to that, which is great. It's nice to have. But it's more about how other people perceive you, as opposed to the extent to which you really are capable.* (Head of division at a science council)

Another interviewee echoed this, highlighting that sometimes others put too much store in the PhD title:

> *At times, people overrate what you are. They expect that you perform miracles. Although you are specialised in a small area, people expect you to do well in a different area.* (Dean at a university)

Interview respondents also spoke about ways in which the PhD had served to increase their own confidence in their abilities and in tackling complex tasks.

> *It also gives you a level of confidence in how you approach issues. And believe it or not, it helps gain a*

little bit of respect and cooperation because your team members, whether they're older or younger than you, they are comfortable that you know what you're talking about. (Manager at a science council)

As was highlighted in section 7.2.2 above, several interviewees spoke about having pursued a PhD for personal reasons. This kind of intrinsic value was also highlighted by respondents who, among others, made reference to having a sense of accomplishment, having developed personally (e.g. confidence, perseverance), and having made their parents proud.

Sometimes people make the mistake of thinking it's just about a PhD, but I think it's the process you go through. I can say that even if someone didn't get a piece of paper at the end of the day, you would still have developed immensely. (Senior lecturer at a university)

The PhD, to some extent, is obviously personal gratification rather than anything else. (Associate professor at a university)

Fulfilment in terms of career and family expectations. I mean, my dad was completely over the moon when I got my PhD, and he came to my graduation. He's always sort of been kind of my pillar. And you also feel really empowered when you have a PhD. (Network and research manager at a university)

What comes to mind is the confidence that I have when I present in a public forum. (Senior lecturer at a university)

I would say one is you really learn to persevere when things are going wrong. It teaches you to just keep going because you have signed up for this. The other thing is that it's amazing how much you learn to improvise and find resources, because no one's going to do this for you. So, you just have to find it within yourself to do things that you never thought you could do. You want to get this done, you've got to do it. (Senior research fellow at a university)

Finally, respondents reported that their PhD had afforded them opportunities and experiences – such as travelling to different countries – that they would not otherwise have had.

The PhD for me personally, the process was more amazing than the outcome. Because in my PhD, I spent almost two years just travelling. I spent about seven, eight months in Germany, I spent eight months in Belgium, spent a month in Morocco. I travelled the Middle East for a month on holiday. I mean I went to Denmark, I saw Vienna, I saw parts of Africa. (Senior lecturer at a university)

I think my expectation is, and it's something I tell students often, that working in research and working in a university academic environment, and having a PhD behind you, does give you the opportunity to meet and learn from a range of different people across the globe. And especially in what I'm doing. And then we've got projects in India, and we've got projects in the US, in Southeast Asia, in Africa, and I'm constantly learning. And I think that's one thing that did draw me to do a PhD. This idea of having a very diverse and dynamic job that will take you to places and take you to meet different people, that changes every year. So, I think that is something that is extremely beneficial. And it's one of the things I love the most about my job. I definitely wouldn't have had that opportunity. (Postdoctoral fellow)

The entire process in there, and the people I had to deal with because I travelled to Zimbabwe by myself and I drove through Mozambique and Swaziland and Malawi, and I went to all these places by myself, and I kind of had to figure out where all the vulnerability assessment committees were based and stayed in expensive hotels and went to offices with no electricity. So yeah, I think the process was invaluable. And I wouldn't be where I am today if it wasn't for it. (Business owner)

By way of concluding this section, we provide a mini case study of one of our interview respondents as a way of illustrating various points highlighted in the discussion above, including how obtaining a PhD can be leveraged in a number of different ways – not only for personal advancement but also for the betterment of others. It is also an example of someone from another African country who undertook her PhD in South Africa and stayed – to the benefit of the South Africa and her home country. The story below has been anonymised in line with the ethical code for this study.

A PhD graduate success story

Bishara* is a Kenyan national who came to South Africa to do her PhD. She described herself as a mature student because she started her PhD 10 years after having completed her master's. She was married with children, and had been working as a lecturer at the University of Nairobi for nine years.

Bishara's primary motivation to do a PhD was so that she could be promoted in the university environment. As she remarked: "I was really stuck, I could not be promoted, and so it was really to pursue my academic career." While she had the opportunity to register at a university in the UK or the USA, she felt she'd prefer to stay on the African continent. She'd heard good things about the department of computer science at a particular South African university and decided to register for her PhD there.

Her PhD involved the development of a computer science prediction model which integrated African indigenous knowledge and modern scientific approaches to drought prediction. Her topic was inspired, in part, by her own life experiences: "Having grown up in a village myself, I knew exactly what the small-scale farmers were lacking."

Bishara's PhD was funded through a combination of study leave granted by her home university and support from her husband. She also took on some tutoring work in the department. During the second year of her PhD, the department managed to secure funding from a German software company to finance the research lab. According to Bishara, this "changed everything" for her as it enabled student exchanges with the laboratory in Berlin.

The main output of Bishara's PhD was a computer modelling system for drought prediction. While the critical component is the backend engine, the system also comes with a web portal, an SMS function and a mobile app. Bishara remarked that it "changed the career trajectory" of her life. Almost immediately there was uptake, and the system became a "living project" used by small-scale farmers in KwaZulu-Natal, Kenya and Mozambique, with significant financial backing from USAID. The project has been running for three years. A spin-off company was created at the university based on the intellectual property generated through her PhD, and this will create employment for Bishara and others.

She has subsequently taken up a full-time post at a higher education institution in another province. Several months into her permanent appointment she became head of the department. She has subsequently been sponsored by the institution to do an MBA. At the time of the interview she had just been informed that she had been awarded a C2 rating by the National Research Foundation, and that the following year she would finally be able to be promoted to professor.

** Real name not used*

8.3. Summary of key findings

Salient findings on the utilisation of the PhD:

1. The survey revealed that doctoral graduates rated the general knowledge acquired during their doctoral studies to have been the most useful for their current employment. This was supported by comments gained from the interviews where, aside from research skills, respondents most often highlighted what might be termed "transferable" and "soft" skills as the most valuable. Such skills included, for example, the ability to think critically and conceptually, to solve problems, to communicate effectively (both verbally and in writing) and to manage projects or large amounts of information or time.
2. It is perhaps not surprising that recent graduates (i.e. those who received their PhDs between 2015 and 2018) were more likely to use the findings produced by their doctoral research than the other groups.
3. More than two thirds (70,5%, n=3 875) of respondents indicated that a doctoral degree was a requirement for their current employment position.
4. More than 80% (83%, n=3 324) of respondents who were currently employed in the higher education sector considered a PhD a job requirement compared to 53% (n=354) in the government sector. The plurality of respondents in the private non-profit sector (43%, n= 149), business enterprise sector (53%, n=221) and other education sector (62%, n=24) did not consider the doctorate to be a requirement for their current employment position.
5. Overall, 70,4% (n=3 930) reported that research activities make up a large part of their current work. The data show that 81% (n=3 271) of respondents in the higher education sector reported that research formed part of their day-to-day work activities. The second highest proportion was the government sector (60%, n=415), followed by the non-profit sector (44%, n=176), the business enterprise sector (36%, n=246), and finally the "other" education sector (22%, n=24).
6. Overall, just over half (53,8%, n=3 004) of respondents indicated that managerial responsibilities were part of their current employment responsibilities to a great extent, compared to 6,5% (n=364) who indicated that they had no managerial responsibility at all. There were no sectoral differences in relation to whether or not managerial responsibilities were part of respondents' most recent employment.

Salient findings on the value of the PhD:

1. Most survey respondents expressed satisfaction with their choice to do a PhD.
2. Recent graduates were less likely to consider the PhD to be a good return on investment compared to earlier graduates, but this might well be because insufficient time had passed for them to realise the benefits.
3. Similarly, doctorate holders' perceptions about whether their expectations of doing a PhD had been met differed between recent graduates and those who completed their studies more than 10 years ago.
4. A small proportion of doctorate holders felt that they should have done their PhDs in a different field. The highest percentage of these (13%) had PhDs in the field of education.

5. The interviews revealed that individuals decide to undertake PhD degrees for a variety of reasons, mostly related to career advancement. As such, doing a PhD was either an entrance to a particular career, a ladder to upward mobility, and/or a bridge from one career and/or sector to another.
6. Respondents reported that their doctoral degrees had improved their existing stock of knowledge, skills and networks which, in turn, markedly broadening their career prospects or gave them a competitive edge in the labour market.
7. Some interviewees pointed to the "symbolic" value of the PhD insofar as it signals to prospective employers and others an expected level of competence or skills set. They also highlighted that having a PhD – and often the title that comes with it – brought with it a certain cachet. All in all, the positive perceptions of others towards the PhD could be leveraged to doctorate holders' advantage.

Chapter 9: Recommendations

9.1. Recommendations

First national tracer study to act as benchmark

This study constitutes the most comprehensive tracer study of doctoral graduates who graduated from South African universities in the recent past. The findings presented in this report for the first time provide accurate, precise and generalisable information on a wide variety of issues – the employability of SA doctoral graduates, the financing of doctoral studies, the differences in the career trajectories between full-time and part-time students, the peculiar challenges facing postdoctoral fellows, the absorptive capacity of different employment sectors, the geographic mobility of these graduates, and new insights into the perceived value and utility of pursuing doctoral studies. **It is fair to conclude that this study provides a baseline for any future studies of this nature**. Our first recommendation is that it is essential that doctoral tracer studies (or some form of tracking of doctoral graduates) become a regular feature of higher education and labour studies in the country. It is essential that this study is replicated every three to four years to establish whether the main trends remain the same, whether new challenges in the ecosystem of high-level skilled graduates arise that need to be addressed and specifically to assess what interventions are required to address any new challenges.

The way such future studies should be conducted, however, needs to be critically assessed. In some countries (e.g. Canada) it is compulsory for doctoral graduates to complete an "exit" survey on completion of their studies in which they indicate their immediate career plans and expected employment. This arrangement is written into the statutory act of Statistics Canada and all Canadian universities are required to comply. This is one way in which future tracer studies in South Africa could be approached – especially if initial thoughts about establishing some digital platform to support this are pursued. However, it should also be clear that pursuing this course of action will require a huge amount of advocacy and the involvement of USAf and other relevant bodies to make it a viable course of action.

The alternative would then be that studies such as this one be repeated every three to five years using the same methodology. This a feasible option and reasonably inexpensive, and should therefore remain on the table as a way of obtaining information of this nature in the future.

Further research needed on financing doctorates

One of the main findings of this study refers to the sources of financing of doctoral studies. As far as we are aware this is the first study of this scope that provides a comprehensive and granular picture of the different (and relative) sources of funding that doctoral students mobilise to pursue their studies. The study has revealed that there are many differences between full-time and part-time students, between students from different disciplines, and between students of different races and ages. The fact that the single biggest source of financing was identified as self-financing by the student is a clear indication that government funding of doctoral studies is inadequate and has become one of the main reasons why many doctoral students have no choice but to study part time. As a result, the majority of doctoral students in most scientific disciplines commence their studies in the early to mid-thirties and then take on average

4,5 years to complete it. **Our second recommendation is therefore that further research should be undertaken into the financing of doctoral studies**. Such research should combine quantitative and qualitative approaches to gain a better understanding of how doctoral students are financed and supported by their universities, their employers, and national and international funding agencies, and how these different funding modalities affect their studies and their subsequent career trajectories.

More specifically, we believe that such research should be undertaken as a collaborative project across all universities, possibly using funding from the NRF or the DHET's University Capacity Development Grant. Not only will the results be of extreme value for national bodies such as the DSI, DHET and NRF for planning the future financing of doctoral students, but the results will also be useful for planning at individual universities.

