PATHWAYS INTO THE LABOUR MARKET AND SELF-EMPLOYMENT FOR NATURAL SCIENCE GRADUATES

REPORT
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A RESEARCH REPORT PRODUCED FOR SACNASP BY THE HUMAN SCIENCES RESEARCH COUNCIL (HSRC)

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SACNASP
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Integrity in science

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Executive Summary

Introduction

Understanding the experiences of graduates within the economy is critical in enhancing the *relationship* between employers' skills demands, graduates' aspirations and skills development endeavours at post-secondary and training institutions. This relationship is even more important within the context of rising levels of graduate and youth unemployment on the one hand, and persistent reports of skills shortages on the other. With the drive towards a knowledge economy within the changing South African skills landscape, fostered by global advancement in technology, the natural sciences have received even more attention. While there have been significant interventions to increase the pool of STEM enrolments and graduates, the important question is how these graduates are performing within the labour market.

For SACNASP, which has the mandate to oversee and support natural science professionals, understanding the labour market dynamics of natural scientists is a main priority. Hence, to make a meaningful contribution towards enhancing the employment outcomes of its members, a thorough understanding of the profile and determinants of the various labour market destinations, i.e. employment, unemployment, underemployment, or inactivity of natural scientists has been identified. Understanding experiences at the field of study level, and transition into work as scientists or otherwise is needed in order to develop appropriate policy responses. This requires an analysis which will draw from an adequate sample of natural scientists. This study is a pioneering effort which seeks to build on the shortcomings of the national level labour market data, to survey and provide evidence on the state of natural science graduates in the labour market. The focus of the analysis was on natural science graduates affiliated with SACNASP.

Study objectives

The main aim of the study is to determine the employment outcomes of natural science graduates. Below are the core research questions that the study sought to address:

i. What are the final destinations of natural science graduates?
ii. What are individual and institutional determinants that influence successful/unsuccessful transitions into the labour market?
iii. What factors influence graduate destinations in terms of the three main possible labour market states: employment (includes underemployment), unemployment or economic inactivity?

Research Methods

This study adopts a mixed methods approach using qualitative and quantitative data from a range of stakeholders to examine the employment outcomes of natural science graduates within the South African labour market. The study draws data from a range of data sources, including the Quarterly Labour Force Survey from Statistics South Africa, a 2020 survey of natural science professionals on the SACNASP database, as well as qualitative interviews with a range of natural science stakeholders including employers, graduates and university lectures.

Research Findings

Destinations and employment pathways of natural science graduates

A key finding from the analysis of all quantitative datasets is that the majority of natural science graduates successfully transition to the labour market, with a sizeable proportion moving into self-employment. Demographic, institutional, organisational and economic factors combine to influence transition outcomes.

Analysis of the 2020 survey data on natural science graduates identified five transitions: full-time and part-time employment, self-employment, further study, and unemployment.

A large majority (70%) of natural scientists were in *full-time employment*, whilst a 5% worked on a *part-time* basis. A large majority (78%) of natural science graduates took less than 6 months after graduation to find their first job, with most (34%) finding work through responding to advertised job vacancies. The second most important channel of finding work is being approached by employers or 'headhunted' (14%). Over half of the scientists in employment are white (51%), with about 40% African, 6% Indian/Asian and 2% Coloured. There are more male natural scientists, 54%, relative to females, 46%.

Data from the survey of natural scientists suggest a significantly low *unemployment* rate of about 5%, with only 68 respondents indicating that they were unemployed. More than two-thirds (68%) of all unemployed natural scientists are youths below 35 years of age. The largest proportion of unemployed scientists came from the Animal Sciences (14%), followed by Agricultural Sciences and Environmental Sciences (12%), then the Geological Sciences (10%) and Botanical Sciences (9%). A larger proportion of 21% cited lack of appropriate work opportunities, lack of work experience (19%), and general scarcity of jobs (12%) as main reasons why they are unemployed. The analysis demonstrates that the unemployed scientists employ a wide variety of job search strategies concurrently, with responding to job adverts, social media and social networks playing a large role.

A substantial proportion of 17% are *self-employed*, and this includes natural scientists working as consultants. More White males seem to navigate better through self-employment compared to other population groups. This can be linked to strong social capital and social networks compared to others. The analysis provides evidence for an association between self-employment and field of study, where scientists with backgrounds in Geological (15%) and Environmental Sciences (13%) were more likely to be in self-employment. Mining and agriculture are two sectors with the highest shares of self-employed scientists. More than half (51%) cited independence as the main reason for choosing to be self-employed, whilst about 14% pursued self-employment because they were unable to find a job. A large proportion of scientists entering self-employment voluntarily is a positive finding, demonstrating that natural science business ventures could benefit from improved business support and development initiatives.

Although in general there is a smaller proportion of scientists who are engaged in *full-time studies* (3%), the analysis shows that females are overly represented amongst this group (53% compared to 47% males). This category is also mainly constituted by African (79%) and younger natural scientists. More than 50% of those in further studies said that these were job related and not necessarily due to their academic interest.

Supply factors

Level of qualification

The results for highest qualification completed are highly gendered and racially stratified. In general, Master of Science degree holders form the largest proportion of natural scientists in the sample, representing 35% of the total sample population. This is followed by those who have completed an Honours degree, which is the qualification required to register as a Professional Natural Scientist, who make up 30%, with PhD graduates at 18%. Some small proportions with less than 10% came from BSc (7%) and BTech (6%), two- and three-year diplomas and DTech contributing the remaining 4% of respondents.

Notably, about 63% of males (almost double the proportion of females) versus 37% of females hold PhDs. What is surprising is that there are comparable percentages of male and female scientists with an MSc degree (49% and 51%). The within-gender analysis shows that almost two-fifths (40%) of females achieved an MSc, compared to 32% of males. The question then becomes what barriers are making it difficult for women to advance in their academic careers or to reach doctoral level? Analysis of the data shows a close correlation between employment outcomes and levels of education, with those with terminal degrees being more employed than those with first degrees.

Field of study

Graduates with Agriculture-related degrees experienced lower employability probabilities, while Maths and life science graduates show a higher employment outlook. The rapid rise in new applied fields such as nanotechnology, which employs life science graduates, can be attributed to the perceived enhanced employment outlook of life science graduates compared to those with agriculture-related degrees. Furthermore, due to the rapid growth in computer-related applications occupations and in the information and communication technology (ICT) sector, including data science and data management, graduates from Mathematics and Statistics-related fields seem to have better employment outcomes than those from general science fields.

Racial, age group and gender dynamics influencing natural science graduate outcomes

Analysis of the data support previous studies showing that White graduates fare better within the labour market.

Whites are more likely to find work within six months of graduation compared to Africans and Coloureds, who on average spent 7–11 months before finding first employment. As expected, young graduates aged 20–34 were more likely to be in unemployment compared to older graduates aged 35–65 years. Most employed natural scientists are between the ages of 30 and 49 years. This is related to the need for more experience among the younger scientists, which suggests the need for more initiatives to absorb younger natural scientists into the labour force.

There are disproportionately more women scientists in the 20–34 age cohort. However, further analysis revealed a large drop of 29% in the number of female natural scientists between the 35–49 and 50–65 age cohorts, providing evidence that women exit the profession after the age of 45. This suggests that males tend to be more mobile than their female counterparts, who remain tethered to the home and are expected to fulfil other responsibilities on top of pursuing a lifelong career.

Geographical location of universities and graduates

The location variable showed that graduates located in non-urban areas were slightly more likely to be unemployed when compared to graduates who lived in urban settings. Graduates from or living in the Western Cape and Gauteng showed stronger employment outcomes compared to other provinces. The major employer of natural scientists is the private sector, with just over half (51%) of the natural scientists working for private sector employers. A quarter (25%) of the graduates are employed by government, while 15% are in the higher education institutions and science councils, with the remaining 9% in the parastatals. Despite national declines in agriculture and farming, about 27% of natural scientists are employed in these sectors. This is followed by research and development, which accounts for about 22% of employment. Forty-four per cent of all respondents have spent at least 6 years in the current job, with about a quarter having spent more than 10 years in it. This suggests more stable working conditions and continuity within the field of practice, which could also be interpreted as the availability of support and potential for more specialisation within the fields of practice and professions.

Demand factors

Two main demand factors were identified as affecting labour market outcomes of graduates: the nature of the economy, and the attitude of employers towards natural science graduates. Employers continue to favour graduates from specific institutions, with those from the historically white universities benefitting most. Main supply factors included the perceived gap between academic institutions' curriculum and employers' skills demands. More universities are heavy on theory and have not adequately adopted practical aspects in aligning their curriculum to support employment outcomes, especially for those from historically disadvantaged universities. This includes even the naming of university degrees. There is a variance between institutional readiness and capabilities of career offices to adequately support graduate development. There is also a sense of inadequate support by institutional efforts towards graduate development and preparation for the world of work. In terms of the economy, the South African economy has over the last couple of years struggled to create jobs. A combination of weakening state-owned enterprises, poor political governance and weak fiscal outlook has resulted in shrinking opportunities for all graduates in general, even though natural science graduates are perceived to have fared better.

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The HSRC project team was comprised of the following individuals: Bongiwe Mncwango, Sam Fongwa, Stewart Ngandu, Lolita Winnaar, and Catherine Namome who were involved in the various activities including questionnaire design; acquisition, preparation, analysis and reporting of Quarterly Labour Force Survey data from Statistics South Africa; collection, cleaning, and analysis of the 2020 survey data. We also thank Fabian Arends who assisted with the analysis of HEMIS data, and Nkululeko Makhubo who assisted with setting up of qualitative interviews.

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List of Acronyms

CHEC	Cape Higher Education Consortium
CPD	Continuing professional development
DHET	Department of Higher Education and Training
DoE	Department of Education
DSI	Department of Science and Innovation
DST	Department of Science and Technology
HAUs	Historically Advantaged Universities
HBUs	Historically Black universities
HCT	Human Capital Theory
HEMIS	Higher Education Management Information Systems
HSRC	Human Sciences Research Council
HDUs	Historically disadvantaged universities
HWUs	Historically White universities
4IR	Fourth Industrial Revolution
ICT	Information and Communication Technology
ILO	International Labour Organisation
LMDS	Labour Market Dynamics Study
LMIP	Labour Market Intelligence Partnership
NDP	National Development Plan
OECD	Organisation for Economic Cooperation and Development
OHS	October Household Survey
OIHD	Occupations in high demand
PIVOTAL	Professional vocational and technical occupational list
QLFS	Quarterly Labour Force Survey
SACNASP	South African Council for Natural Science Professions
SET	Sciences, engineering and technology
SME	Small and medium-sized enterprises
Stats SA	Statistics South Africa
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
TVET	Technical and Vocational Education and Training
VA	Voluntary Association
WEF	World Economic Forum

1 Introduction

Graduate employment continues to be an issue of concern to policy makers, employers, education and training institutions and graduates. Understanding graduate outcomes is important in shaping the curriculum, pedagogy and the relationship between graduates and the world of work. One of the key aspects of this relationship is ensuring that the relevant skills and attributes are developed by graduates as part of their university experience. Furthermore, being able to change and adapt in the workplace is important within the contemporary labour market, which is characterised by changing skills and attributes demands (Organisation for Economic Cooperation and Development [OECD], 2012).

Analysis by the World Economic Forum (WEF) (2017:2) showed that Africa's

> capacity to adapt to the requirements of future jobs – measured by assessing the quality and extent of its education and staff training systems, post-basic education attainment and breadth of skills – relative to the region's exposure to future trends measured by the impact of latest technologies, local economic diversification and complexity, employee productivity and unemployment – leaves no space for complacency. Hence the need for such studies to enhance the role of the education system and the readiness of post-school graduates.