Need for studies on the changing nature of work and expectations of doctoral education

Our study found that most South African doctoral graduates are employable (with only 2-3% unable to find employment). However, further disaggregation of the more qualitative data also showed that 20% of graduates (especially those who graduated in the recent years) were unable to find employment related to their technical skills or fields of expertise. This raises a number of questions about the nature of the "standard" doctoral degree and the knowledge and skills students acquire, specifically whether these skills align well with changes in the labour market. It is obvious that all (doctoral) graduates require new skills in the digital age. Many more jobs, including in the science and technology fields, require that students not only have the standard analytical and research skills that they gain through postgraduate studies, but also new skills related to big data analytics and transversal skills, as it is increasingly clear that the changing nature of work requires easier movement across disciplinary boundaries. The big societal challenges of our age – climate change, pandemics and their impact on society, adapting to virtual forms of work, the increasing inequality in many societies – require graduates that are adaptable and sufficiently educated and trained to deal with complex problems. **Our third recommendation is that more is done to study how – in different parts of the labour market – changes in the nature of work are affecting expectations related to the kind and range of skills doctoral graduates should have**. Such research would ideally also address how the changing nature of work may have to be taken into consideration in a possible rethinking of how we conduct doctoral education at our universities.

Need for policy review based on empirical evidence

This study has confirmed the results of previous studies conducted by CREST (SciSTIP), which indicated (a) that the average doctoral student in SA commence their studies at age 34; (b) that there are large differences between fields (in the SSH the average age at commencement is 36); and (c) that the majority of doctoral students in the country (60%) study while they are employed (Mouton et al., 2015, Van Lill, 2019). This last refers to the large numbers of academics at the beginning of their academic careers who are in their early to mid-thirties and are encouraged to complete their doctoral studies and obtain a PhD for the purpose of promotion. It is clear that South Africa has too few doctoral students who are (1) studying full time; (2) properly funded and (3) able to commence and complete their doctoral studies at a much earlier age than the average of 40/41. From a policy point of view, these facts call into question

the most recent NRF funding policy that focuses exclusively on students who study full-time (the minority in the system), who are not older than 32 at the commencement of their PhD studies (again the minority of students across all disciplines) and also to ignore (for all practical purposes) the huge contribution that non-South African students (more than 30% of all doctoral students are from the rest of Africa) have made to our higher education and science system. **We therefore strongly recommend that the NRF revisits and revises their current policy to align it better with the available evidence**.

Investigate the status of the postdoctoral fellow

Our study has confirmed what has been found in many studies in other countries – that many doctoral students pursue a postdoctoral position not because they want to, but because they have no alternative. This is particularly true for students who aspire to find a permanent position in academia where the stagnation of the system has resulted in very low growth in the availability of new positions for young entrants. As a result of this, many postdoctoral fellows accept successive fellowships simply because no permanent position is available. It is therefore not surprising that many of our postdoctoral fellows indicated that they believe that their precarious position is not properly appreciated, and that this affects their self-identity and future expectations. **We therefore recommend that the relevant role players (USAf, DSI, CHE and funding agencies) convene an expert group to investigate in more detail how the position and status of postdoctoral fellows can be strengthened and what measures are required to ensure that the value and talent of this group is not lost to academia and the science system in general**.

Need for investigations into the absorptive capacity of the knowledge sector

Our study has provided, for the first time, precise and comprehensive data on the intersectoral and geographic mobility of doctoral graduates. The evidence suggests that the capacity of the system to absorb increasing numbers of PhD graduates is already strained. There are signs that, although we may continue to produce larger numbers of doctoral graduates every year, the lack of growth in new posts in academia and other knowledge-intensive sectors may soon translate in lower employability rates for doctoral graduates in the country. This phenomenon is particular evident in the STEM fields, where increasing numbers of graduates in the biological and environmental sciences end up in serial postdoctoral positions. If interventions are not taken to address this issue, we may soon find that the targets for PhDs that are set and programmes implemented to increase the number of STEM graduates will be of no value. We risk losing STEM graduates to other countries. We already found in this study that doctoral graduates in the biological and environmental fields are more likely to leave South Africa on completion of their doctoral qualification. **Our final recommendation, therefore, is that a specific initiative is launched to investigate further (also through predictive modelling of the current mobility trends) how the results of this study will impact on the absorptive capacity of the knowledge sector in the economy so as to ensure that there is an optimal alignment between the supply and demand of highly skilled graduates**.

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Annexure A: Tracing doctoral graduates in the water sector

1. Methodology

In identifying survey respondents whose doctorates fell within "water and water-related" fields, our point of departure was to define "water" fields and develop a set of search terms that could be used to identify graduates in the water sector. Our search terms were applied to the thesis title and scientific field entries in the survey database. The output records were then reviewed manually to ensure that they accurately reflected the search criteria. This process generated a list of 220 respondents who we consider to hold a doctorate in the water sector. Water graduates constitute 3,4% of our total sample of doctoral graduates.

The search terms used to identify participants in this second group are captured in Figure A.1 below. We based the field demarcation of water graduates on three sources: (1) the section on water research in the 2019 SciSTIP report, The State of the South African Research Enterprise (Mouton et al., 2019); (2) commonly used bibliometric approaches to identifying water-related articles according to subject journal categories; and (3) a review of the WRC and Department of Water and Sanitation websites.

PhDs in water-related fields

General:

- Water supply, catchment, hydrology
- Water sources, rivers, oceans, lakes, estuaries, aquifers, wetlands, groundwater
- Water storage, dams, reservoir, catchment
- Water demand
- Water distribution, services
- Water infrastructure
- Water quality, pollution, effluent, wastewater treatment
- Water scarcity, drought, desalination
- Sanitation, effluent, sewage

In relation to specific industries, especially mining and agriculture:

- Water use efficiency, irrigation, wastewater treatment, water technology

Cross-cutting aspects:

- Water-related planning, management, governance, funding, human resources, education and training

Oceanographic:

- Ocean, marine, aquatic, polar, Arctic

Within biological or chemical domains:

- E.g. limnology, bioprocessing or nanotechnology

Figure A.1 Search terms used to identify survey respondents in the water sector

Defining graduates in the water sector is not a simple task because the sector spans a number of disciplines, such as agriculture, engineering, biology, conservation studies, ecology and so forth. Within HEMIS, there is no CESM code allocated to students who pursue qualifications in the water sector. For these reasons we cannot accurately determine the population of doctoral graduates in the sector. However, in our doctoral thesis database, a rough estimate of doctoral theses with a water-related topic, between 2000 and 2019, is about 800 to 900 possible titles. Given that our total sample of doctoral

graduates constitute 20% of the population of doctoral graduates produced in South Africa, we consider a fivefold estimation of doctoral graduates in the sector, with about 1 000 doctoral graduates produced at South African universities over the last two decades.

Our analysis of doctoral graduates in the water sector presented in the forthcoming pages are thus based on smaller numbers of respondents. In terms of the headline findings of our main report, we compare the results of our total sample with that of the water sector and we do this for our entire dataset. In other words, given the small number of respondents in the water sector, we do not filter out graduates who obtained their doctoral qualifications in 2019 and 2020 and to ensure fair comparison, we therefore include the entire dataset for all respondents. This might therefore explain any possible discrepancies with the results presented in the main report.

2. Findings

In the following sections, we present the headline findings of the main report for the water sector. We therefore track how the headline findings from the main report compare on the same topic to the water sector (sub-sector) trends. We therefore ask the following questions in this sub-sector report:

1. What is the profile of doctoral graduates in the water sector in terms of gender, race, nationality and age?
2. What is the mode of study of doctoral graduates in the water sector?
3. Are doctoral graduates in the water sector employable and where do they find employment? What types of employment do water graduates typically hold?
4. What is the mobility of doctoral graduates between employment sectors?
5. What is the geographic mobility of doctoral graduates in the water sector?
6. How do doctoral graduates in the water sector consider the value and utility of a doctoral qualification?

2.1. Description of graduates in the water sector

2.1.1. Demographic profile

By means of the figures below, we describe the profile of doctoral graduates in the water sector along a number of demographic variables. In Figure A.2 below we illustrate the distribution of graduates in the water sector by gender. We see that two thirds of graduates are male (67%, n=145) while a third (33%, n=73) are female. We see that male graduates in the water sector are better represented than in our total sample. This result is in line with trends where female graduates are generally underrepresented in STEM disciplines, more specifically the natural sciences.

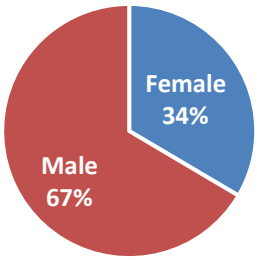

Figure A.2 Gender of water graduates

When we look at the distribution of graduates by race, Figure A.3 show that 65% (n=78) of graduates are white, 28% (n=34) black African, and small numbers of graduates are coloured (3%, n=4) or Indian/Asian (3%, n=4). When we compare the shares of white and black graduates (generic black comprising of black African, Indian/Asian and coloured) we find that the 65/35% split is comparable with the share of black graduates in the South African doctoral population (38%) (as reported in HEMIS) as an average for the period 2000 to 2019.

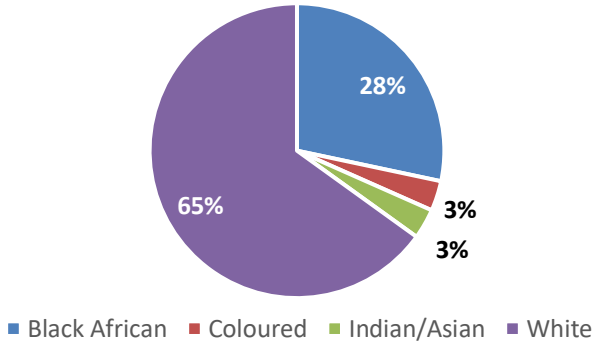

Figure A.3 Race of water graduates

We have shown in the main report that large numbers of students from the rest of Africa pursue their doctoral qualifications at South African universities. In Figure A.4 below we see that 59% (n=128) of doctoral graduates in the water sector are South African, compared to 36% (n=79) from the rest of Africa and 5% (n=11) from the rest of the world. When we compare the profile of doctoral graduates in the water sector in terms of nationality with that of the entire population (as reported in HEMIS) we find that the water sector attracts a larger share of international students (41%) compared with the national trends (31%) (as averages across 2000 to 2019).

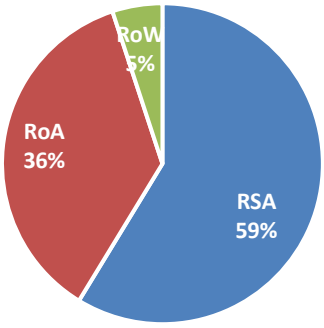

Figure A.4 Nationality of doctoral graduates in the water sector

When we look at the average age of doctoral graduates in the water sector for the total period we find that graduates in the water sector are on average younger, at 37 years, than all doctoral graduates (at 40/41 years) when they complete their doctoral qualifications. This result is expected, as we have shown in the main report that graduates in the STEM sciences are generally younger when they complete their doctoral degrees.

2.1.2. Description of doctoral graduates while enrolled for their doctoral qualifications

In the main report we have shown that doctoral graduates in the STEM sciences are likely to be enrolled full-time towards their doctoral studies, but that there is an interaction effect with age, as younger students are also more likely to study full-time compared to their older counterparts. In Figure A.5 below, however, we see that in the water sector, doctoral graduates were equally likely to study whether they were employed or unemployed. The results show that 50,2% (n= 110) of graduates were employed while working on their doctorate and therefore studying part-time, compared with 49,8% (n=109) of graduates who were enrolled full-time.

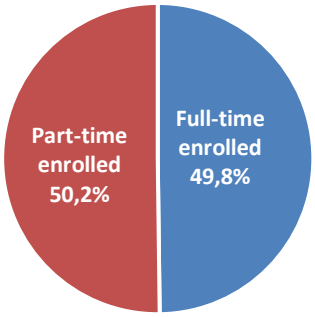

Figure A.5 Enrolment status of doctoral graduates in the water sector

In Figure A.6 below we see that among graduates who were employed during their doctoral studies, 57% (n=65) worked in the higher education sector, 23% (n=27) in the public or government sector, 11% (n=18) in the business sector and a small number of graduates in the private non-profit sector (n=5). When we compare these results with that of all graduates, we find that more graduates in the water sector were employed in the public sector compared to all graduates (23% vs 14%). These may include graduates who work in local or provincial municipalities or water councils.

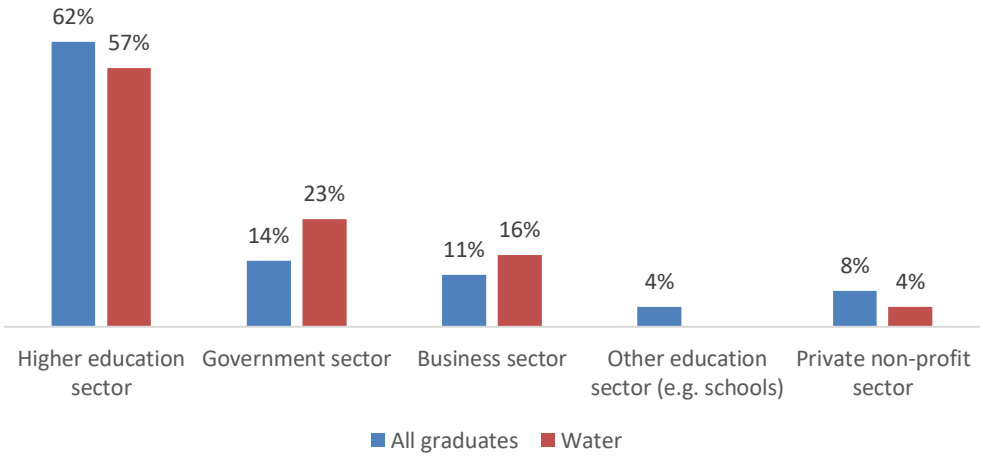

Figure A.6 Sector of employment during doctoral studies

In Figure A.7 below we show the sources of financial support of graduates in the water sector during their doctoral studies. The graph shows the sources of financing for students enrolled both full time and part time. Given the small numbers in our sample, we show the count rather than percentages. For full-time enrolled students, the most cited source of financial support was a bursary or scholarship from a South African funding agency (n=74), followed by financial assistance from a university (n=39). We see that part-time students were more likely to be self-financed (n=42) and received financial assistance from their university (n=42), where they are likely employed as a staff member while completing their doctoral qualification. These results are congruent with those found for our total population where full-time students are more likely to receive bursaries and scholarships while part-time students rely on self-financing or support from their university as an employee.

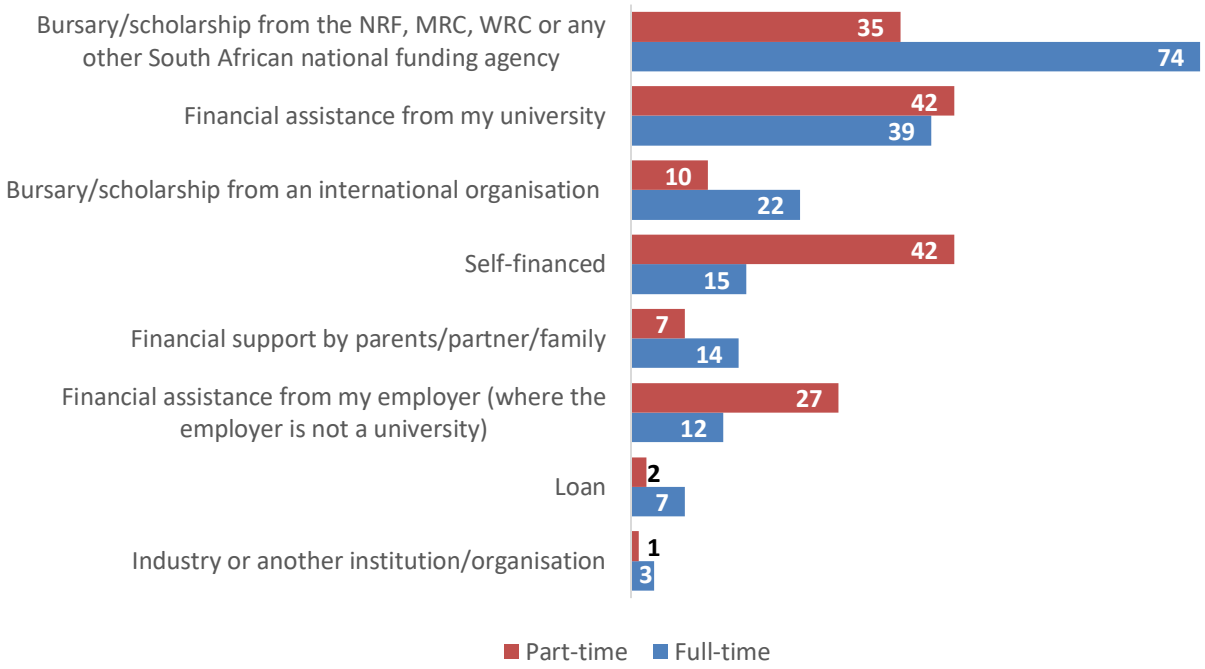

Figure A.7 Sources of financial support for graduates in the water sector

2.2. Employability of PhD graduates in the water sector

In this section we investigate the employability of doctoral graduates in the water sector. We look first at the employment status of graduates immediately upon completion of their doctoral studies. Secondly, we look at water graduates who accepted postdoctoral research positions. Finally we look at the employment status of graduates at the time of the survey. We look especially at the mobility of graduates between sectors as well as the employment positions held by graduates in various sectors.

2.2.1. Finding employment upon completion of doctoral studies

In Figure A.8 below we show the employment status of doctoral graduates within the first year after completing their doctoral degrees. We compare the employment status of graduates in the water sector with that of our entire sample. We find that 42% (n=91) remained with the same employer, while a quarter of water graduates (n=55) accepted a postdoctoral fellowship. We see that a larger percentage

of doctoral graduates in the water sector accepted a postdoctoral position than our total sample. We have shown in the main report that graduates in the STEM sciences are more likely to do a postdoctoral research fellowship. The results show that a smaller percentage of water graduates remained with the same employer (42% compared to 53% for all graduates), but that a larger share of water graduates found employment for the first time. This could be explained by the fact that a larger share of water graduates studied full-time towards their doctorate compared with our total sample.

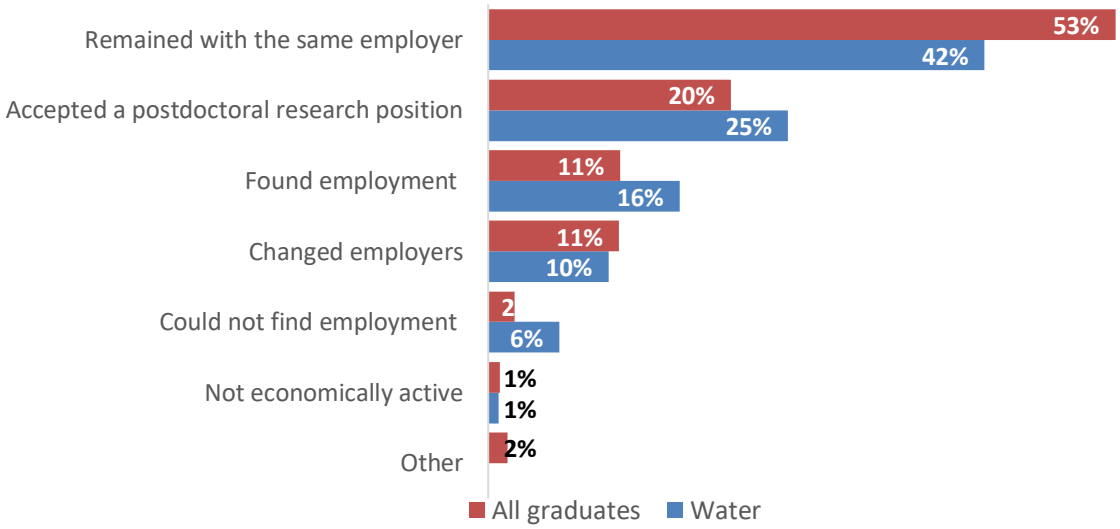

Figure A.8 Employment status of water graduates during first year of completing PhD

We find that a small percentage (6%, n=13) could not find employment within the first year of completing their doctoral qualification. This compares to 2,2% of our total sample. However, the number of water graduates who could not find employment was very small. We found that for our total sample respondents who completed their doctoral studies between 2015 and 2018 were more likely to experience challenges in finding employment. When we look at those water graduates who could not find employment we see a similar trend, where 10 of the 13 graduates received their doctorate in the last 10 years.

When we explore the type of employment found after graduation, Figure A.9 shows that 20% (n=38) of water graduates indicated that they could not find a position directly related to their field of expertise/technical skills. This finding is comparable to the 18% reported by our total sample, which indicates that graduates in the water sector do not necessarily experience greater challenges in finding employment that is aligned with their qualification.

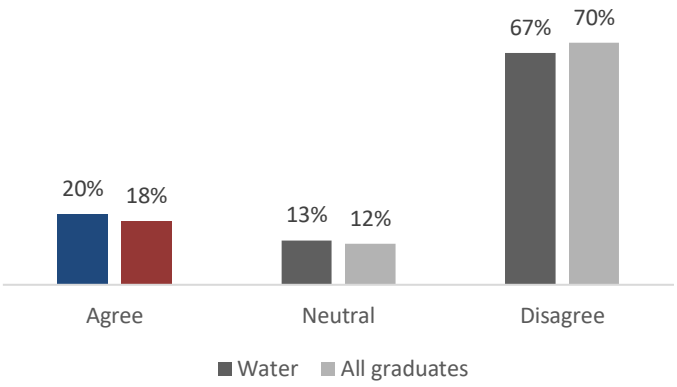

Figure A.9 Unable to find a position related to technical skills/expertise

2.2.2. Postdoctoral fellows

In the previous section we found that almost one out of four water graduates accepted a postdoctoral research position upon completion of their doctoral studies (25%, n=53). This compares to one out of five for our total sample (20%). This finding supports those of our national study where the results show that doctoral graduates in the STEM fields are more likely to pursue postdoctoral positions, specifically in the biological and environmental sciences. Figure A.10 below shows that nearly 42% of water graduates (n=22) who accepted a postdoctoral position held multiple postdocs. This compares to only 34% of our total sample.

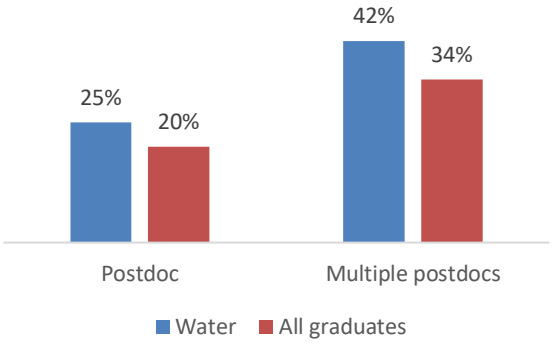

Figure A.10 Graduates who completed a postdoctoral position and multiple postdocs

Table A.1 below lists the reasons for taking a postdoctoral fellowship of water graduates compared to all graduates. Given the small numbers of postdocs we report on the counts in the tables below. The primary reason for accepting a postdoctoral position for water graduates, as with our total sample, was to gain additional training the field of the doctorate. We see that the reasons listed by water graduates generally correspond (with the exception of "this type of position is generally expected for a career in my field") with that of the total sample. This finding suggests that the reasons for pursuing postdoctoral fellowships in the water sector is not specific to the sector.