The National Development Plan (National Planning Commission, 2011) places significant emphasis on the role of the natural science fields, including science, engineering and technology (SET), in achieving the aspirations of a knowledge economy. The White Paper on Science, Technology and Innovation (STI) (Department of Science and Technology [DST], 2019) emphasises SET-related fields in positioning South Africa within the Fourth Industrial Revolution (4IR). According to the White Paper (DST, 2019, p. x) the

> STI can be instrumental in improving public service delivery and decision making for public policy, thereby improving the quality of life of South Africans for instance educational outcomes can be improved through equipping children [and graduates] with the thinking [and employment] skills they will need in a technologically advanced world.

However, understanding these skills gaps or skills needs requires comprehensive research with triangulation of stakeholder perspectives on how graduates experience and navigate the world of work.

The South African Council for Natural Scientific Professions (SACNASP) is mandated with the registration, development and regulation of natural science professionals. As part of executing this mandate the Council seeks to understand the employment trajectory of the registered scientists within the world of work. Previous research showed that SACNASP is contributing to skills development through its graduates (Fongwa and Mncwango, 2018). However, while there is a breadth of knowledge regarding graduate outcomes in general, there is limited information about natural science graduates: where they are employed, the factors affecting their employment outcomes and how these can be enhanced through, inter alia, the work of SACNASP and its Voluntary Associations (VAs).

1.1 Study objectives

The main aim of the study is to determine the employment outcomes of natural science graduates. More specifically, the study seeks to uncover and report the determinant factors that influence the current (un)employment trends and to use a triangulation of data sources to explain patterns of labour market participation of graduates[1]. As will be further explored in the report, labour market participation not only includes those employed formally but stretches to include self-employment and underemployment.

Specific research questions include the following:

1. **What are the final destinations of natural science graduates?**
   - What is the proportion of employed, unemployed and under-employed natural science graduates?2
   - How has this trend changed over time?
2. **What are individual and institutional determinants that influence successful/unsuccessful transitions into the labour market? Specifically:**
   - How does this differ in terms of individual (demographic and socio-demographic profiles including race, gender, age) characteristics?
   - How does this differ in terms of institutional (type of university) characteristics?
   - How does this differ across provinces with different economic and labour market structures?
3. **Overall, what factors significantly influence graduate destinations in terms of the three main possible labour market states: employment (and underemployment), unemployment or economic inactivity?**
   - What are key stakeholders' perceptions of employability attributes of natural science graduates in South Africa?
   - What are the current perceptions regarding graduate employment in general, and for natural science graduates in particular?

1.2 Rationale: Why this study is important

Understanding the experiences of graduates within the economy remains critical in understanding the relationship between skills development at university and other higher education institutions and employers. This relationship is even more critical within the natural science field where, due to rapidly changing technology, it becomes even more pertinent that graduates are adequately prepared for work or to be able to kick-off an entrepreneurial venture. With the relevance of science and science- related fields within the economy, such a study becomes critical in providing both a quantitative account of natural science employment outcomes – employed (including self-employed), underemployed and unemployed – as well as a qualitative account from diverse stakeholders – employers (public and private), recruiting organisations, universities and graduates themselves –regarding the work readiness of graduates in general and natural science graduates in particular.

Furthermore, patterns of labour market imbalances characterised by a rise in proportions of qualified or underqualified individuals in the labour market are becoming evident (Mncwango, 2016; Reddy et al., 2016, Grapsa et al., 2018). In 2010, of the 13.1 million working-age South Africans that had jobs, about 544 000 were underemployed. These workers either work less hours than they would prefer to, or their qualifications or skills are not adequately utilised. Either way, this reflects a misallocation of labour resources in the form of human capital, which can dampen goals for attaining inclusive economic growth.

While there is relatively positive evidence of natural science graduates' employment outcomes, much of the studies have not carefully delineated the difference between employment and underemployment. Employment has usually been used to refer both to employed and underemployed persons, which blurs the social and structural factors responsible for graduate underemployment. Considering the importance of underemployment in relation to quality of work, such a focus helps to analyse the ability of the economy to leverage full employment opportunities to graduates.

Several adverse labour market outcomes have been associated with a mismatch of employment and qualifications. This includes under-utilisation of skills, high turnover and overqualified workers which together could affect overall productivity levels. Similarly, under-qualification, possibly resulting from inadequate education or qualifications, can dampen attempts to meet new market demands. Findings from such a study can then help inform curriculum, pedagogy and the development of graduate skills at graduate offices and through the work of professional regulatory bodies such as SACNASP.

1 These include Life Sciences; Physical Sciences; Mathematics, Statistics and. Agriculture and Related Sciences.

2 Statistics South Africa only began including field of study in its Quarterly Labour Force Survey (QLFS) data from the third quarter of 2012, hence the cut-off point of 2013.

1.3 Study background and context

The last decade has been marked by a dramatic increase in higher education participation, with rising enrolments and graduation rates across the Global South and Global North (Marginson, 2016). According to Trow (2007) this reflects a shift from elite to mass higher education systems, the latter being defined as a system in which more than 15% of young people participate in higher education –as is the case in South Africa (at about 18%). However, the rise in enrolment and graduations has not been adequately matched by employment demand.

While the economy continues to face structural unemployment challenges, there are growing concerns that graduates face poor working conditions, including increased potential for ending up in situations of unemployment and underemployment. The key question for SACNASP is therefore how to align educational opportunities with labour market opportunities. This is succinctly captured by O'Connor and Bodicoat (2016:446):

> ... the current climate of massification of higher education, a simultaneous shrinkage of the graduate labour market and an increasing neo-liberal emphasis on students to improve their own employability makes the transition to employment a more complex one.

The successful transition of graduates into the labour market has been an area of increasing research and policy concern globally, but more so in economies with weak economic growth, such as South Africa's (Tomlinson, 2007; Rothwell et al., 2009). With employment outcomes closely linked to the economic performance of the national economy, South African graduates are faced with a challenging and changing labour market environment. South Africa has a growing proportion of graduates from the different institutions of higher learning – but is characterised by poor and varied labour market outcomes.

The broad question of interest in the current study underpinned by this literature review is: What are the current patterns of labour market outcomes or destinations of graduates with a focus on natural science graduates and professions? This is of particular importance for SACNASP, which is mandated with the registration and regulation of natural science professionals. As part of executing this mandate the Council seeks to understand the employment trajectory of science graduates within the world of work. Although evidence shows that individuals with university degrees experience a range of benefits (better health, higher rates of employment, and increased earnings) compared to those with lower levels of education (Van Broekhuizen & Van der Berg, 2013), understanding the labour market dynamics of natural scientists within the broader labour market becomes critical in informing enrolments, and student and graduate support as well as responding to employers' skills needs. Furthermore, while recognising that natural science graduates are also gainfully employed in other sectors, conducting empirical investigations enhances understanding of the factors responsible for potential trends.

Box 1 : Definition of key terms / concepts

- *For the purposes of this report, the following definitions were adopted:*

__A natural scientist:__ Individuals with a Science qualification, including the following: Life Sciences, Physical Sciences, Mathematics and Statistics, and Agriculture, Agricultural operations, and related services. These fields are categorised as follows: Life Sciences=Life Sciences + Physical Sciences, Agriculture=Agriculture + Agricultural Operations and Related Sciences, Math Stats=Mathematics + Statistics. A scientist is therefore a person working in these fields and who has these qualifications.

The natural sciences __working-age population__ comprises everyone aged 20–64 years who fall into the three labour market components (employed, unemployed, not economically active).

The following definitions are identical to those used for the QLFS (Statistics South Africa, 2019a):

__Employed persons__ are those who were engaged in market production activities in the week prior to the survey interview (even if only for one hour) as well as those who were temporarily absent from their activities (StatsSA, 2019a). Market production employment refers to those who:

a) Worked for a wage, salary, commission or payment in kind.

b) Ran any kind of business, big or small, on their own, or with one or more partners.

c) Helped without being paid in a business run by another household member.

Unemployed: *Standard definition of unemployment refers to someone aged between 15 and 64 years who is completely without work, currently available to work, and taking active steps to find work. The expanded definition excludes the requirement to have taken steps to find work (StatsSA, 2019a:17).*

Not economically active persons *are those who did not work in the reference week because they either did not look for work or start a business in the four weeks preceding the survey or were not available to start work or a business in the reference week. The not economically active are composed of two groups: discouraged work-seekers and other (not economically active, as described above).*

Discouraged work-seekers *are persons who wanted to work but did not try to find work or start a business because they believed that there were no jobs available in their area, or were unable to find jobs requiring their skills, or had lost hope of finding any kind of work. Discouraged work-seekers and other (not economically active) are counted as out of the labour force under international guidelines as they were not looking for work and were not available for work (StatsSA, 2019a:16).*

2

Research Methods

Bongiwe Mncwango and Samuel Fongwa

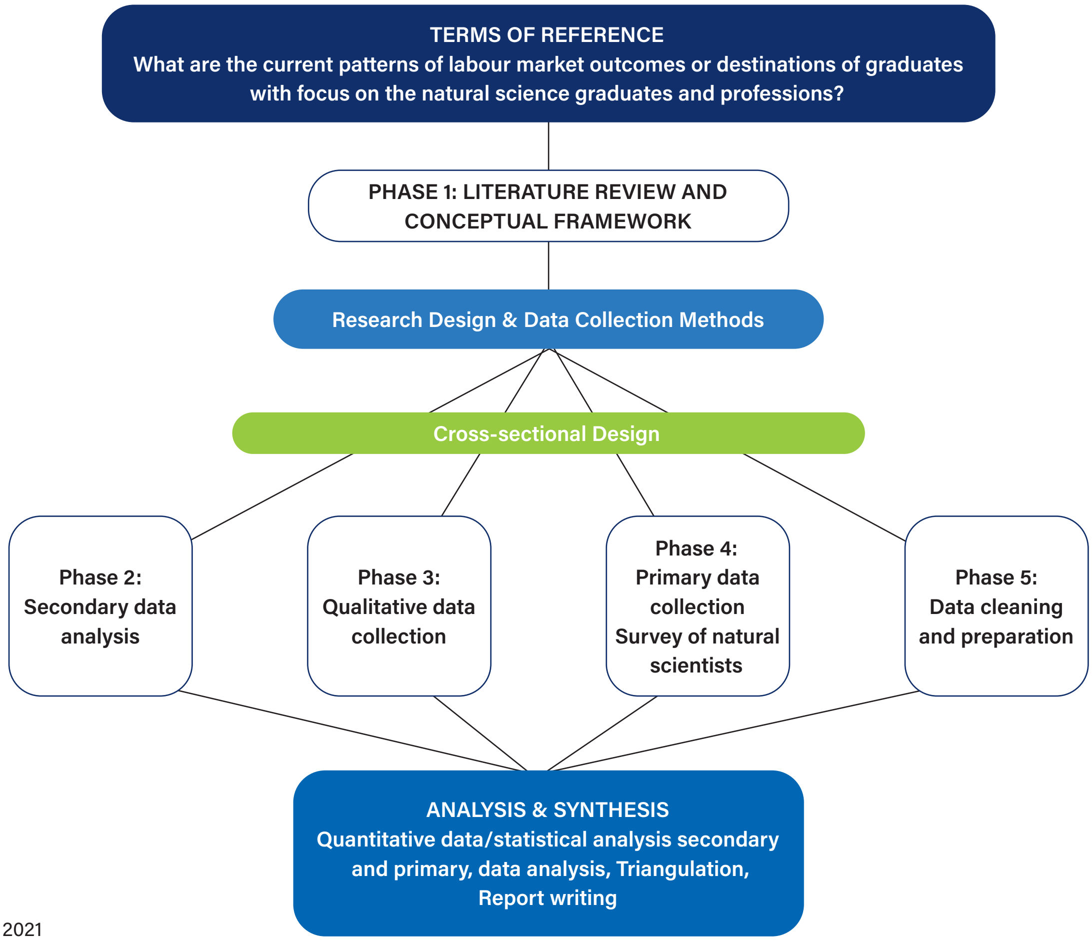
This section provides a more detailed account of the research methods and procedures adopted in the study. Table 1 provides a summary of the key research questions and data sources utilised.