Table A.1 Reasons for taking a postdoctoral fellowship

	Water graduates	All graduates
	n	n
To gain additional training in the field of my doctorate	26	591
To carry out research independently	22	557
To work on a specific project/study	21	376
Other employment was not available	17	344
To gain training in an area outside of the field of my doctorate	16	232
This type of position is generally expected for a career in my field	12	305
To work with a specific person or in a specific place	10	271

Table A.2 below lists the reasons for accepted more than one postdoc. For water graduates the numbers are very small, but the two most cited reasons are (1) to work on a specific project/study and (2) other employment was not available. Despite the very small numbers of serial postdocs in our water sample, these results support those found across all sectors that doing a second or third postdoc is generally motivated by a lack of other employment positions.

Table A.2 Reasons for accepting more than one postdoctoral fellowship

	Water	All graduates
	n	n
To work on a specific project/study	12	116
Other employment was not available	11	162
To gain additional training in the field of my doctorate	7	115
To gain training in an area outside of the field of my doctorate	7	103
To carry out research independently	5	147
To work with a specific person or in a specific place	5	99
To carry out and support teaching activities	3	26
This type of position is generally expected for a career in my field	2	70

2.2.3. Employment at the time of the study

In this section we explore water graduates' employment at the time of the survey. We explore their sector of employment, and specifically where graduates who were employed in South Africa at the time of the survey, are employed. We also study the intersectoral mobility of water graduates and explore the nature of graduates' employment in terms of activities related to doing research, managerial tasks and involvement in technology development, innovation and entrepreneurial activities.

When we look at the employment status of water graduates at the time of the survey, as illustrated in Figure A.11, we see that a large majority (85%, n=185) were employed and working for a wage or a salary, 6% held a postdoctoral research position (n =14), 6% were self-employed (n=13) and 6 respondents were not economically active. When we compare these results with that of our total sample we see that water graduates are less likely to be self-employed (although the differences are not statistically significant).

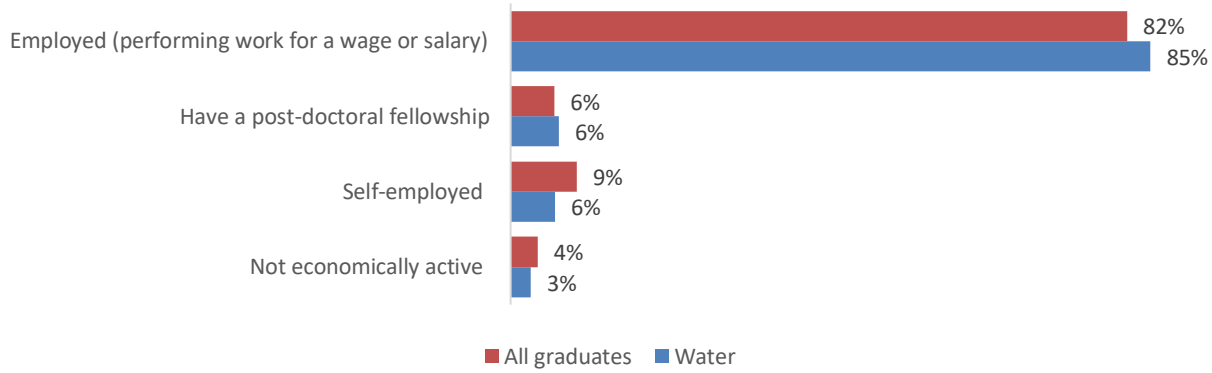

Figure A.11 Employment status of water graduates at the time of the survey

At the time of the survey, the majority, 56% (n =122) of water graduates were employed in the higher education sector, followed by 18% (n=39) graduates in the government/public sector, 17% (n =37) in the business enterprise sector and 8% (n=17) in the private non-profit sector. In Figure A.12 below we show these results.

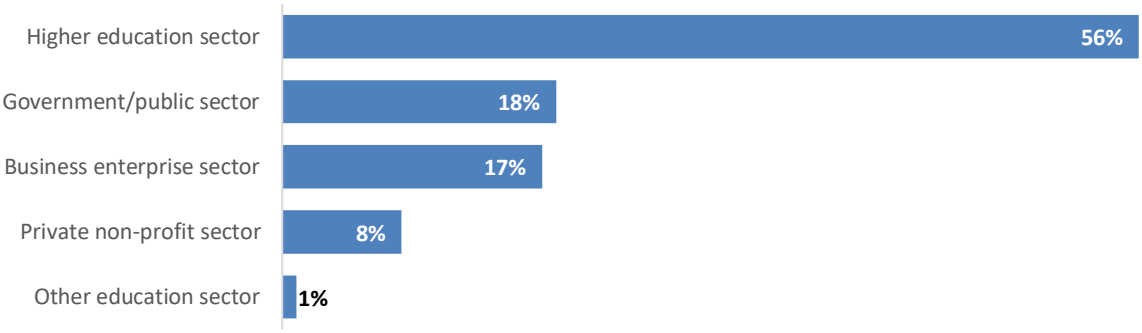

Figure A.12 Employment sector of current employment

When we look at movement between employment sectors, as shown in

Table A.3 below, we see that 43 water graduates who were employed in the higher education sector during their doctoral studies were still employed in the higher education sector at the time of the survey. In terms of outward mobility from the higher education sector, we see that five graduates moved to the government/public sector while 14 left the higher education sector for the business sector. In terms of inward mobility into the higher education sector, we see very small numbers of water graduates who moved to the higher education sector.

Table A.3 Intersectoral mobility of water graduates

	Employment sector during PhD		
	Higher education	Government	Business
Sector of employment at time of survey	n	n	n
Higher education	43	4	4
Government	5	17	1
Business enterprise	14	3	12

In the next section on the geographic mobility of water graduates, we report that 86 water graduates were employed in South Africa at the time of the survey. When we look at the employers of these graduates, we find that 56 graduates were employed at a South African university. Ten graduates were employed at a South African government department and another 10 were employed at a South African science council.

In Figure A.13 below we show that only 7% (n=15) of water graduates indicated that they did not have any research responsibilities or requirements in their employment positions at the time of the survey. This finding is comparable with that of our total sample and indicates that the majority of graduates in the water sector are required to perform research-related tasks as part of their daily responsibilities.

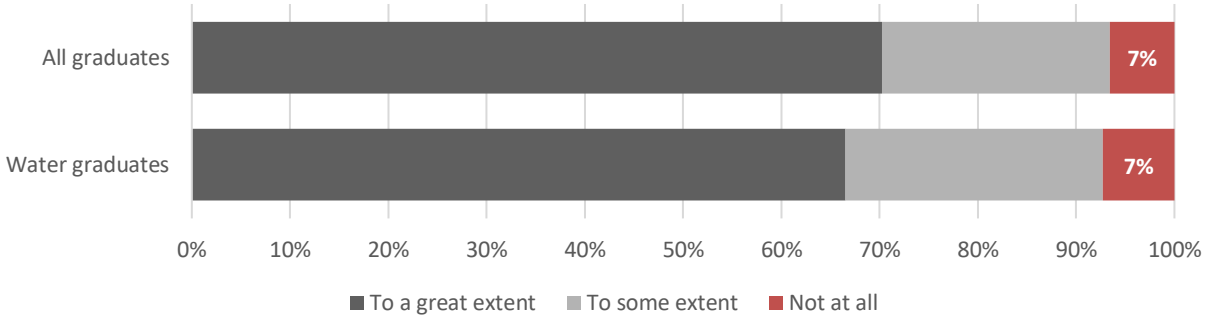

Figure A.13 Doing research as a component of employment responsibilities

In terms of managerial tasks and responsibilities, we find that most water graduates (as well as graduates across all sectors) reported having some form of managerial tasks and responsibilities, with 54% (n=111) reporting that they were involved in such tasks "to a great extent". Once again the findings for graduates in the water sector are comparable to that of graduates across all sectors.

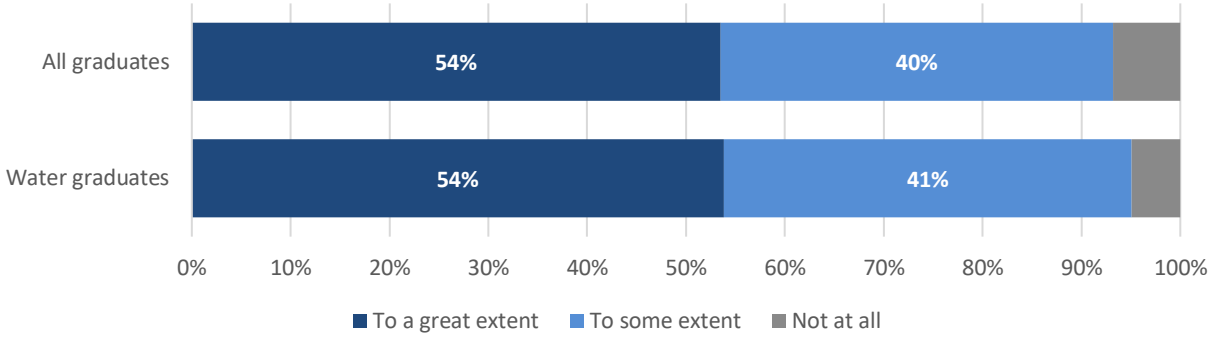

Figure A.14 Managerial tasks and responsibilities in employment position

When we look at the types of employment that graduates in the water sector hold, we find that 34% of water graduates (n=74) had active involvement in technology development, entrepreneurial activities or innovation. In comparison to all graduates across sectors, we find that graduates in the water sector reported more involvement in innovation or technology development.

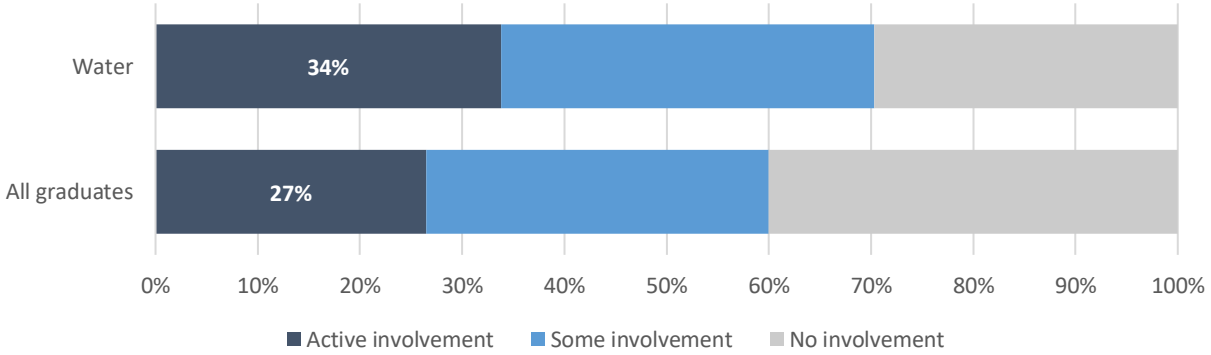

Figure A.15 Water graduates' involvement in technology development, entrepreneurial activities or innovation

2.3. Geographic mobility

In this section we explore the geographic mobility of doctoral graduates in the water sector. Figure A.16 below illustrates the in- and outbound mobility of water graduates by their nationality.

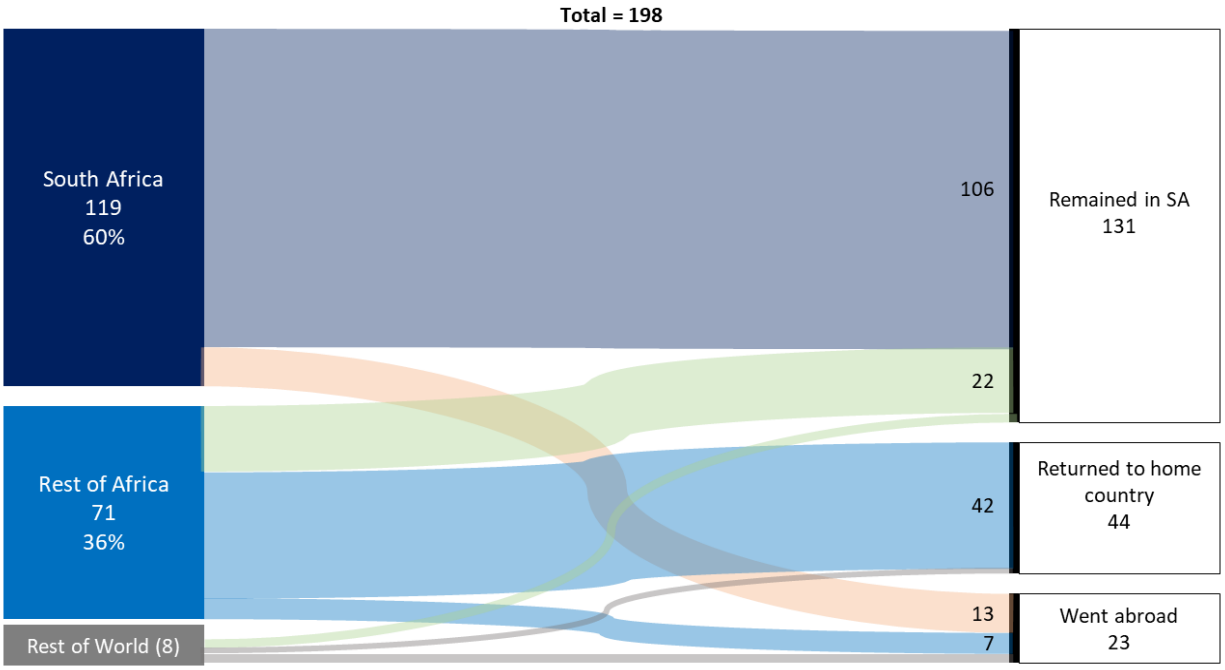

Figure A.16 Geographic mobility of water graduates

When we look at South African graduates, as illustrated by the dark blue block, we see that 89% of South African graduates (106 of 119) remained in South Africa in the first year after completing their doctoral studies. In terms of inbound mobility (brain gain), 31% of African graduates (22 of 71), as illustrated by the light blue block, remained in South Africa. A small number (n=3) of international students (RoW) remained in South Africa upon completion of their doctoral studies.

In terms of outbound mobility (brain drain), 11% (n =13) of South African graduates pursued opportunities in another country. When we look at graduates from the rest of Africa, 60% (42 of 71) returned to their home country. A small number (n=7) of African graduates pursued opportunities further abroad.

When we look at the country of water graduates' current employment, of the 106 South African graduates who initially remained in South Africa upon completion of their doctoral studies, 81% (n=86) were working in South Africa at the time of the survey, while 13% (n=14) reported being employed outside of South Africa. Of the 22 African graduates who remained in South Africa upon completion of their doctoral studies, 55% (n=12) reported that they were employed in South Africa at the time of the survey.

When we look at the geographic mobility of doctoral graduates in the water sector, we find that South African graduates generally remain in South Africa upon completion of their doctoral qualifications and there is little evidence to indicate a brain drain of water graduates. There is also some evidence for brain gain, especially from students from the rest of the African continent who remain in South Africa upon completion of their doctoral studies.

2.4. Utilisation of the PhD

In this section we look at how doctoral graduates in the water sector consider the utility of the skills gained during their doctoral studies. Survey respondents were asked to what extent they use a list of skills and types of knowledge in the daily tasks of their employment positions at the time of the survey. In Figure A.17 we illustrate first the rank order of the skills and knowledge as well as the percentage of respondents that indicated they "agree" and "strongly agree" that these skills are useful. The results show that water graduates consider general knowledge obtained through their doctorates as the most useful in their responsibilities (82%). This is followed by research skills (76%), subject/technical knowledge (62%), methods used in the PhD (46%), and lastly the findings of their PhD (34%). When we compare these results of that with the total sample we find no difference in the ranking of the respective skills and knowledge. We do see, however, that water graduates considered the findings of their PhD less useful (46%) than graduates in our total sample (58%).

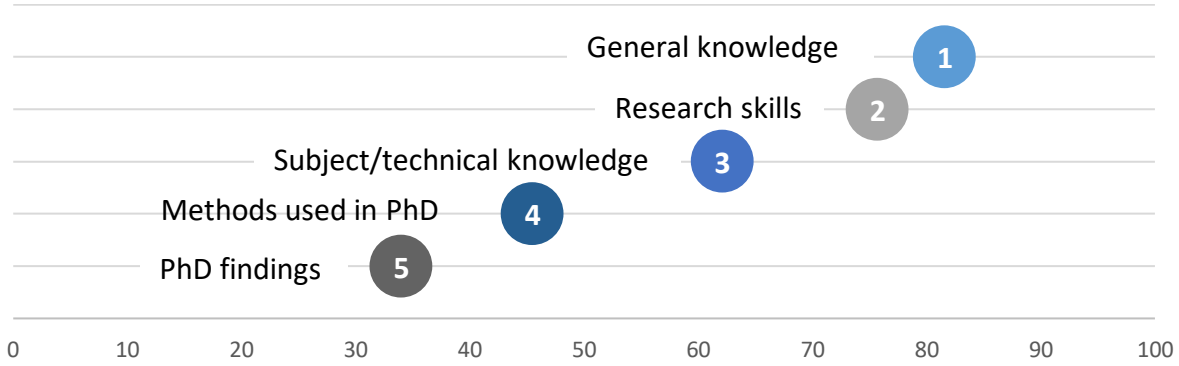

Figure A.17 Utilisation of skills gained during the doctorate in current employment of water graduates

In Figure A.18 below we consider whether there are differences in the utility of skills and knowledge gained during the PhD, over time. We find that the rank order of skills and knowledge as used in graduates' employment responsibilities at the time of the survey are largely consistent over the four year-windows. However, recent graduates tended to cluster the utility of the respective skills and knowledge much closer together when compared to graduates who graduated more than 10 years ago. From the results below we see that the findings of the PhD become less relevant as graduates progress through their careers. When we compare these results with that of the overall sample we find that the trends observed for water graduates reflect those of graduate across all sectors.

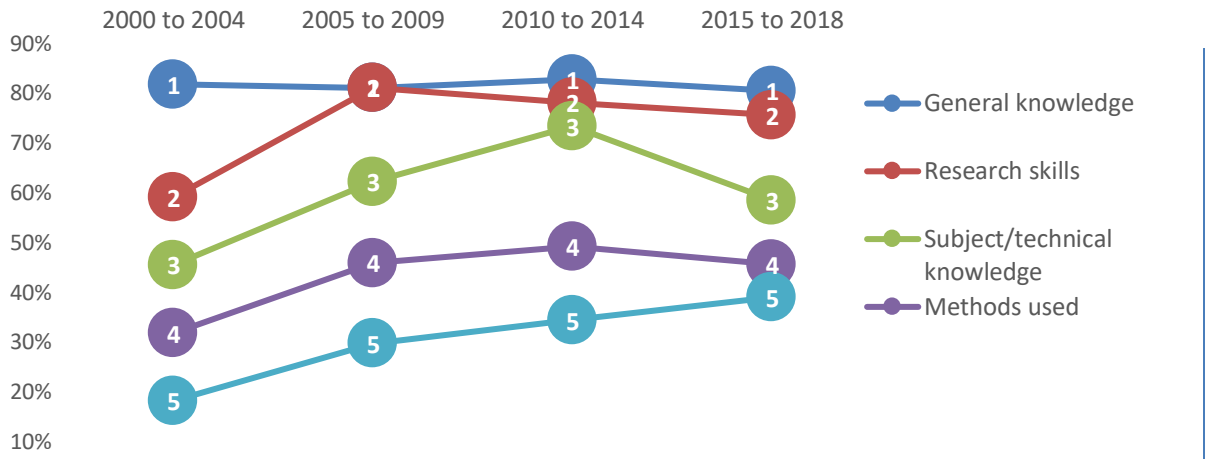

Figure A.18 Ranking of utility of skills gained during doctoral study in current employment of water graduates

2.5. Reflections on the value of the PhD

In this final section, we report on the reflections of water graduates on the value of their doctoral qualifications. Figure A.19 below shows water graduates' responses to questions about their perceived value of the doctorate. We find that 8% of water graduates felt that they should rather have pursued a PhD in another field, while 4% felt that they should never have done a PhD at all. When we compare these findings with that of our total sample, we find no significant differences between graduates in the water sector and those across all sectors (as shown in Table A.4).

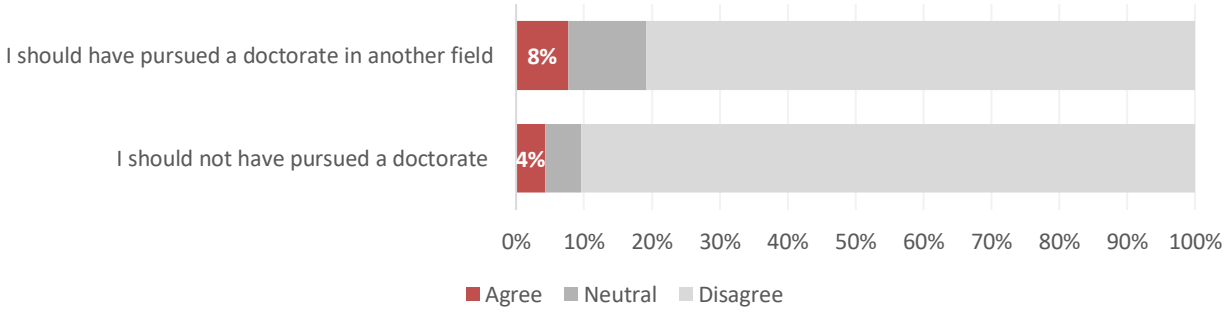

Figure A.19 Reflections on value of the doctorate

In Figure A.20 below we see that 74% of graduates in the water sector felt that their expectations of doing a doctorate have been met, while 77% considered the doctorate as a good return on investment. Once again when we compare these findings with that of the total sample we see that the trends observed for water graduates are comparable with that of doctoral graduate across all sectors (as shown in Table A.4).