Table 1: Research questions and data sources

Research questions	Data sources for the analysis
1. What are the final destinations of natural science graduates? ▪ What is the proportion of employed, unemployed and underemployed natural science graduates (2013 – 2018 cohort) ▪ How has this changed over time?	▪ Labour Markets Dynamics Study (LMDS) 2013, 2014, 2015, 2016, 2017 ▪ Quarterly Labour Force Survey (QLFS): 2013-2018 ▪ 2020 Survey of natural scientists of South Africa
2. What are individual, and institutional determinants that influence successful/unsuccessful transitions into the labour market? Specifically: ▪ How do these differ in terms of individual, demographic and socio-demographic profiles, including race, gender, and age? ▪ How does this differ in terms of institutional (type of university) characteristics? ▪ How does this differ across provinces with different economic and labour market structures? ▪ Overall, what factors significantly influence graduate destinations in terms of the three main possible labour market states: employment (and underemployment), unemployment or economic inactivity?	▪ Labour Markets Dynamics Study (LMDS) 2013-2018 ▪ Quarterly Labour Force Survey (QLFS): 2013-2018 ▪ 2020 Survey of natural scientists of South Africa
3. What are key stakeholders' perceptions of employability attributes of natural sciences graduates in South Africa? ▪ What are their current understandings, propositions and assumptions regarding graduate employment in general, and for natural science graduates in particular? ▪ What factors do they perceive to be affecting the employment outcomes of natural science graduates? ▪ This includes skills, attributes and values, and other structural factors affecting graduate outcomes of natural science graduates.	*Semi-structured qualitative interviews with the following five target groups:* ▪ Academics ▪ Career offices ▪ Employers ▪ Recruiting agencies ▪ Students (employed and unemployed)

The study adopted a mixed methods approach in its execution and comprised five phases. The first phase included an in-depth literature review and a conceptual framing. The second phase was an analysis and write-up of secondary data from the QLFS. The third phase was a qualitative data collection from a range of stakeholders. The data is analysed thematically and presented in section seven. The fourth phase quantitative component with two main activities: secondary analysis of the QLFS and the 2020 survey of natural science graduates. The fourth phase was a quantitative survey of natural scientists within SACNASP database. The final phase was the analysis, presentation and writeup of the primary survey data. This is done in consolidating all other sections towards this comprehensive report.

FIGURE 1: Study Research Design



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2.1. Phase 1: Detailed review of the literature

Research on graduate outcomes has received significant attention globally. While there is no centralised graduate tracer survey conducted in South Africa, graduate outcome research has been conducted by several institutions, including universities, regulatory bodies, government departments and individuals. There is a wide breadth of research on graduate and youth employment outcomes in South Africa. The first step of this report is to provide a carefully documented summary account of such studies, with particular attention on natural science graduate outcome research. We do not in any way attempt to do a comprehensive review of the literature, as this has already been done elsewhere (See Fongwa, 2018; Case et al., 2019). The literature review then informed the conceptual framework and the design of the instruments for both the survey and the qualitative component.

2.2. Phase 2: Secondary data analysis

The study drew from the Stats SA's Quarterly Labour Force Survey (QLFS) from between 2013 and 2018. The QLFS is a household-based representative sample survey which has been collecting data on labour market activities since 2008. The information is collected from individuals aged 15 years and above residing in South Africa. Results from the QLFS are released on a quarterly basis; however, since 2008 the quarterly datasets have been collated into the Labour Market Dynamics Study (LMDS), which is made available through the Data First research data repository. The latest available LMDS is for 2017, and therefore the project team had to annualise the 2018 QLFS. The selection of 2013 as a base year was informed by the availability of information on the 'field of study', which is only available from the third quarter of 2012 and hence annual data could not be computed.

Additional data sources were also explored, including the Higher Education Management Information Systems (HEMIS) as well as the university institutional databases. The following three activities formed part of data preparation and processes:

Step 1: Preliminary analysis of the database/s

A thorough preliminary analysis of the databases and individual records was conducted. This was with the primary aim of understanding the data structure and assessing what fields are available to assist in planning and setting up the data analysis plan. In the case of the LMDS data, this meant interrogating the datasets for each year to ensure that:

- The required variables existed in all years;
- The content of all variables considered for the analysis made sense;
- The naming conventions of all variables were the same; and
- All variable categories were the same across years.

Step 2: Database cleaning and preparation

The data cleaning and preparation included conducting a thorough scrutiny of all records in the databases through a series of data checks. The aim was to identify data anomalies, such as missing information. This step largely involved data coding and manipulation to create variables, and preparation to create indicators of interest.

Step 3: Defining the target group

For the purposes of the analysis, the study samples have been restricted to:

- Natural scientists only. This includes individuals with Life Sciences, Physical Sciences, Mathematics and Statistics qualifications, Agriculture and related services,.
- Individuals aged between 20 and 65 years. This reflects a slight departure from the Stats SA definition of the working population, which includes individuals aged between 15 and 65 years.

It should be noted that although the focus is on those categorised as natural scientists across the six years 2013, 2014, 2015, 2016, 2017, and 2018, the data are representative of the South African population and hence will be analysed as such. 2013 will be used as a baseline against which change is measured.

2.3. Phase 3: Qualitative component

Over and above the quantitative phases described in the preceding section, the qualitative component targeted a sample of 30 stakeholders; however, only 19 interviews were achieved due to challenges in the field within the COVID-19 restrictions and the unavailability of targeted stakeholders. The qualitative dimension adopted a purposive sampling technique to identify key stakeholders as informants who will participate in semi-structured interviews to understand their experiences and views regarding the training and employment of natural science graduates. Furthermore, the qualitative interviews sought to interrogate perceptions of the skills, attributes and capabilities which natural science graduates develop at university, and how these relate to evolving labour market needs. Due to limited time and financial resources, only universities in two provinces were approached. As a result of COVID-19 restrictions, where informants could not meet physically interviews were conducted telephonically, as indicated in Table 2.

Table 2: Target groups and research questions

Target group	Information sought
Public sector employers	Perceptions of the quality of natural science graduates: skills developed as well as skills and attributes lacking. Recruitment experiences (how easy or difficult it is to attract and retain, skills, competencies and attitudes) of natural science graduates.
Private sector employers	Perceptions of the quality of natural science graduates: skills developed as well as skills and attributes lacking. Recruitment experiences (how easy or difficult it is to attract and retain, skills, competencies and attitudes) of natural science graduates.
University career offices	Various initiatives and interventions to enhance the employability of natural science graduates and to track graduate employment outcomes.
Recruiting agents	An understanding of the attitudes of employers to employing natural science graduates, including areas of skills shortage and how to enhance graduate employment skills.
Postgraduate students	How they themselves as intermediators perceive natural science graduates. How they experience the employability and employment outcomes of natural science graduates.

2.4. Phase 4: The survey of natural science professionals

The fourth phase of the study included a survey of the natural science professionals which was conducted between October 2020 and February 2021 as a collaboration between the Human Sciences Research Council (HSRC) and SACNASP. Data were collected through an online survey using REDCAP which is an electronic data capture tool hosted at the HSRC.

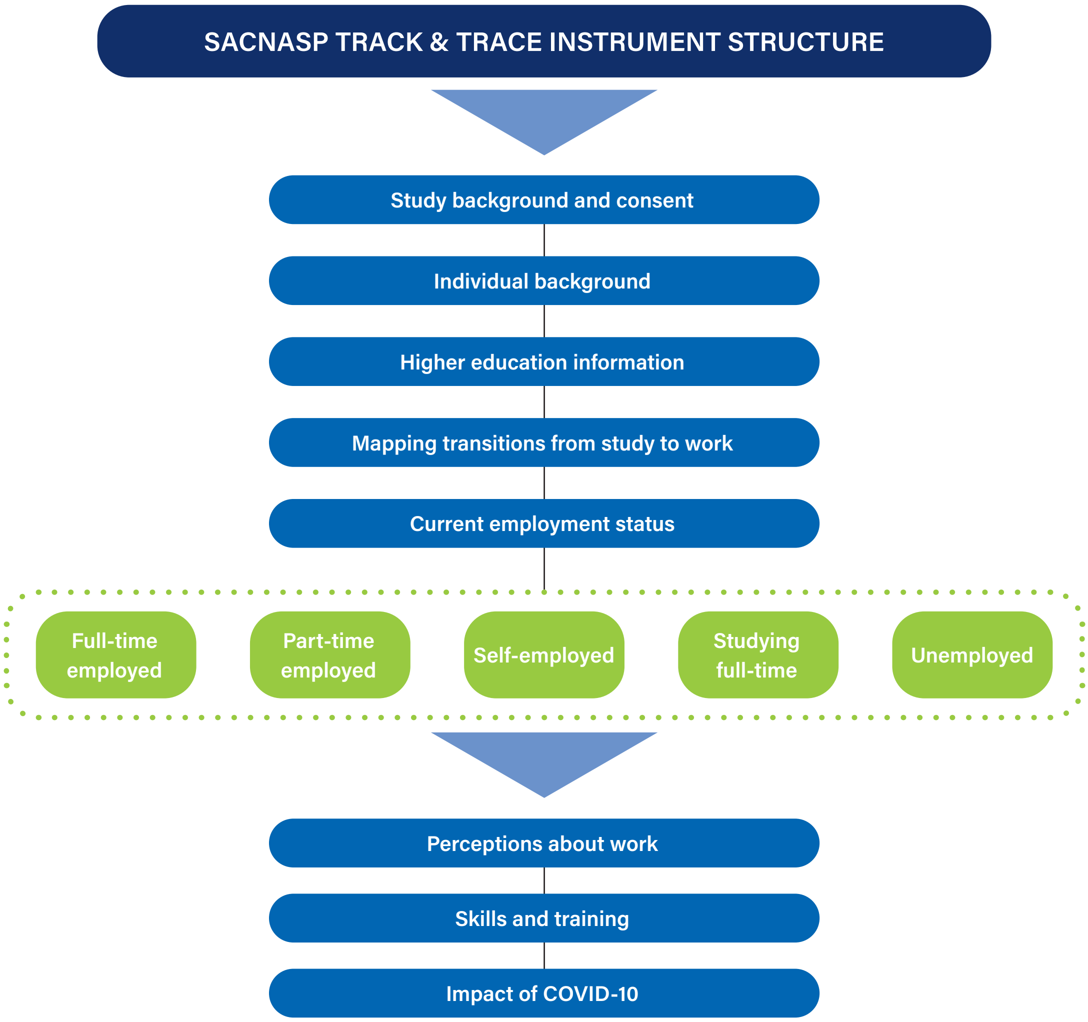
The purpose of the instrument was to collect information on the natural science graduates' pathways and outcomes. Such information will improve the understanding of different transitions followed by natural scientists from varied socioeconomic backgrounds and higher education institutions to understand labour market destinations, experience and quality of work, the relationship between work and qualifications, and labour market expectations of natural scientists. The instrument had six modules, with specific modules set out for respondents to respond based on their employment status.

A total of 1951 completed survey questionnaires were received. This represents more than 10% of the targeted sample of 14 000 natural scientist graduates registered with SACNASP.

2.4.1. The survey questionnaire

The design and development of the survey instrument was informed by the literature review and the conceptual framework arising from that, review of previously empirically tested instruments, wide consultation which included a number of meetings between the HSRC and SACNASP project members, and inputs from researchers and natural science experts. Figure 2 depicts the different components of the survey instrument.

Figure 2: Structure of the survey instrument



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The section on current employment status sought to determine whether the scientist is

- Full-time employed;
- Part-time employed;
- Self-employed; or
- Unemployed.