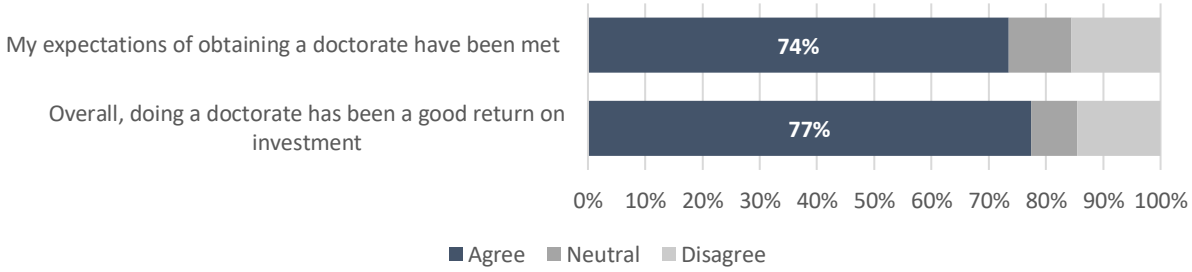

Figure A.20 Water graduates' reflections on the value of the PhD

Table A.4 Doctoral graduates' reflections on the value of the doctorate

		Water graduates		All graduates	
		n	%	n	%
In hindsight, I should not have pursued a doctorate	Agree	9	4,3%	264	4,7%
	Disagree	188	90,4%	5198	91,8%
	Neutral	11	5,3%	203	3,6%
In hindsight, I should have pursued a doctorate in another field	Agree	16	7,7%	473	8,4%
	Disagree	168	80,8%	4669	82,7%
	Neutral	24	11,5%	503	8,9%
Overall, doing a doctorate has been a good return on investment	Agree	164	77,4%	4501	79,4%
	Disagree	31	14,6%	636	11,2%
	Neutral	17	8,0%	535	9,4%
My expectations of obtaining a doctorate have been met	Agree	155	73,5%	4330	76,2%
	Disagree	33	15,6%	775	13,6%
	Neutral	23	10,9%	581	10,2%

3. Conclusion

We have here provided an analysis of doctoral graduates in the water sector as a sub-sectoral component of the national tracing of doctoral graduates in South Africa. We have discussed in detail the methodology behind identifying doctoral graduates in the water sector. We have found 220 graduates in our sample of the sub-sector which we estimate to be a fifth of the population of doctoral graduates in the sector. Notwithstanding the relatively small size of the sample, we consider the sample to be representative of doctoral graduates in the sector.

In our tracer study of doctoral graduates in the sector we found the following differences between water graduates and those in our total sample:

1. In terms of gender, there were fewer female doctoral graduates in water and water-related fields than in the total sample, and total doctoral population.
2. We also found higher percentages of international (especially RoA) students among water graduates. This suggests that the water sector is attracting talent from Africa and providing training and skills in a strategic area of specialisation, especially in Southern Africa.

3. Our findings showed that water graduates are on average four years younger at the time of completing their doctoral degrees than our total sample.
4. A plausible explanation for a lower graduation age for water graduates is that students in the natural or STEM sciences tend to progress directly through the doctoral pipeline, and are more likely to study full-time (Van Lill, 2019, Mouton et al., 2015). We have found that water graduates are more likely to study full-time than graduates in all other sectors, which corroborates the findings of previous studies on this matter.
5. Our results also showed that water graduates are more likely to accept a postdoctoral research position on completion of their doctoral studies. A large share of water graduates who do a postdoctoral fellowship continue to do more than one postdoc as a possible substitute to finding suitable employment.
6. In looking at the type of employment held by water graduates, our findings show that graduates in the water sector were more likely to be involved in technology development, innovation or entrepreneurial activities.
7. In terms of the utility of skills obtained during the doctorate, water graduates considered the findings of their PhD as less useful than graduates in our total sample.

Despite the above differences between graduates in the water sector and those of our total sample, we found that the trends observed in the employability of graduates in the water sector are generally comparable to that of the overall sample.

Annexure B: Comparison with pilot tracer study

The rationale for the national, cross-sectional tracer study of doctoral graduates in South Africa was informed by a pilot tracer study which included a small sample of doctoral graduates in the water and sanitation fields (Pouris & Thopil, 2019). The pilot study was commissioned by the WRC and its objective was to investigate the employment of doctoral graduates who completed water and sanitation related doctoral degrees at South African universities between 2013 and 2017. The current study was subsequently commissioned to explore whether the employment trends found for graduates in the water sector are representative of trends across all scientific disciplines as quoted below:

> *It is important to investigate whether the identified results are unique in the water sector or they apply across the board in other sectors as well. It is suggested that a similar investigation covering the majority of broad scientific sectors in South Africa should be undertaken (Pouris & Thopil, 2019: iv).*

In this section, we compare the main findings of this study with the Pouris & Thopil (2019) study in order assess whether the findings of the pilot study are consistent with that of the current study.

1. Methodology

Recent data and knowledge about the career trajectories of doctoral graduates in the country are lacking. The single biggest challenge in graduate destination studies is to identify the graduate after he or she has graduated from a university. In the pilot study the authors indicate that they extracted information of PhD graduates in the water sector (time period not specified) by searching the Nexus database of completed research projects, including theses and dissertations. This search resulted in a sample of 112 graduates. Below is a brief description of the methodology employed by Pouris and Thopil (2019) in identifying 112 doctoral graduates who received their doctoral education in the water and sanitation fields.

> *The National Electronic Theses and Dissertations (NETD) and NEXUS databases were utilised in identifying doctoral awardees, whose theses' titles and/or abstracts contained relevant keywords. The identified theses were then examined for "precision", and 112 theses relevant to the scope of the investigation were identified. The identified theses (approximately 300 of the 12 500 total theses for the 5-year period) were examined for "precision" and ended up 112 relevant theses. A thesis was excluded if its topic, although including one or more of the relevant terms, could not inform any of the issues mentioned in the Water RDI Roadmap (WRC/DST 2015). The web sites of relevant universities; databases indexing academic articles and social media were investigated in order to identify the relevant characteristics of the authors of these theses. From the 112 identified relevant theses, contact details (in the form of either email addresses or phone numbers) were obtained for 100 doctorate graduates. In five cases out of the 112, the profiles were not traceable. For seven PhDs graduates limited information (about employment, residence, etc.) was traceable, but phones numbers or e-mails were not traceable. Accordingly, questionnaires were sent out to 100 doctorate graduates out of which 48 individuals returned completed questionnaires.*

As this paragraph shows, the "target population" of the pilot study were the 112 identified graduates. However, it is also clear from the elaboration above that contact details for only 100 of these could be found and that in the final analysis only 48 completed questionnaires were received through the subsequent survey. **Further reading of the pilot study shows that some of the conclusions presented in**

the report refer to information that had been gathered about the 112 graduates in the target population (possibly through web sources) and some conclusions are based on the completed responses of the 48 graduates who responded to the survey.

It is also unfortunate that the authors of the pilot study do not explain in any detail which information in their report pertains to their target population of 112 water graduates and which was collected through the survey which yielded only 48 responses. Of the 10 graphs included in the study, the first nine are seemingly derived from secondary sources and only Figure 10 from the actual completed responses by the 48 respondents. We believe that this constitutes a serious weakness of the pilot study and misrepresents the purported importance or value of the findings.

2. Main findings

Below we compare the results of the main findings of the pilot tracer study (Pouris and Thopil, 2019) with the findings of the current cross-sectional tracer study of doctoral graduates in South Africa. The main findings of the Pouris and Thopil study (2019) are listed below (numbered and indicated in the text box) while the findings of the current study are discussed with the corresponding finding of the pilot study.

1. *All PhD holders were engaged in jobs. Out of the sample of 112, 107 profiles were very traceable. Specifically, employment profiles were traceable for 104 graduates, all of whom were found to be employed. Statistically all population is employed (Pouris & Thopil, 2019).*

The pilot study's finding that "all PhD holders were engaged in jobs" at the time of the study can be taken at face value to be true. The additional conclusion that "statistically all population is employed" is not – given the methodology of the pilot study – warranted.

Our study showed that between 2 and 3% of graduates could not find employment within the first year of completing their studies. But it is important to note that 61% of graduates were employed at the time of their doctoral studies and that the majority of these graduates remained with the same employer after completing their studies. When investigating the employability of doctorate holders, it is therefore imperative to distinguish between graduates who are seeking employment for the first time and graduates who already held employment during their PhD studies.

Although both studies found that PhD graduates generally find employment, our nuanced analysis showed that nearly one in five (18%) of respondents (n=901) indicated that they could not find an employment position related to their field of expertise. Further disaggregation of the data shows that graduates who received their doctoral degrees in the past five years were more likely (22%) than those who received their degrees more than 15 years ago (13%) to indicate that their current job or position is not related to the field of expertise of their doctorate.

When we look at doctoral graduates in the water sector, we found that a small percentage (6%, n=13) could not find employment within the first year of completing their doctoral qualification, which compares to the 2,2% of our total sample. However, the number of water graduates who could not find employment is very small. We found that for our total sample, respondents who completed their doctoral

studies between 2015 and 2018 were more likely to experience challenges in finding employment. When we look at those water graduates who could not find employment, we see a similar trend, where 10 of the 13 graduates received their doctorate in the last 10 years.

2. *More than 50% of the PhD holders occupied positions in the university sector. Of those in the university sector roughly 23% held postdoctoral positions (Pouris & Thopil, 2019).*

Finding 2 above can be taken to apply to the 112 graduates in the pilot study. Again, this statement need further elaboration and nuance.

We have indicated above that 61% of graduates were already employed at the time of their doctoral studies and that a large percentage (44%) remained with the same employer after completing their studies. This group most likely consist of academics who pursue their doctoral studies as an integral requirement of advancement in an academic career and thus remained in academia after graduation. Our study found that 66% of doctoral graduates are employed in the higher education sector compared to 61% of graduates who held employment in higher education during their doctoral studies.

Our study found that 56% of graduates in the water sector were employed in the higher education sector at the time of the survey with small numbers of graduates having left academia for the public and private sector. These results show that slightly fewer doctoral graduates in the water sector are employed in the higher education sector compared with graduates in our total sample.

Our results show that 25% of water graduates accepted a postdoctoral research position within the first year of completing their doctoral studies. This compares to 20% across all sectors (total sample). Although this percentage correspondents to the 23% reported by Pouris & Thopil (2019), it seems that the authors report only on the number of postdoctoral fellowships held at the time of their study. No indication is given in the pilot study whether these proportions apply to a single year cohort or to all the graduates in their study who had graduated over a period of time.

3. *Approximately 30% of the PhD holders were in other African countries having gone back to their country of origin. Seventy percent of the graduates remain in the country and 87,5% remained within the Africa continent (Pouris & Thopil, 2019).*

The results of the pilot study are not supported by our study. Our study shows that 26% of doctoral graduates in South Africa were from the African continent and nearly 60% of graduates from African countries returned home within the first year of completing their studies, while 9% of graduates remained in South Africa. When we look at trends in the water sector, our study showed that 36% of doctoral graduates in South Africa were from the rest of Africa, and in terms of geographic mobility, 60% of African graduates returned to their home country upon completing their doctoral studies.

When we compare these results with that of Pouris & Thopil (2019) it is difficult to make a direct comparison as the authors report that 24 graduates (out of their realised sample of 48) had African nationality (not including South Africa) and that 28 graduates (out of their target population of 112) were working in an African country (excluding South Africa) at the time of their study.

The authors report that 70% of graduates remain in South Africa upon completion of their doctoral studies. The current study, which explores the mobility of graduates between the first year after graduation to their most recent employment position held at the time of the survey, found that 67% (n=3 649) of doctoral graduates' most recent employment was primarily located in South Africa. This compared to 18% (n=993) who were employed in an African country, and 15% (n=834) who were employed elsewhere in the world.

4. *Approximately 90% of the respondents were in occupations related to the water and sanitation sector (Pouris & Thopil, 2019).*

The cross-sectoral nature of our study does not allow for a direct comparison with the findings of the pilot study but our findings show that 56% (n =122) of water graduates were employed in the higher education sector, followed by 18% (n=39) in the government/public sector, 17% (n =37) in the business enterprise sector and 8% (n=17) in the private non-profit sector. Of water graduates who held employment in South Africa at the time of the study, 65% were employed at a South African university, 12% at government department and 12% at a science council. However, we found that 20% of water graduates indicated that they could not find a position directly related to their field of expertise/technical skills, which suggests that the percentage of graduates in our sample who work in the water and sanitation sector is somewhat lower than that reported by Pouris and Thopil (2019).