This section thus served as a streaming variable through which different sets of questions relevant to the participants' employment status were asked. For instance, individuals in employment were asked about the nature of their work and working conditions (e.g., contractual arrangements, hours worked) and outcomes (e.g. earnings, job satisfaction). Those who are self-employed were asked about the nature and size of their establishments and challenges they encounter as businesses. Those who indicated being unemployed were asked about how long they have been unemployed, how they are searching for work, and challenges experienced in searching for work.

Piloting is an important part of the questionnaire development process as it gives warnings about possible challenges that might be encountered. The instrument was tested to ascertain how long it takes to complete; to determine whether the wording of all questionnaire items was clear and unambiguous. The survey instrument was piloted amongst a group of natural scientists, who provided feedback and inputs which helped in refining the instrument. The instrument was re-piloted again to minimise all ambiguities and ensure clarity of content.

After the instrument was approved by SACNASP project steering committee members, the survey instrument was shared through the survey link which was advertised through SACNASP's website, its associate organisations, such as the VAs, as well as through other social media platforms such as Facebook. An incentive was given to scientists who participated in the survey by granting them continuing professional development (CPD) points. This was an attempt to enhance the response rate of the study. Natural science professionals are required to complete CPD activities across a 5-year cycle to remain compliant and to renew their professional registration (SACNASP, 2017).

2.5 Phase 5: Data cleaning, preparation, analysis and synthesis

This phase included cleaning and processing of the quantitative data in preparation for analysis, using data management and analysis tools such as STATA and SPSS. Open-ended questions were also recoded for purposes of analysis.

2.6 Study limitations

Data utilised for secondary analysis cannot account for graduates who have left South Africa.

2.7 Structure of the report

Section 3 of this report presents a broad overview of the literature on graduate outcomes, with a focus on the South African literature. Section 4 is an overview of the higher education profiling based on data from the HEMIS. Section 5 uses Labour Market Dynamics data (2013 – 2018) from Stats SA to demonstrate some of the key factors affecting the employment outcomes of natural science graduates through a multinomial logistic regression analysis. Section 6 presents findings from the survey of South African natural scientists. Section 7 focuses on qualitative inputs from stakeholders. Sections 8 presents a critical synthesis and conclusions, followed by some suggested recommendations.

3

Literature Review

Samuel Fongwa and Bongiwe Mncwango

3.1. Researching graduate employment outcomes

In South Africa, as in most other countries, there is a strong evidence-based understanding that graduates from the natural sciences or the Science, Technology, Engineering and Mathematics (usually referred to as STEM)-related fields find it less difficult to access employment after graduation (Van der Berg & Van Broekhuizen, 2013), or that there are more opportunities for natural science graduates. However, evidence from more advanced countries suggests no significant difference between the employability of graduates from the STEM-related fields and those from other fields. Given this background, it becomes important to explore the broader literature on graduate employment outcomes to tease out some of the experiences of graduates from the STEM fields.

There is rich evidence from South Africa and beyond which suggests that personal (gender, age, race, disability status), social (social class, university type) and environmental factors have a strong influence on the employment outcomes of recent graduates beyond their degrees (Wildschut et al., 2018; Walker and Fongwa, 2017; Cape Higher Education Consortium [CHEC], 2013; Rogan and Reynolds, 2016). The consistent finding has been that individuals from low-income households obtain degrees from historically disadvantaged universities (HDUs) and are more likely to be unemployed or underemployed. With the changing labour force conditions and growing role of technology in the economy, individuals in some fields of study find it more difficult to access graduate jobs. Consequently, in the recent past graduate outcomes have been found to be related to factors such as field of study (Green and Henseke, 2016), social capital (Walker and Fongwa, 2017) and university type.

Applying human capital theory (HCT) (Schultz, 1961), there is a strong correlation between length of studies and employment outcomes. The OECD (2012) report Better Skills, Better Jobs, Better Lives indicates a strong correlation between graduate skills developed, employment outcomes and ultimately better quality of life for the graduates. Studies on graduate labour market transition have called for a closer link between graduates and the labour market to reduce transition time and improve access to first employment. While the outcomes differ across field of studies and other factors such as university type and social networks, there are increasing efforts on the part of all stakeholders to improve the labour market access of recent graduates.

In this presentation of graduate employment outcome research three main perspectives are identified in the literature and presented. The aim is to present the material in a more accessible format, but with the aim to highlight the core factors and perspectives within the broader discourse. First, we provide a stakeholder account of how graduate employment studies have been conducted; we then used a methodological account to identify several different methodologies and their implications; and finally, we provide a conceptual account based on how graduates have been defined and conceptualised in the broader literature. The review concludes by zooming into the employment outcomes of natural science graduates and implications for our empirical study. While we do not attempt a comprehensive review of the literature, we aim to highlight some of the core debates and issues within the global and local literature.

3.2 Stakeholders' accounts

Graduate outcome research has sought to document the employment outcomes of graduates based on experiences and perspectives from a wide range of stakeholders. Four main stakeholders have been identified from the literature: employers, higher education institutions themselves, graduates and, to a lesser extent, national or regional/provincial policy players. While many graduate employment studies have focused on employers, it remains important to provide perspectives from graduates themselves, the universities and other training institutions as well as government representatives. In this section the perspectives of each group of stakeholders are briefly presented.

3.2.1 The employers' perspective

From the perspective of employers, graduate employment is the outcome of a balance of behavioural competences, qualifications, skills and the wider range of personal, performative and organisational abilities needed to readily fit into an employment role within the organisation (Tomlinson, 2008; Green et al., 2016). A critical aspect of the employers' perception of graduate outcomes is the amount of previous work experience the graduate has acquired. Work experience has also been emphasised as a critical factor that employers consider in graduate outcomes (Kundaeli, 2016). Furthermore, due to many graduates entering the labour market with little or no work experience, this suggests that employers perceive university graduates as generally not ready for the world of work. Yorke (2004, p. 409) captures this by stating that "there has been a persistent undercurrent of opinion amongst employers and politicians to the effect that graduates lacked a number of the skills that businesses need". Chegg (2013) concurs and asserts that 39% of 1000 hiring managers in the United States did not perceive that graduates were ready for work. However, these managers, do not blame the graduates but rather the higher education system. Similar findings have been observed in the South African context. Griesel and Parker (2009) as well as Walker and Fongwa (2017) suggest the existence of a skills gap between what employers expect and what universities do or the graduates they produce. These perceived skills gaps result in graduate employment outcomes being strongly linked to other external factors such as institutional reputation or prestige.

3.2.2 The government or policy makers' perspective

Linked to the preceding section, government departments and policy makers – even at supra-national or regional levels – have increasingly been caught between these competing and sometimes conflicting perspectives of assessing graduate outcomes. In the European context, Andrew and Higson (2008, p. 420) show through data from four countries that graduate outcome has been linked to the capacity of universities to "produce highly qualified, flexible and employable individuals who are able to meet the ever-changing demands of the modern-day European business". At the supranational level, the Association of African Universities has called on African higher education institutions to become responsive to labour market demands and provide necessary competencies and skills to their students [graduates] to make them employable (Association of African Universities, 2013:3). This is a shifting position from the early conception of the African universities, which were perceived as instruments of national identity and elite formation of the post-independence universities of the 1960s (Yesufu, 1973). This shift at the supranational or regional level has been observed within the South African context. While in the 1997 Higher Education White Paper 3 higher education was conceived as an agent to enhance transformation from the inequality of the past, recent policies from the Department of Education (DoE) and Department of Higher Education and Training (DHET) have started to align enrolments to the needs of the labour market (DoE, 2001). The WEF (2018) stated that there is an urgent need for governments to address the impact of new technologies on labour market outcomes through education and training policies, especially in the STEM fields, and developing non-cognitive soft skills (WEF, 2018).

3.2.3 The graduates'/students' perspective

Compared to the employers' perspective, less work has been done in seeking to understand graduates' labour market outcomes from the perspectives of graduates themselves. While universities perceive themselves as places to develop critical thinking and developing the entire person, aligned with the German concept of "*Bildung*" or the pure and immaculate conception understanding of the function of universities (Martin and Etzkowitz, 2000), graduates seem to have a different perspective. They have generally subscribed to the neoliberal principles, where visibility, commodification and instrumentalisation of the degree and university experience have become central to their university outcome. Graduates perceive universities as places to gain skills and capabilities to earn employment and enhance their social mobility (Hu, 2015). Their degrees are a testament or attestation to validate these acquired skills. As stated by Moxley, Najor-Durack and Dumbrigue (2001:123): "students come into post-secondary and higher education perhaps more with vocation, profession and career in mind than academic matters". However, many graduates generally feel relatively unprepared for the workplace, as they struggle to link their educational experience with employers' skill needs. This is somewhat different for graduates in degree programmes involving work-based learning, such as nurses, doctors, engineers and other vocational courses (Jollands and Molyneaux, 2012). With increasing calls for relevance of studies to employer needs, students and graduates therefore display a significantly different perspective regarding the role of the university, the purpose of the degree and the implications for their employment as graduates.

3.2.4 The institutional perspective

Regarding the institutional perspective of graduate outcome research, most universities are faced with growing tensions regarding their role in enhancing graduate outcomes. While there are increasing calls for universities to produce graduates who are ready for employment, universities are caught between the ideological versus instrumental debate. However, Castell (2001) argues that universities have a four-fold function, which includes serving as an ideological apparatus for society, knowledge production, elite formation, and finally human capital development. Within these four roles, some higher education systems have experienced system differentiation aimed at establishing universities with specific functions, such as research universities for knowledge formation, Technical and Vocational Education and Training (TVET) colleges for skills development and specialised colleges for particular elite professionals such as doctors and engineers and other liberal colleges (Van Vught, 2009). With increasing calls for relevance, along with university rankings and a growing and changing profile of students, universities are increasingly creating better links with employers and industry to enhance employment skills and outcomes of their students and graduates (Cranmer, 2006). Within the higher education institutions, however, is another group of stakeholders who are supposed to bridge this gap between the education approach to graduate outcomes and the employers and graduates' skills-based approach – the careers guidance services. Career guidance offices are units or centres established to enhance students' and graduates' transition to employment through several targeted initiatives and activities. However, due to limited support and exposure, much research still needs to be done to understand their perspective. This study will seek to interrogate a few career offices at some South African universities.

3.3 A methodological account

Designing the right methodology for graduate surveys has been a growing area of research and practice within the higher education research landscape. Higher education institutions, career guidance offices, independent research organisations and researchers have consistently developed different methodologies and instruments to respond to various research questions around graduate employment outcomes. Three methodologies are discussed here: cohort studies data, graduate exit surveys, and large-scale survey secondary data.

3.3.1 Cohort studies approach

Graduate outcome research studies have employed the use of cohort studies to investigate graduate outcomes within cohorts. The participants in the cohort, usually graduates from a particular year, are selected based on assumptions, including the fact that they experienced higher education and the labour market at a particular time and hence share similar opportunities and risk factors (Bailey et al., 2015). According to Healy and Devane, (2011:32) "cohort studies are generally concerned with information regarding the prevalence, distribution and inter-relationship of variables in a [particular] population". Some cohort studies have been done using a longitudinal approach to allow for the measurement of time-varying explanatory variables (covariates) and to make statistical inferences about changing relationships between perceived outcomes and the covariates, which is not always possible in cross-sectional cohort studies (Carrillo & Karr, 2012:151). A recent cohort study in the South African context has been that by the CHEC (2013) which traced 2010 graduates from all four Western Cape universities two years after graduation. The study led to several important findings, which are discussed later in this report.

3.3.2 Graduate exit surveys

Graduate exit surveys, mostly conducted by the individual institutions or at national level, have been a main methodology for investigating graduate employment outcomes (Alderman, Towers and Bannah, 2012). Graduate exit surveys are generally conducted upon graduation, usually a few months after completing the degree. They are more appropriate than graduate destination surveys, because they are easier to manage as most students change their email or postal or phone addresses upon graduation. However, as pointed out elsewhere (Du Toit, Kraak, Favish and Fletcher, 2014) graduate exit surveys pose their own challenges of sometimes being done too early, usually during graduation or less than six months after completion. However, graduate exit surveys tend to have a much higher response rate than graduate destination surveys.

Many of the South African graduate outcome studies have used secondary large-scale survey data (Fongwa, 2018). This methodology uses large-scale data that have been collected, usually by other institutions, for much broader purposes such as household census data, or the labour force survey. Analysis of the October Household Survey (OHS) and the QLFS has been a frequently used approach in determining graduate participation in the labour market and ultimately outcomes. Other studies, such as this one, have made use of more than one survey methodology to investigate graduate outcomes. The use of both secondary data from the QLFS and empirical cross-sectional graduate destination data can enhance both methodologies to improve the response rate as well as explore a wide range of variables.

3.4 A conceptual account

Several conceptual approaches have been used in researching and measuring graduate outcomes, including the expanded versus narrow definition of graduates (graduateness). A second approach focuses on the sector of employment – formal versus informal (or self-employed). A third account looks at the factors affecting graduate outcomes along the two broad themes of demand and supply.

3.4.1 Expanded versus narrow definition of graduateness

Employment outcomes studies have often been conceptualised using either an expanded or narrow framing. Regarding employment outcomes broadly, strict unemployment according to Statistics South Africa and even the International Labour Organisation (ILO, 2005) refers to the unemployed who have been actively seeking employment as opposed to the expanded version, which includes even those who have not actively sought employment within a specific timeframe. For graduate employment outcomes, one can identify from previous studies an expanded versus narrow definition of graduate employment (Fongwa, 2018).

While graduate outcomes research in South Africa has previously used the term graduate to refer to all graduates with qualifications from post-secondary institutions, Van den Berg and Van Broekhuizen (2013) provided a narrower and more stratified definition of graduateness. They limit their analysis of graduate employment outcomes to those with a university degree, and do not include those with certificates and diplomas[3]. Based on this revised definition of what or who a graduate is, they argue using a combination of labour force survey data that graduate unemployment in South Africa is much lower than previously conceived by earlier scholars (Bhorat, 2004; Development Policy Research Unit, 2006; Pauw et al., 2008). Such an approach can be made even narrower when graduate outcome is analysed from a specific field of study, such as the engineering graduates, health science graduates or natural science graduates, as proposed in this study.

3.4.2 Formality versus informality versus self-employed

Another conceptual approach in the South African context relates to the sample of the study. Most graduate studies have largely focused on employment patterns, levels of employment and fields of employment within the formal sector, and not very much attention has been given to those who go into the informal sector or are self-employed. The study by the CHEC (2013) attempts a more expanded approach to explore the various pathways graduates take after graduation beyond the employed or unemployed binary. Using a survey of 2010 graduates from all four Western Cape Universities, two years after graduation, the study uncovers seven potential pathways graduates take upon graduation. These included returnees to their previous jobs, first time entrants into the labour market, self-employed (in formal sector), employed in informal sector, unemployed, further education, and lastly care givers (CHEC, 2013). The study echoed findings from earlier studies in Europe (Schomburg & Teichler, 2006) which have conceived graduate outcome research beyond the narrow definitions of employed versus unemployed within the formal sector but includes those in the informal sector, self-employed and even care givers. This study, through the survey of those registered on the SACNASP database, will provide insight into those employed in the formal sector as well as the self-employed.

3.4.3 Graduate outcome as an interplay of personal and external factors

A third approach that has influenced graduate outcome research has been demand-supply factor analysis. Graduate outcome has been analysed in relation to several core factors affecting the demand and supply of graduates. Within this demand/supply discourse several conceptual framings have been used to understand graduate labour market dynamics. These include the HCT, job competition theory, and segmented labour market theory. Human capital theorists (Becker, 1964; Schultz, 1961) have over the years conceived education as an investment and drawn a correlation between years of educational attainment and employment outcomes, productivity and ultimate earnings (Teixeira, 2014). Graduates are therefore expected to perform better in the job market based not only on their years of study but also on the investment into the field of study as well as the perception of being more productive.

Linked to the HCT, the job competition theory argues that graduates who are not yet employed form queues at the ports of entry into the labour market, and one's position in the queue depends on a combination of their

3 The concern is that the inclusion of diploma and certificate qualifications in addition to degrees significantly decreases the employment and earnings returns.

individual characteristics or labour market features known as supply factors as well as the nature of the economy/ employers or demand factors (Moleke, 2006). Demand factors would include economic growth, inflation, and social constructs amongst employers (race, gender, ethnic groups), while supply factors include work experience, gender, and social capital (Thurow, 1975). This difference in labour market outcomes based on other personal attributes amongst graduates with similar educational credentials has been conceptualised as a segmented labour market theory. Unfortunately, such segmentation can result in differences in working conditions and wage gaps, ultimately entrenching inequalities socio-economically (Deakin, 2013). There is a plethora of evidence in the South African labour force to show evidence of such inequalities across race, gender and social class (Bhorat, 2004; Leibrandt et al., 2010; Van der Berg and Van Broekhuizen, 2013)the results of those studies are subject to a number of criticisms, ranging from inadequate definitions of \" graduates \" to the use of incomplete, dated, or unrepresentative data. This paper reviews the existing evidence on graduate unemployment in South Africa and analyses levels of, and trends in, graduate unemployment in the country since 1995. To overcome the deficiencies of previous studies, \" graduates \" are explicitly defined as individuals with bachelor's degrees or equivalents and higher educational qualifications (honours, Masters, and doctorate degrees.

From a conceptual approach, this study focuses on an analysis of graduate outcome beyond some of the traditional approaches. While the study will use secondary labour force data from Stats SA, the study will employ a survey of natural science professionals who might be in the informal sector or self-employed and not captured by the QLFS data. Furthermore, observing Green and Henseke's (2016) concern about the importance of study fields, the study zooms in within the natural sciences as a single broad field of study with several sub-fields or areas of specialisation. The research seeks to explore how the experiences of natural science graduates can be understood and explained using a variety of methodologies as well as from several stakeholder perspectives. To better locate the study in the existing literature, the next section captures some of the core factors affecting graduate outcomes with a focus on the South African literature.

3.5 Factors affecting graduate outcomes

In the face of rapidly changing digitalisation, innovation and the role of technology in society, the employability of graduates in general becomes even more critical than it was in previous decades. Graduates are increasingly expected to acquire a set of generic and soft skills which will enable them to almost immediately integrate into the world of work. However, graduate employment outcomes are increasingly observed as an interplay of external demand and supply factors, as well as personal attributes. In this section we highlight some of the main factors affecting South African graduates in the labour market. These factors are presented in three main themes: contextual factors, demand factors and supply factors.

3.5.1 Contextual factors

The South African society has in the last decade experienced several socio-political and economic events which have affected the growth projections and trajectories of the economy, and ultimately shaped the experiences of graduates in the labour market. Along with changing skills demands and in the fast-changing technological era, graduate outcome can be perceived within the context of a changing economic climate and nature of work.

3.5.1.1 Understanding Natural Scientists' skills supply and demand policy imperatives

The National Development Plan (NPC, 2011) places significant emphasis on the role of the natural sciences fields, including sciences, engineering and technology (SET) in achieving the aspirations of a knowledge economy. The Draft White Paper on Science, Technology and Innovation (STI) (DST, 2019) emphasises SET-related fields in positioning South Africa within the 4IR. According to the Draft White Paper (DST, 2019, p. xi)

> STI can be instrumental in improving public service delivery and decision making for public policy, thereby improving the quality of life of South Africans ... for instance educational outcomes can be improved through equipping children [and graduates] with the thinking [and employment] skills they will need in a technologically advanced world.

However, understanding these skills gaps or skills needs requires comprehensive research with triangulation of stakeholder perspectives on how graduates experience and navigate the world of work. For instance, Reddy et al. (2016:71) argue that while government-supported policies and growth initiatives have sought to prioritise the creation of low-skill jobs, there is a growth in the development of high-skills jobs – even more so in the natural science, engineering and technology areas.

3.5.1.2 Economic climate

The WEF in its 2014 report makes the case for a close interconnection between unemployment and other problems facing society. For any economy, high economic growth usually serves as a stimulus for additional human capital injection into the labour market. For the last decade, the South African economy has not attained projected economic growth targets (Stats SA, 2018). Since 1994 the South African economy has been characterised by positive but very low economic growth, rising levels of unemployment and inequality. Between 1994 and 1997 the economy grew at an average rate of 3.6%, compared to the 5% growth experienced between 1995 and 2007 (Ibid).

The economy was affected by the global crises of 2008 and the growth rates have not fully recovered to pre-crisis levels. Importantly, economic growth has been driven largely by capital-intensive industries, the retail trade, and financial services rather than productive and labour-intensive sectors such as agriculture and manufacturing, where most skills including natural science skills can be absorbed. Unsurprisingly, conditions of poor economic growth and periods of recession have entrenched unemployment, as unemployed individuals not only compete with other unemployed persons but also with the employed who seek better employment conditions and higher earnings (Longhi & Taylor, 2013). The South African economy has been described as paradoxical in the sense that on the one hand a large proportion of the population has very low levels of education, while on the other hand well developed skills are required for the economy to grow.

While the first quarter employment trends from Stats SA for 2020 showed growth in unemployment, the effects of COVID-19 have entrenched a dire employment climate. Research by the National Income Dynamics Coronavirus Rapid Mobile Survey suggest that between February and April of 2020 a massive three million people lost jobs, with less people in 'active employment' (NIDS-CRAM, 2020). Another survey by Stats SA conducted on 2100 small and medium-sized enterprises (SMEs) shows that at least 36% of SMEs laid off staff in the short term, between 14 and 30 April of 2020, and 9% had to permanently stop working (Stats SA, 2020). The effects of this will most likely be reflected in the upcoming unemployment statistics.

3.5.2 Demand factors

Several demand factors have been identified as affecting employment outcomes in general and graduate employment outcomes. In this section two main issues are briefly highlighted: the changing nature of work, and the shifting perceptions of employers regarding graduate skills and changing skills needs as captured in the lists of high skills needs or occupations in high demand (OIHD) and linked to the economy (Reddy, et al., 2017).

3.5.2.1 Changing nature of work

South Africa's skills needs have been changing significantly for the last two decades, from a predominantly low-skill base to medium to high skills. Kraak (2010:82-84) contends that "the structural shift in South African economy from low-skill occupation and labour-intensive industries towards high-skill occupations and capital-intensive industries since 1994 coincided with a change in employers' preferences". The implications of this shifting skill base are the large unemployed skills base and the decline in employment of graduates with degrees, and more so those with degrees in hard science- related fields (Van der Berg & Van Broekhuizen, 2013)the results of those studies are subject to a number of criticisms, ranging from inadequate definitions of \" graduates \" to the use of incomplete, dated, or unrepresentative data. This paper reviews the existing evidence on graduate unemployment in South Africa and analyses levels of, and trends in, graduate unemployment in the country since 1995. To overcome the deficiencies of previous studies, \" graduates \" are explicitly defined as individuals with bachelor's degrees or equivalents and higher educational qualifications (honours, Masters, and doctorate degrees. Structural unemployment can become more permanent based on the underlying factors, depending on how they affect demand and supply factors such as skills and technology uptake. The WEF estimates a 10% change in the structure of employment by 2022 because of changing technological developments, with 10% of current jobs becoming redundant. While another 11% of new professions will emerge, implications are that employees within the 10% who do not get reskilled as well as those currently skilling in those professions will have low employment prospects due to the changing nature of the labour force. This also has implications for natural science professions as for all other professions.