5. *Mobility between sectors was identified to be 16%. Eighteen out of 112 graduates identified to have transitioned between sectors (Pouris & Thopil, 2019).*

Given that our survey asked graduates to indicate their sector of employment during their doctoral studies as well as their current (or most recent) sector of employment, we were able to estimate the mobility of our graduates between sectors. The results of the current study show that those who were already employed in academia during their doctoral studies have remained in the sector. Small percentages have moved to the public, business and the other sectors. However, these "losses" were offset by gains in the government sector (which includes science councils) and business. The end result is a net gain for the higher education sector (66% currently employed in the sector compared to 61% of graduates in the sector during their studies). The government sector has witnessed an overall net loss: mostly through migration of staff to the universities. At the time of their studies, 15% of all graduates were employed in this sector; by the time of the survey, this percentage had decreased to 12%. When we look at the mobility of water graduates between sectors, we found that the results were similar to those reported for all doctoral graduates in South Africa.

6. *The work experience of 40,1% of the PhD holders was identified to be between two and five years. Twenty PhDs (18%) stated that they had management experience (Pouris & Thopil, 2019).*

It is difficult to compare the results on Finding 6 as reported in the pilot study given the lack of information provided about how this information was gathered. We therefore make do with presenting our findings as they relate to the issue of management experience.

While the acquisition of managerial skills is not necessarily an expected outcome of doctoral studies, we were interested to see to what extent the respondents' current employment positions involved

managerial responsibilities and to what extent this differed across sectors. Survey respondents were asked to indicate whether managerial tasks/responsibilities were a requirement or component of their current employment position. Overall, just over half (53,8%, n=3 004) of respondents indicated that managerial responsibilities were part of their current employment responsibilities to a great extent, compared to 6,5% (n=364) who indicated that they had no managerial responsibilities. When we look at graduates in the water sector In terms of managerial tasks and responsibilities, we find that the majority of water graduates (as well as graduates across all sectors) reported having some form of managerial tasks and responsibilities, with 54% (n=111) reporting that they were involved in such tasks "to a great extent". In comparing these findings to those of the pilot study, the current study shows that doctoral graduates in South Africa are likely to engage in managerial tasks. Given the complexity of tracer studies, the career pathways of doctoral graduates and the inclusion of graduates from 2000 to 2018, the study did ask respondents to report on their work experience in terms of years.

Annexure C: Survey questionnaire

South African PhD Tracer Survey

Welcome to the PhD Tracer Study survey.

We appreciate that you are taking the time to complete the survey. Not all questions in the survey may apply to you. We have therefore designed the survey in such a manner that, depending on your response to a particular question, you may be routed to another section so as to ensure that you only answer questions that are relevant to you.

We again want to assure you that the responses will be treated with the utmost confidence and will only be analysed in aggregate form. Under no circumstance will we publish the findings of this study in such a way that the responses can be traced or linked to any individual respondent.

Please read each question carefully. Note that your progress is autosaved as you complete the survey. Please use the "prev" and "next" buttons at the bottom of each page to navigate between the survey pages.

South African PhD Tracer Survey

Section 1: Employment status during your doctoral studies

1. In which scientific field or discipline did you complete your doctoral degree?

[Please be as specific as possible, for example, water waste management OR theoretical physics OR educational management]

2. Were you employed for more than 30 hours on average during a typical week whilst enrolled for your doctorate?

- ◯ No
- ◯ Yes

South African PhD Tracer Survey

3. Which of the following statements describe how you financed your doctoral studies?

[You may select more than one option]

- [ ] I received a bursary/scholarship from the NRF, MRC, WRC or any other South African national funding agency
- [ ] I received a bursary/scholarship from an international organisation (e.g. DAAD or Mellon)
- [ ] I received financial assistance from my university
- [ ] I received financial assistance from my employer (where the employer is not a university)
- [ ] I was supported financially by my parents/partner/family
- [ ] I took a loan
- [ ] I financed my studies myself
- [ ] Other (please specify)

South African PhD Tracer Survey

4. Which of the following statements describe how you financed your studies?

[You can select more than one option]

- [ ] I received a bursary/scholarship from the NRF, MRC, WRC or any other South African national funding agency
- [ ] I received a bursary/scholarship from an international organisation (e.g. DAAD or Mellon)
- [ ] I received financial assistance from my university
- [ ] I received financial assistance from my employer (where the employer is not a university)
- [ ] I was supported financially by my parents/partner/family
- [ ] I took a loan
- [ ] I financed my studies myself
- [ ] Other (please specify)

5. In which of the following sectors were you employed during your doctoral studies?

[Please select all that apply. Please see the definitions of sectors provided below.]

- [ ] Higher education sector
- [ ] Government sector
- [ ] Business sector
- [ ] Other education sector (e.g. schools)
- [ ] Private non-profit sector
- [ ] Other (please specify)

Definitions:

*The **higher education sector** includes (a) universities, colleges of technology and other institutions providing tertiary education, whatever their source of finance or legal status; and (b) research institutes, experimental stations and clinics under the direct control of or administered by or associated with higher education institutions.*

*The **government sector** includes (a) departments, offices and other bodies that furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community; and (b) non-profit institutions controlled and mainly financed by government, not administered by the higher education sector.*

*The **business enterprise sector** includes (a) firms, organisations or institutions whose primary activity is the market production of goods or services (other than higher education) for sale to the general public at an economically significant price; and (b) the private non-profit institutions mainly serving them.*

***Other education sector** includes institutions providing pre-primary, primary or secondary education.*

*The **private non-profit sector** includes (a) non-market, private non-profit institutions serving households (i.e. the general public); and (b) private individuals or households.*

South African PhD Tracer Survey

6. Did you publish peer-reviewed journal articles that are directly related to your doctoral studies?

- ◯ No
- ◯ Yes

Please indicate the number of articles.

7. Which of the following forms of outputs based on your doctoral degree did you produce?

[Select all that apply]

- ☐ No intellectual property produced
- ☐ Patents
- ☐ Plant breeders' rights
- ☐ ICT software and applications
- ☐ Business processes *(e.g. administrative, marketing or production processes)*
- ☐ Creative outputs *(e.g. literary arts, fine and visual arts, theatre and dance or film and television)*
- ☐ Designs *(e.g. trademarks, graphic or industrial design)*
- ☐ Other (please specify)

South African PhD Tracer Survey

Section 2: Career since completing my doctoral degree

8. To what extent were you involved in any technology development, innovation or entrepreneurial activities **after** your doctoral studies?

[These activities include, for instance, the ideation, design, development or implementation of improved or new processes, products or services, or in business creation such as a start-up company or social enterprise.

- ◯ Not at all
- ◯ Little involvement
- ◯ Moderate involvement
- ◯ Active involvement
- ◯ Very active involvement

9. Which of the following best describes your situation upon completing your doctoral degree?

- ◯ I accepted a post-doctoral research position
- ◯ I remained with the same employer (organisation/ institution/ business)
- ◯ I changed employers
- ◯ I could not find employment within the first year after completing my degree
- ◯ I found employment within the first year of completing my degree
- ◯ I was not economically active due to family care responsibilities (e.g. household duties, child rearing)
- ◯ I was not economically active due to other reasons (e.g. retirement, health)
- ◯ Other (please specify)

South African PhD Tracer Survey

10. At which university/research institution was/is your post-doctoral fellowship?

First post-doctoral position	
Second post-doctoral position *(if applicable)*	
Third post-doctoral position *(if applicable)*	

11. Please provide details of your post-doctoral fellowship(s)

	Start date	End date
First post-doctoral position		
Second post-doctoral position *(if applicable)*		
Third post-doctoral position *(if applicable)*		

12. What were your reasons for taking a postdoctoral research fellowship?

*[Please select as many as are appropriate. If you have had more than one post-doctoral fellowship, this question refers to your **first** position.]*

- [ ] To gain additional training in the field of my doctorate
- [ ] To gain training in an area outside of the field of my doctorate
- [ ] To carry out research independently
- [ ] To work with a specific person or in a specific place
- [ ] To work on a specific project/study
- [ ] To carry out and support teaching activities
- [ ] Other employment was not available
- [ ] This type of position is generally expected for a career in my field
- [ ] Other (please specify)

13. If you have had more than one post-doctoral fellowship, please indicate your reasons for taking (an) additional fellowship(s).

[Please select as many as are appropriate]

- [ ] To gain additional training in the field of my doctorate
- [ ] To gain training in an area outside of the field of my doctorate
- [ ] To carry out research independently
- [ ] To work with a specific person or in a specific place
- [ ] To work on a specific project/study
- [ ] To carry out and support teaching activities
- [ ] Other employment was not available
- [ ] This type of position is generally expected for a career in my field
- [ ] Other (please specify)

South African PhD Tracer Survey

SECTION 3: Current employment status

14. Which one of the following best describes your current employment?

- ◯ I am employed (performing work for a wage or salary)
- ◯ I am self-employed (working for myself as a freelancer or the owner of a business rather than for an employer)
- ◯ I am not economically active but have been employed or self-employed at some stage after my doctoral degree
- ◯ I am not economically active and this has been the case since completion of my doctoral degree
- ◯ I have a post-doctoral fellowship

South African PhD Tracer Survey

15. Were you employed prior to your post-doctoral fellowship?

- ◯ Yes
- ◯ No

South African PhD Tracer Survey

16. What is the name of your current employer?

South African PhD Tracer Survey

17. How would you describe your work?

18. For how many different institutions/organisations/companies have you worked since completing your doctorate?

- ◯ One
- ◯ Two
- ◯ Three
- ◯ Four
- ◯ Five or more

19. Have you changed from one sector of employment (e.g. Government) to another (e.g. Business or Industry) or have you remained in the same sector since completing your doctoral studies?

- ◯ I remained within the same sector (e.g. Higher Education or Government)
- ◯ I have changed sectors
- ◯ The nature of my work is cross-sectoral

20. Select the countries in which you have been employed (or where you have been primarily based if self-employed) for period/s of three months or more since you completed your doctoral degree.

[Please select all that apply]

	Please select a country
Country 1	
Country 2	
Country 3	
Country 4	
Country 5	

21. In which country are you currently employed?

[If self-employed, select the country in which you are primarily based]

22. In which one of the following sectors are you currently employed?

[Please select all that apply. Refer to the definition of sectors below]

- ☐ Higher education sector
- ☐ Government sector
- ☐ Business enterprise sector
- ☐ Other education sector (e.g. schools)
- ☐ Private non-profit sector
- ☐ Other (please specify)

South African PhD Tracer Survey

23. To what extent do you agree with the following statements regarding your current position of employment?

[Please mark your response on the scale ranging from strongly disagree to strongly agree]

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
My position reflects my chosen career path	○	○	○	○	○
My position was the only option available	○	○	○	○	○
My position is closely linked to my PhD studies	○	○	○	○	○
My position allows me to take into account family needs	○	○	○	○	○
My position provides me with the opportunity to work in a locality I prefer	○	○	○	○	○
My position provides me with the opportunity for part-time/flexible schedules	○	○	○	○	○
My position is more interesting than positions in another sector	○	○	○	○	○
My position offers better job security than positions in another sector	○	○	○	○	○
My position offers better career prospects than positions in another sector	○	○	○	○	○
My position offers higher income than positions in another sector	○	○	○	○	○

24. Taking into consideration your current employment's requirements and demands, to what extent do you (still) use the following in your day-to-day tasks?