3.5.2.2 Employers' perceptions of skills shortages (Occupations In High Demand)

With changing labour market structures, as highlighted in the previous section, most countries as well as supra-regional bodies such as the International Labour Organisation, the OECD and others, are beginning to develop lists of occupations which they perceive to be in high demand as the labour market responds to the changing skills needs. In Canada, the National Occupation Classification List classifies occupations in different categories based on the level of demand (Level O, Level A, Level B). In the South African context, the labour market intelligence partnership between the HSRC and the DHET also led to the development of a List of Occupations in Higher Demand (Reddy et al., 2017). The list is an indication of occupations or positions in the labour market where demand outstrips supply and indicates to students/graduates the type of skills which are in high demand and for which graduates will easily gain employment in the economy. Relevant to this study, employers from 15 occupations within the Sector Education and Training Authority (SETA), as observed in the Professional Vocational, and Technical Occupational list (PIVOTAL), ranked science- and engineering-related professions as the second highest skills in demand (Reddy et al., 2016). Employers seem to prefer natural science graduates, even in non-natural science fields.

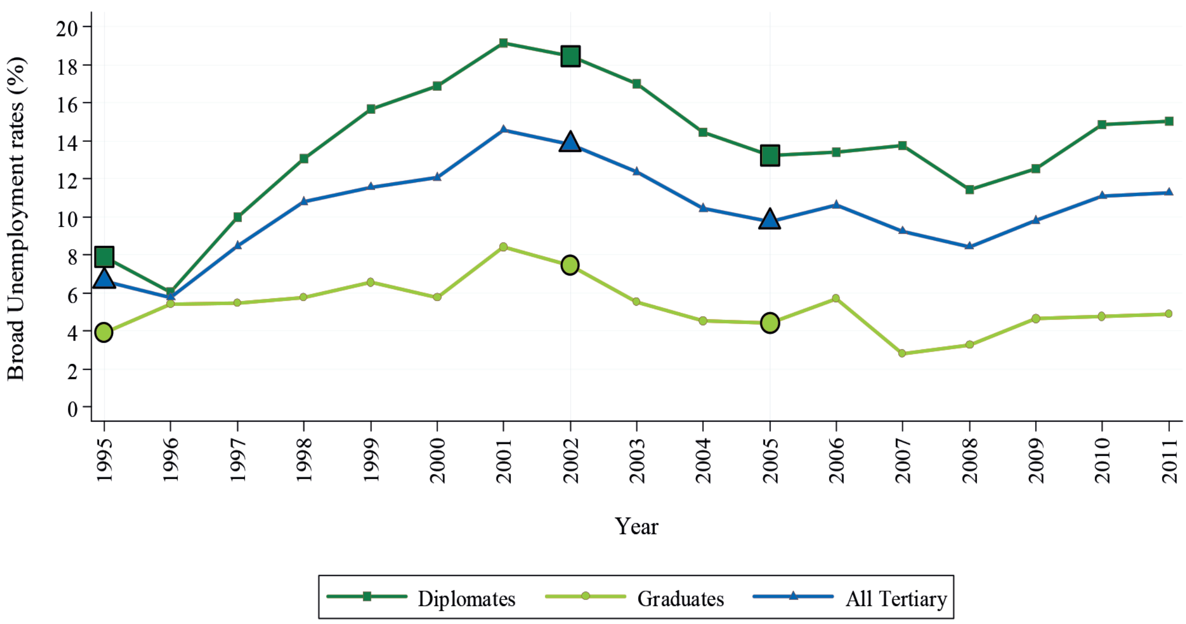
3.5.3 Supply factors

Three supply factors are presented here: the type of higher education institution, field of study and other personal attributes such as gender, race and social capital.

3.5.3.1 Institutional type

From the South African literature, as is the case globally, it can be clearly observed that graduate employment outcome is strongly linked to the type of higher education institution that was graduated from. The South African Graduate Development Association observed that while 9.7% of unemployed graduates are from a university, about 16.2% are from universities of technology. The figure becomes even more precarious for graduates from further education and training institutions, of whom 60.3% are unemployed (Jenvey, 2012). These findings were confirmed by Van der Berg and Van Broekhuizen (2013), who show from an analysis of the QLFS and OHS that unemployment rates amongst university graduates are lowest (about 5%) compared to amongst those with certificates or diplomas (16%).

Figure 3: Broad post-secondary unemployment rates in South Africa, 1995-2011



Source: Van der Berg & Van Broekhuizen (2013)

Letseka and colleagues (2010) go further, to show that when analysed by university type, graduates from historically Black universities (HBUs) take a much longer time to be absorbed into the labour market than those from historically White universities (HWUs), who easily get absorbed within the first few months of graduation. Walker and Fongwa (2017) confirm these findings, highlighting the weak conversion factors of graduates from HBUs compared to those from HWUs. The CHEC (2013) study confirms the role of institutions, as they observe that while overall unemployment of 2010 graduates was at 10%, when viewed by institutions the Cape Peninsular University of Technology graduates experienced higher unemployment (16%) compared to graduates from the University of Cape Town and Stellenbosch University, for whom unemployment was at about 5% and 6% respectively.

3.5.3.2 Field of study

Koen (2006) argues that students who choose SET-related disciplines, are more likely to be immediately employed upon completion of their studies than their fellow graduates in fields such as commerce and the humanities (Arts and Social Sciences). Van der Berg and Van Broekhuizen (2013) concur with other research that Arts and Humanities graduates are less likely to find work upon graduation when compared to graduates from other fields. However, they are more likely to do so within six months than commerce graduates. Using Grade 12 mathematics and natural science symbols attained as a proxy factor, the CHEC study observed that unemployment increases as the matriculation symbols of graduates in mathematics and science decrease (CHEC, 2013).

Letseka et al. (2010) observe a change in dynamics when the field of study is included in their graduate outcome analysis. Natural science graduates (white and African) experience similar absorption into the labour market (35% and 31% respectively) compared to their peers in the education field, where 48% of African graduates find jobs compared to only 15% of Whites. This trend in education between Whites and Africans can be related to the fact that African graduates can easily move to the more rural areas/provinces to take up teaching jobs in rural schools, as opposed to White graduates who are more often located in the metropolitan areas. Across the board, Indian graduates have the lowest absorption rate.

Labour Market Intelligence Partnership (LMIP) research shows a higher number of natural science- related skills being in demand compared to other fields. The authors argue that "at the professional level the key signals for policy makers are related to the significant demand for Science, Technology, Engineering and Mathematics graduates" because the current 55 000 graduates being produced yearly does not meet current and growing needs (Reddy et al., 2016).

3.5.3.3 Other personal characteristics

Graduate employment outcomes have been observed to be influenced by personal attributes which include race, gender, social capital, previous work experience, and primary/secondary school attended. Relating to race, White graduates tend to enjoy better employment outcomes compared to their peers. Letseka et al. (2010:91) observe that virtually all white graduates seeking employment were absorbed into the workforce within a year of searching, with 92% finding employment within six months. For African graduates, only 56% found employment within six months. Coloured and Indian graduates had good absorption rates, at 78% and 84% respectively.

Rogan and Reynolds (2016) in a study of two institutions further unpack the role of personal and social characteristics on graduate outcomes. They observe that a combination of socio-economic factors and the secondary/high school graduated from seem to play a significant role in graduate outcomes. They argue for the need for more policy initiatives on demand and supply factors as students from poorly resourced schools struggle to complete their first-degree choice and secure decent employment.

Based on employers' preferences, graduates with social capital and social networks tend to use them to their benefit in the labour market (O'Shea, 2019). Walker and Fongwa (2017) show that social capital is a strong factor in influencing how graduates access internships as well as work opportunities during their studies and upon graduation. Family background factors such as parental levels of employment, type of schooling attended and if siblings had completed higher education were identified by the CHEC (2013) study as strong predicting factors of graduates' employment outcomes.

3.6 Towards a conceptual framework for graduate employment outcomes

Three possible graduate labour market outcomes are used to frame the study – unemployment, underemployment and employment. While the concepts of unemployment and employment have been substantively researched and interrogated within the broader education and economics literature, understanding graduate underemployment has been fairly under-researched globally, as well as within the South African context (Beukes et al., 2016; Mncwango, 2016; Reddy, 2016; Grapsa, Rogan and Mncwango, 2018). These investigations were, however, all at a national level, with no consideration whatsoever of underemployment at the sectoral level. Furthermore, these studies were not particularly focused on the graduate labour market.

While there are clearly positive trends in terms of employment rates of graduates, the simple binary between employment and unemployment status has increasingly become inadequate to capture the conditions of employment, such as hours per week of work as well as the level to which one's skills, qualifications and competences are applied within employment. Furthermore, unemployment has been found to be accompanied by both shortages of skills and over-qualification (Grapsa et al., 2018). It therefore becomes important to conceptualise underemployment for this study.

Two broad definitions of underemployment are identified in the literature: a time-based approach and an inadequate employment situation approach. An inadequate employment situation, as defined by the ILO, refers to any situation where workers have a desire to change their work situation and the presence of a reason why individuals are not able to either fully exploit their capabilities or maximise their wellbeing. Bonnal et al. (2009:217) provide a more specific definition of an inadequate employment situation; that is, when employees find themselves in jobs or employment that under-utilise their qualifications and skills. Three subcategories of inadequate employment situations are skill-related underemployment, income-related underemployment and excessive working hours.

In contrast, time-related underemployment refers to a situation where an employed person's actual hours of work are insufficient relative to the number of hours the individual is willing or available to work. This form of underemployment is also referred to as a quantitative or visible underemployment. According to the ILO (2005), for one to be described as underemployed the following criteria need to be considered simultaneously: willing to work for an additional hour, or extra hour, have worked less than 35 hours during the reference week, and can start extra work in the next four weeks if the additional work is available. Capturing all key conditions outlined by the ILO, Stats SA has used the time-based approach in determining underemployment within the QLFS. This definition captures the number of persons employed in jobs where they work below the minimum number of hours permitted (35 hours), even though they are willing and available to work additional hours (Yu, 2009:20; O'Shea, 2019). In most countries, since underemployment has not been conceptualised and measured, the exact statistics on the magnitude of underemployment are not easily obtainable (Gibbons, 2016). In South Africa, using self-reported measures of qualification mismatches, Mncwango (2016) estimated that about 34% of the South African workers are either overqualified or underqualified.

Consequently, authors such as Livingstone (2004:220) have referred to underemployment research as an inexact science due to its subjective nature, as graduates' perceptions of overqualification for current job, unfulfilled aspirations of used skills and a sense of entitlement to a better job inform and shape how graduates view themself within the employment spectrum. Cunningham (2016) argues that an area under research is the relationship between education and underemployment. This research seeks to show the correlation between field of study and underemployment with a focus on the natural sciences.

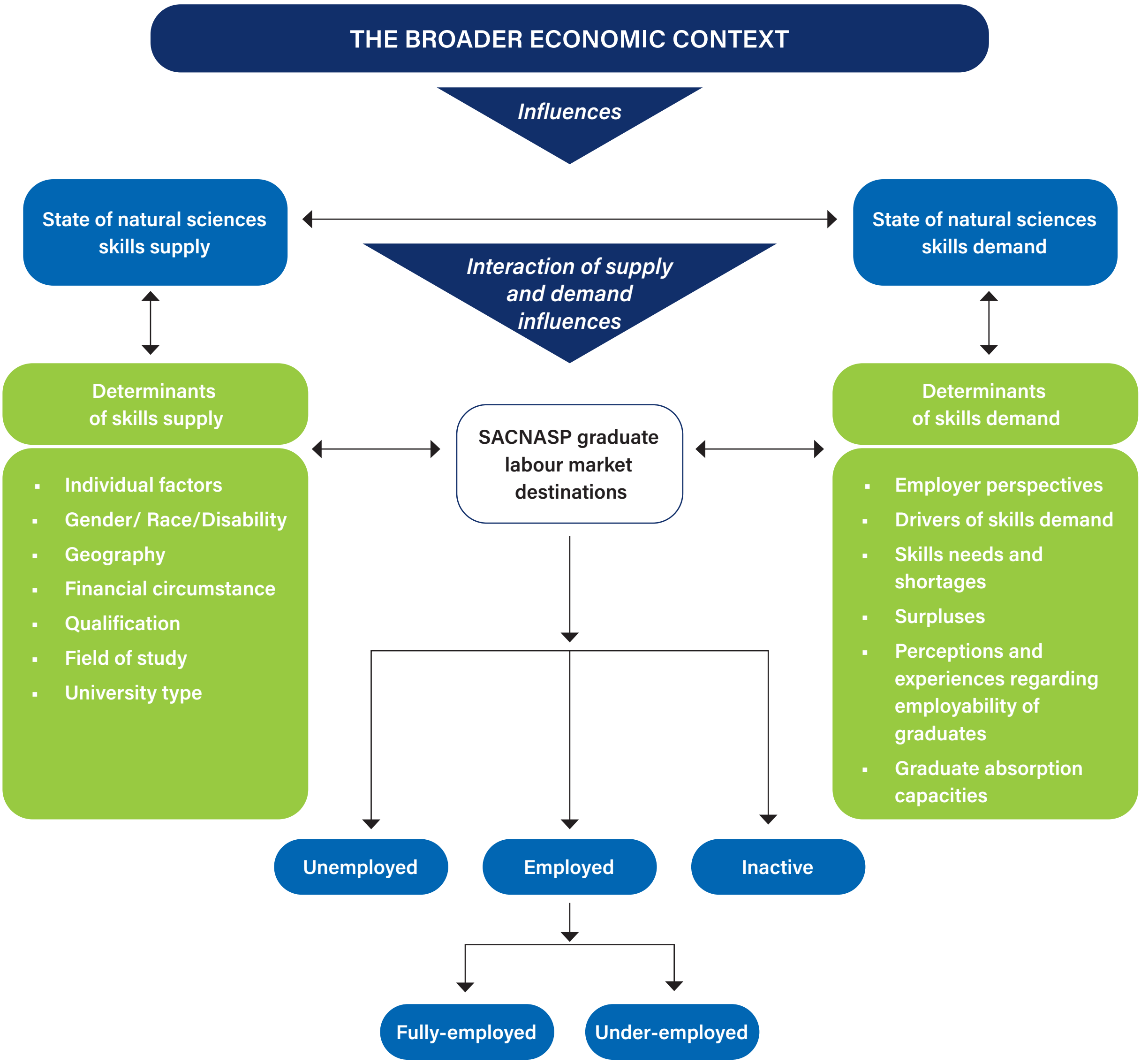
With growing evidence of increasing unemployment and shrinking employment opportunities, there is growing underemployment amongst graduates. This is largely undocumented within the broader economy, as well as in the various sectors and fields of work. Although underemployment appears to have become prevalent in the labour market, particularly amongst young graduates, only a small body of research exists on the causes of underemployment. However, this limited evidence suggests that the already marginalised are at the risk of being underemployed, with underemployment being closely associated with the overall state of the economy, job type, career history, job search strategy used, or racial and ethnic inequalities.

One important form of underemployment that has negative effects on individual employees is when they are over-skilled and over-qualified for their employment, and those with a university higher education or who are highly skilled are more likely to be affected by this. Several risks related to underemployment include the following: precarious employment, skills alteration, out of date qualifications, low living standards, low wage, and extended periods of financial dependency on parents (Dana-Ioana, 2014, p. 89).

This research therefore aims to contribute to this conceptual and empirical gap by using the natural science graduates within the SACNASP-related fields of studies to investigate the levels of employment and unemployment of graduates towards addressing the educational needs. Using a combination of primary and secondary data, the study will identify labour market outcomes according to the three broad categories of unemployed, employed, and underemployed. Furthermore, the study will also investigate the main factors affecting the observed outcomes across and within the three categories. Figure 4 overleaf captures the core aspects affecting graduate outcomes along with the main determinants as indicated in the literature.

This review aims to provide a summary of the main debates within graduate employment outcomes research with a focus on the South African context. The review has presented some methodological, conceptual and stakeholder perspectives influencing graduate outcomes research and measurement in South Africa. The review has also highlighted some of the main determinants and pathways of graduate outcomes, which will inform the empirical part of the study.

Figure 4: Conceptual framework for graduates' outcomes



Source: Conceived by authors

4

Profiling Natural Science Graduates

Lolita Winnaar and Bongiwe Mncwango

According to the Department of Basic Education, there have been improvements in secondary education completions, which is evident from the increase in matric pass rates between 2008 and 2019. Matric pass rates have changed from 62% in 2008, averaging at 75% in 2017 and increasing to 81% in 2019[4] (Department of Basic Education, 2020). Acknowledging this general increase in matric pass rates, the next question of interest is: What percentage achieved a pass in the so-called 'gateway subjects'[5], particularly maths and science? Performance in maths and science has significant implications for university entrance, since these are the main subjects required to proceed with any STEM-related qualification.

Figure 5 overleaf shows the proportions of those who could enrol for such qualifications. It displays the numbers of learners who obtained a bachelor's pass across years as well as those who achieved above 50% in mathematics. The percentage of learners obtaining a bachelor's pass has increased slightly from 31% in 2013 to 34% in 2018. Conversely, a slight reduction in the percentage of learners getting over 50% in maths is evident during this period (from 26% in 2013 to 22% in 2018).

Strong performance in maths is important for careers in computer science programming, finance and machine learning associated with developments brought about by the impending 4IR requiring competent graduates in STEM (Shay, 2020). The new National Skills Development Plan for 2030 explicitly expresses commitment to *"Increase the number of students eligible to study towards maths and science-based degrees to 450,000 by 2030"* (National Planning Commission, 2019:6). The National Development Plan and the National Skills Development Plan both outline the Department of Basic Education's mandate to improve outcomes in the basic education sector, with particular emphasis on improving outcomes in literacy, mathematics, and science. This is with a view to increase the number of learners enrolling in SET programmes at the institutions of higher education and training. The main goal is to increase the pool of individuals qualified for occupations in science and technology, particularly those OIHD.

Profiling natural science graduates will be done by investigating patterns and sociodemographic differentials in the labour market in terms of the participation or lack thereof of individuals who indicated having completed a natural science qualification from a university. This is a critical exercise considering the political past of the country, resulting in structural inequality and unemployment with a disproportional concentration of African graduates amongst the unemployed or not in the labour force at large. The following figures should be viewed in the context of the overall demographics of the country, where according to the recent population estimates from Stats SA, the total population stands at 58.8 million people, of whom 80.7% are African and 51.2% (approximately 30 million) are female (Stats SA, 2019b). South Africa's unemployment rate hovered between 23% and 27% during the period of interest, being the highest figure amongst OECD countries which average 6.3%, with only Greece coming close with 23.5%. Unemployment is more widespread amongst women than men. Furthermore, 59% of the unemployed fall under the definition of long-term unemployment – workers who have been without work for more than 27 weeks. One in two young people in South Africa are affected by youth unemployment.

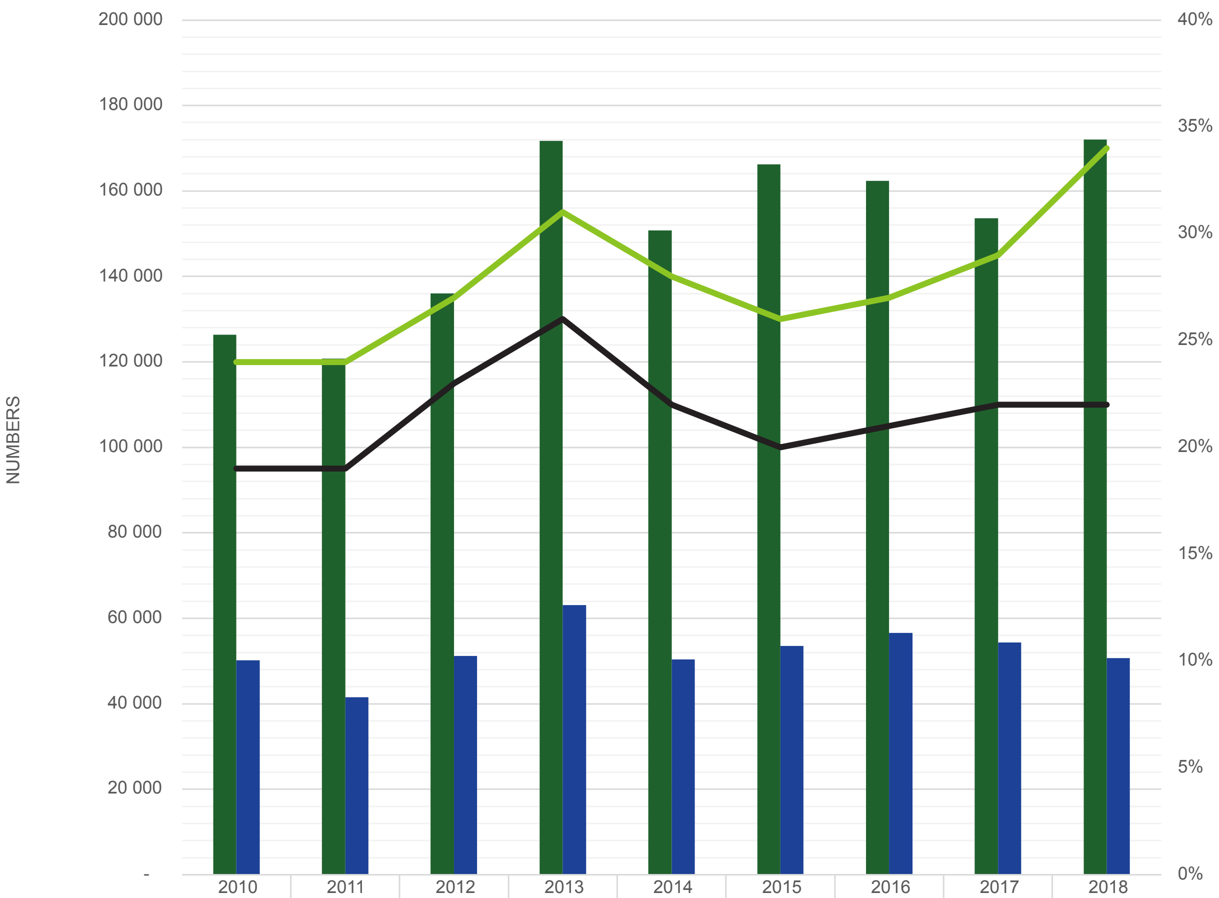
Reaching gender parity as far as careers of scientists are concerned is high on the national agenda. The dominance of men at higher levels of the academic hierarchy is well documented and this has been attributed to a general structural bias against women in science (Joubert & Guenther, 2017). Joubert and Guenther concluded that there are very few African and female scientists who are influential in the country. This was based on the study conducted by

4 A total of 787 717 learners wrote exams in the 2019 National Senior Certificate examinations; 616 754 were full-time and 170 963 were part-time students.

5 Gateway subjects include Accounting, Agricultural Sciences, Business Studies, Geography, History, Mathematical Literacy and Physical Sciences.

the team in 2017, which involved consulting 45 experts working in science to identify the most visible and influential scientists in the country. Key findings included that although only about 8% of the South African population is white, 78% of the identified visible scientists were white, and 63% were men, with only 17% African women identified as publicly visible scientists (Joubert & Guenther, 2017:1).