	Not at all	To some extent	To a large extent
Field specific or subject/technical knowledge acquired during my doctoral studies	○	○	○
Other, more general knowledge acquired during my doctoral studies (such as critical thinking, academic writing, etc.)	○	○	○
Research skills and expertise acquired during my doctoral studies	○	○	○
The methods used in my PhD research	○	○	○
The findings produced by my doctoral research	○	○	○

25. To what extent do you agree with the following statements regarding your current position?

[Please mark your response on the scale ranging from strongly disagree to strongly agree]

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A
My doctorate has prepared me well for my current position	◯	◯	◯	◯	◯	◯
Completing a doctoral degree is a requirement of my current position	◯	◯	◯	◯	◯	◯
I have not been able to find a position that is directly related to my field of expertise/technical skills	◯	◯	◯	◯	◯	◯
I am satisfied with my current position	◯	◯	◯	◯	◯	◯

26. To what extent is doing research a requirement or component of your current employment position?

[Research is defined as being engaged in the conception or creation of new knowledge, products, processes, methods and systems]

- ◯ Not at all
- ◯ To some extent
- ◯ To a great extent

27. To what extent are managerial tasks/responsibilities a requirement or component of your current position?

[Managerial tasks are defined as controlling or administering an organisation or group of staff]

- ◯ Not at all
- ◯ To some extent
- ◯ To a great extent

28. To what extent do you agree with the following statements regarding the value of a doctorate?

[Please mark your response on the scale ranging from strongly disagree to strongly agree]

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A
In hindsight, I should *not* have pursued a doctorate	◯	◯	◯	◯	◯	◯
In hindsight, I should have pursued a doctorate in another field	◯	◯	◯	◯	◯	◯
Overall, doing a doctorate has been a good return on investment	◯	◯	◯	◯	◯	◯
My expectations of obtaining a doctorate have been met	◯	◯	◯	◯	◯	◯

South African PhD Tracer Survey

Section 4: Educational and demographic background

29. What is your year of birth?

30. How would you describe yourself in terms of your gender?

- ◯ Female
- ◯ Male
- ◯ Other

31. Please indicate your citizenship status both during your doctoral studies and after completion of your PhD.

[Use the scroll bar to navigate horizontally]

	Country 1	Status 1	Country 2 (if applicable)
During your doctoral studies			
After completion of your doctoral studies			

32. After having completed your PhD in South Africa, what were your plans or aspirations in terms of international mobility?

- ◯ To remain in South Africa
- ◯ To return to my home country
- ◯ To leave for another country
- ◯ I was uncertain what to do
- ◯ Other (please specify)

33. During the first year after completing your PhD, what actually transpired?

- ◯ I remained in South Africa
- ◯ I returned to my home country
- ◯ I pursued opportunities in another country
- ◯ Other (please specify)

South African PhD Tracer Survey

34. What were the main reasons for remaining in South Africa?

[You may select more than one option]

- [ ] Economic factors (e.g. non-academic job offer, job search)
- [ ] Academic factors (e.g. position at a South African university, post-doctoral studies, member of a research team)
- [ ] Family or personal reasons
- [ ] Issues related to the social, political or economic environment in my home country
- [ ] Other (please specify)

South African PhD Tracer Survey

35. What were the main reasons for leaving South Africa?

[You may select more than one option]

- [ ] Economic factors (e.g. non-academic job offer, job search)
- [ ] Academic factors (e.g. position at a university, post-doctoral studies, academic opportunity in a field not existent in South Africa further studies)
- [ ] Family or personal reasons
- [ ] Issues related to visa or residency in South Africa
- [ ] Issues related to personal safety (e.g. xenophobia)
- [ ] Other (please specify)

South African PhD Tracer Survey

Interview request

We sincerely appreciate your participation in our survey. We intend to conduct interviews (on average 30 minutes in duration), with some of the respondents to this survey questionnaire.

36. If you are willing to be contacted for such an interview, please provide us with an e-mail address where you can be reached.

Email address

37. If you would like us to share with you with the report detailing our results of this survey, please provide us with an e-mail address where you can be reached.

Email address

38. Please share any additional comments or remarks below.

THANK YOU FOR COMPLETING THE SURVEY. PLEASE SUBMIT.

Annexure D: Template letter of invitation to potential interview respondents

[Email subject line] PhD tracer study: Request for follow-up interview

Dear [Prof/Dr] [Surname]

My name is [interviewer] and I am part of the research team working on the national PhD tracer study commissioned by the Water Research Commission, and being undertaken by Stellenbosch University's Centre for Research on Evaluation, Science and Technology (CREST).

As you will recall, in October 2020 you participated in the survey for this study, in which you indicated your willingness to be interviewed as part of the follow-up to your survey responses. It is in this regard that we write to you now as we are currently in the process of undertaking the interview component of the project.
The main aim of the interview will be to probe and seek further clarity and elaboration on some of your survey responses, in order for us to develop a deeper understanding of your experiences in relation to the key themes of the study. These include the circumstances surrounding the inception of your PhD, the opportunities and obstacles you encountered with regard to employment following graduation, and your general perceptions of the value and return on investment of having obtained your doctoral degree.

I will be conducting your interview. We anticipate that the interview will be 20-30 minutes in duration; that it will be conducted via a platform such as MS Teams (our preferred platform), Zoom, Skype or telephonically if necessary; and that it will be recorded, with your permission, for the purposes of transcription.

If you are willing and consent to be interviewed, and by way of response to this email, could you please:

1. Provide me with 2 possible dates and times that would suit you for the interview between [date range]. If you are in a different time zone from South Africa, please let me know.
2. Indicate whether you have MS Teams or would be willing to download the app (I can assist you with that), or whether you would prefer another platform for the interview.
3. Indicate whether we have your permission to record the interview.

If you have any queries about the project as a whole, please feel free to contact the interview coordination, Dr Tracy Bailey (tgbailey@sun.ac.za) or the principal investigator and director of CREST, Prof. Johann Mouton (jm6@sun.ac.za). This study has received formal ethical clearance from Stellenbosch University. For queries regarding your rights as a research subject, you may contact Ms Maléne Fouché (mfouche@sun.ac.za) at SU's Division for Research Development.

I look forward to hearing from you.

Yours sincerely
[Interviewer's name]
cc Prof Johann Mouton

Annexure E: Example of a customised interview schedule

Surname	
First names	
Date of birth	
Gender	
Respondent ID	

- Graduated from the University of Pretoria in 2010 – about 11 years with PhD
- Did two postdocs at UP – 2010-2013 and 2013-2015
- Now a senior researcher at the University of Pretoria
- South African citizen

About the PhD

Thesis title	
In which scientific field or discipline did you complete your doctoral degree?	Zoology
University	University of Pretoria
Year PhD awarded	2010
Which of the following statements describe how you financed your doctoral studies?	I received a bursary/scholarship from the NRF, SAMRC, WRC or any other South African national funding agency
	I received financial assistance from my university
Were you employed for more than 30 hours on average during a typical week while enrolled for your doctorate?	No
Did you publish peer-reviewed journal articles that are directly related to your doctoral studies? If so, how many?	Yes 2

Let's start by talking a bit about the circumstances surrounding your decision to do a PhD:

- Why did you decide to do a PhD?
- What were your circumstances at the time (e.g. just finished Master's degree, in employment)?
- What were your expectations of what it would bring you?
- How/why did you choose university, supervisor, topic?

Tell me a bit about the department/centre where you were registered and your supervisor(s) (e.g. well known in the field? Good networks and resources?)

Regarding how your PhD was financed:

- I see that you received a bursary – which organisation?
- And financial support from your university – can you elaborate on the circumstances surrounding that?
- Did you find that there were many funding options in your field at the time?

Career path

Which of the following best describes your situation upon completing your doctoral degree?	I accepted a post-doctoral research position
At which university/research institution was/is your postdoctoral fellowship?	University of Pretoria 2010-2013 2013-2015
What were your reasons for taking a postdoctoral research fellowship?	To work on a specific project/study
	To carry out and support teaching activities
	Other employment was not available
If you have had more than one postdoctoral fellowship, please indicate your reasons for taking (an) additional fellowship(s).	To work on a specific project/study
	To carry out and support teaching activities
	This type of position is generally expected for a career in my field
Which one of the following best describes your current employment?	I am employed (performing work for a wage or salary)
Current employer	University of Pretoria
Current position	Senior researcher
For how many different institutions/organisations/ companies have you worked since completing your doctorate?	One
Have you changed from one sector of employment (e.g. Government) to another (e.g. Business or Industry) or have you remained in the same sector since completing your doctoral studies?	I remained within the same sector (e.g. Higher Education or Government)
In which country are you currently employed?	South Africa
In which one of the following sectors are you currently employed?	Higher education sector

You indicated in the survey that you did two stints as a postdoc:

- One of the reasons you indicated was that you could not find employment. What obstacles did you face? What comments about the labour market in your field at the time?
- Why did you choose UP? Did you stay in the same department/centre?
- What did you gain from doing the two postdocs (e.g. improved employment opportunities, increased academic profile, academic networks)?

You are now a senior researcher at UP:

- How did this job come about? What does it entail?
- To what extent did having a PhD and the two postdocs help you in getting this job?
- In what ways do you utilise your PhD in this position?

Satisfaction with current position

To what extent do you agree with the following statements regarding your current position of employment?	
My position reflects my chosen career path	Disagree
My position was the only option available	Neutral
My position is closely linked to my PhD studies	Disagree
My position allows me to take into account family needs	Agree
My position provides me with the opportunity to work in a locality I prefer	Agree

To what extent do you agree with the following statements regarding your current position of employment?	
My position provides me with the opportunity for part-time/flexible schedules	Agree
My position is more interesting than positions in another sector	Agree
My position offers better job security than positions in another sector	Agree
My position offers better career prospects than positions in another sector	Disagree
My position offers higher income than positions in another sector	Agree

You responded 'neutral' to the statement 'My position was the only option available' and disagreed with the statement that your current position offers better career prospects than positions in another sector. What other types of positions and in which sectors could you have pursued?

Way in which PhD is utilised

Taking into consideration your current employment's requirements and demands, to what extent do you (still) use the following in your day-to-day tasks?	
Field specific or subject/technical knowledge acquired during my doctoral studies	To a large extent
Other, more general knowledge acquired during my doctoral studies (such as critical thinking, academic writing, etc.)	To a large extent
Research skills and expertise acquired during my doctoral studies	To a large extent
The methods used in my PhD research	Not at all
The findings produced by my doctoral research	Not at all

You indicated in the survey that you draw on the field-specific, general knowledge and research skills you acquired during your PhD in your current position. Can you elaborate?

To what extent do you agree with the following statements regarding your current position?	
My doctorate has prepared me well for my current position	Strongly agree
Completing a doctoral degree is a requirement of my current position	Neutral
I have not been able to find a position that is directly related to my field of expertise/technical skills	Agree
I am satisfied with my current position	Strongly agree

You indicated that you agree with the statement that you have not been able to find a position that is directly related to my field of expertise/technical skills – can you elaborate?

To what extent is doing research a requirement or component of your current employment position?	To a great extent
To what extent are managerial tasks/responsibilities a requirement or component of your current position?	Not at all

Reflections on value of the PhD

To what extent do you agree with the following statements regarding the value of a doctorate?	
In hindsight, I should not have pursued a doctorate	Disagree
In hindsight, I should have pursued a doctorate in another field	Disagree
Overall, doing a doctorate has been a good return on investment	Strongly agree
My expectations of obtaining a doctorate have been met	Strongly agree

In what ways has your PhD been a good return on investment and how have your expectations been met?

Closing questions

What advice would you give to funders (e.g. Water Research Commission, National Research Foundation) and employers (e.g. universities, government sector) about how to improve opportunities, support and return on investment for PhD candidates in your field?

Anything else you would like to add?