Figure 5: An overview of performance in the schooling system (2010–2018)



	2010	2011	2012	2013	2014	2015	2016	2017	2018
N Bachelor Pass	126 371	120 767	136 047	171 755	150 752	166 263	162 374	153 610	172 043
N Math>50%	50 195	41 586	51 231	63 151	50 365	53 588	56 555	54 359	50 701
% Bachelor Pass	24%	24%	27%	31%	28%	26%	27%	29%	34%
% Math>50%	19%	19%	23%	26%	22%	20%	21%	22%	22%

Source: Department of Basic Education data adapted from Reddy et al, 2016 and updated by authors

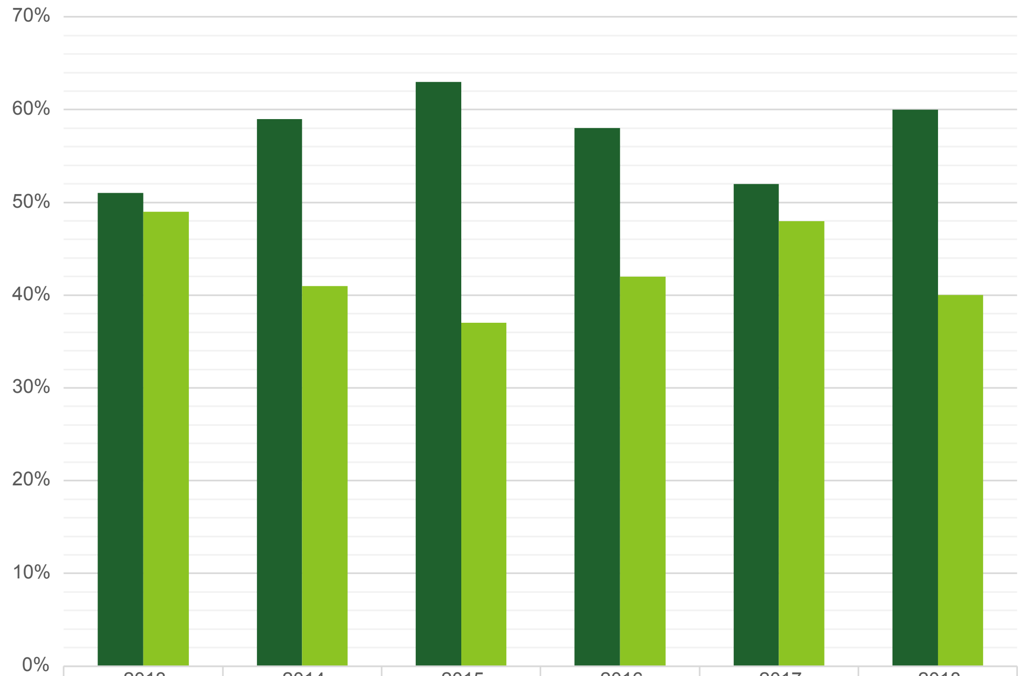
4.1 Gender

In general, there are slightly fewer females than males in the natural sciences field across years. A decrease in the number of females is observed between 2013 and 2015 Figure 6, after which an increase of 11 percentage points is observed by 2017. The percentage of male natural scientists fluctuates considerably between 2013 and 2018.

4.2 Population group

In terms of the distribution by population group, from 2013 to 2018 the shares of the African population group increased by five percentage points, from 42% to 47%; however, a decrease of eight percentage points is experienced between 2013 and 2015. Shares of the Coloured and Indian/Asian groups remained constant, whilst the shares of White natural scientists have increased by 12 percentage points between 2013 and 2015 but then decreased considerably after 2015 to 42% in 2018, as can be seen in Figure 7.

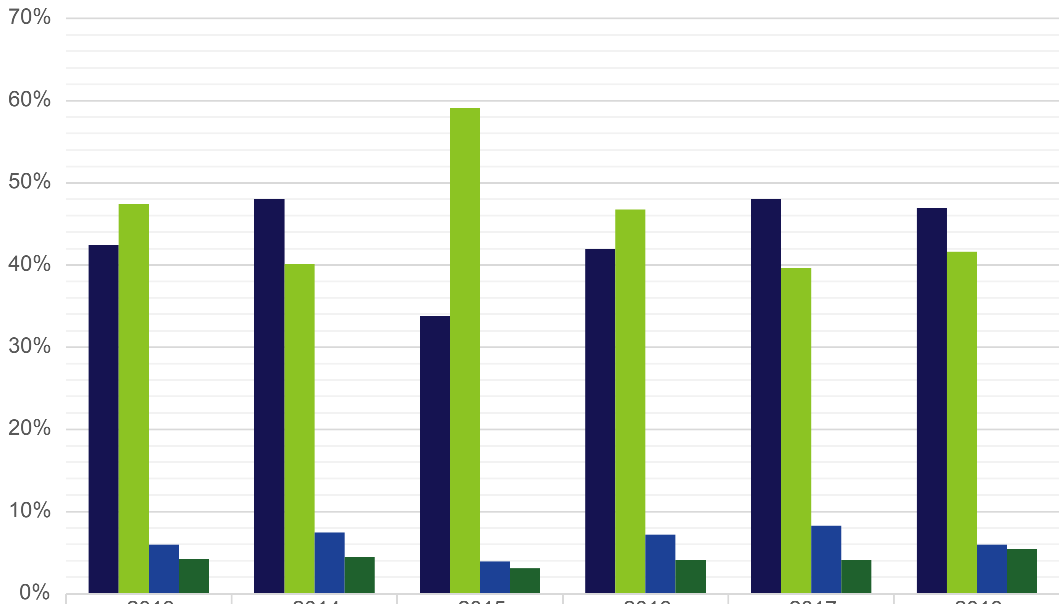
Figure 6: Distribution of scientists by gender, 2013–2018



	2013	2014	2015	2016	2017	2018
Male	51%	59%	63%	58%	52%	60%
Female	49%	41%	37%	42%	48%	40%

Source: Authors, compiled from LMDS, 2013–2018; QLFS 2018

Figure 7: Distribution of natural scientists by population group, 2013–2018



	2013	2014	2015	2016	2017	2018
African/Black	42%	48%	34%	42%	48%	47%
White	47%	40%	59%	47%	40%	42%
Indian/Asian	6%	7%	4%	7%	8%	6%
Coloured	4%	4%	3%	4%	4%	5%

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.3 Age

Numbers of young scientists aged between 20 and 29 years declined slightly between 2013 (23%) and 2015 (24%); since then, it has increased to 31% in 2018 (Table 3). Notably, Table 3 also shows that the proportions of those between the ages of 30 and 39 years increased from 25% in 2013 to 35% in 2018. However, the opposite was true for the age group 40 to 49 year, with a decrease being observed between 2013 (28%) and 2018 (15%). The proportion of natural scientists aged between 50 and 59 years remained consistent from 2013 to 2018.

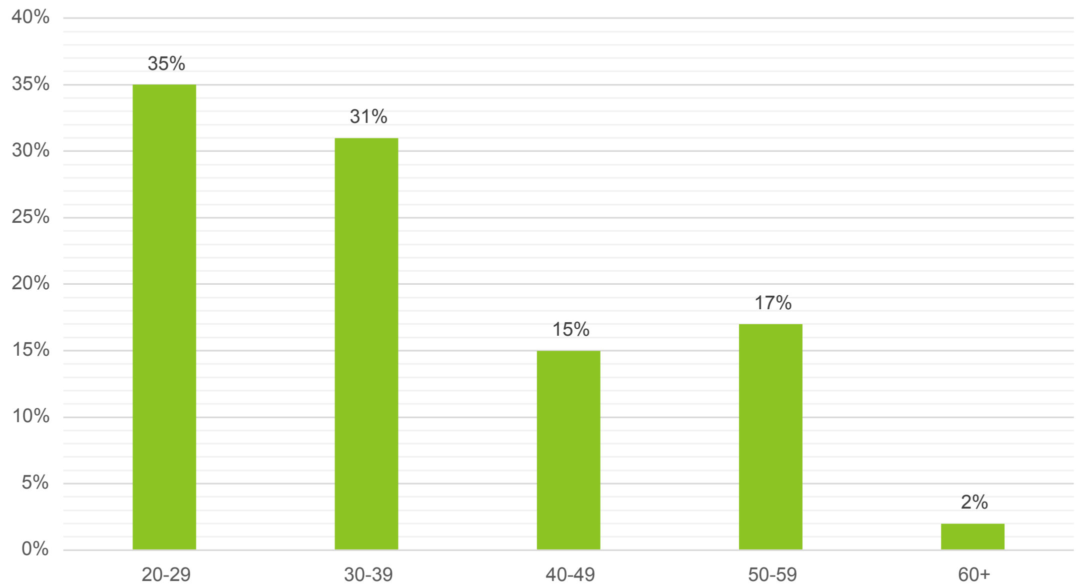
Table 3: Age profile of natural scientists, 2013–2018

	Number of natural scientists						Percentage of natural scientists						
Age group (yrs)	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	Difference between 2013 & 2018
20-29	80	60	53	62	71	96	23	20	24	23	31	31	-16
30-39	78	75	63	94	67	118	25	27	24	29	25	35	-40
40-49	95	85	66	87	58	55	28	35	23	25	20	15	40
50-59	58	53	58	41	42	43	15	14	21	17	17	17	15
60+	22	14	20	21	24	8	8	5	7	7	6	2	14
Total	333	287	260	305	262	320	100	100	100	100	100	100	13

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Looking at the current picture in terms of the age profile of natural scientists in 2018, Figure 8 shows that more than a third (35%) of natural scientists fall within the age group 30 to 39 years. Thirty-one per cent were aged between 20 to 29 years, while only 2% were aged 60 years and older. The youth labour market is considered as distinct from the overall labour market, because younger workers are more likely to be new entrants transitioning into the workforce with minimal skills and experience (Dhillon & Cassidy, 2018). It would thus be useful to look at where the youth is overly represented within the three possible labour market destinations.

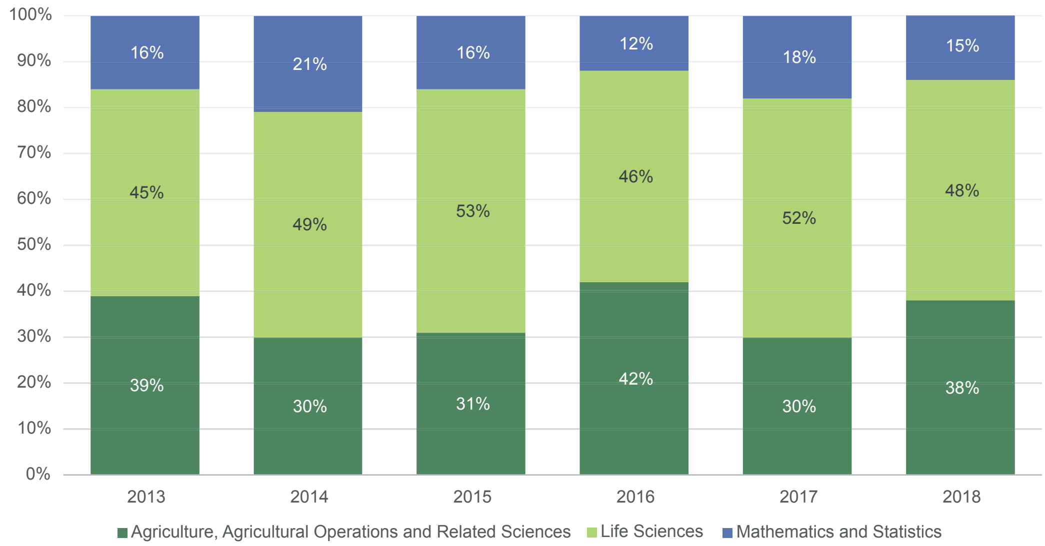
Figure 8: Age profile of natural scientists, 2018



Source: Authors, compiled from QLFS 2018

Figure 9 presents the distribution of natural scientists by field of study. The percentages from 2013 to 2018 have remained consistent across each of the three study fields, with life sciences showing the highest percentages. On average across the years, 35% of science graduates were in the field of agriculture, 48% in the field of life and physical sciences and 16% in the field of mathematics and statistics.

Figure 9: Distribution of natural scientists by field of study, 2013- 2018

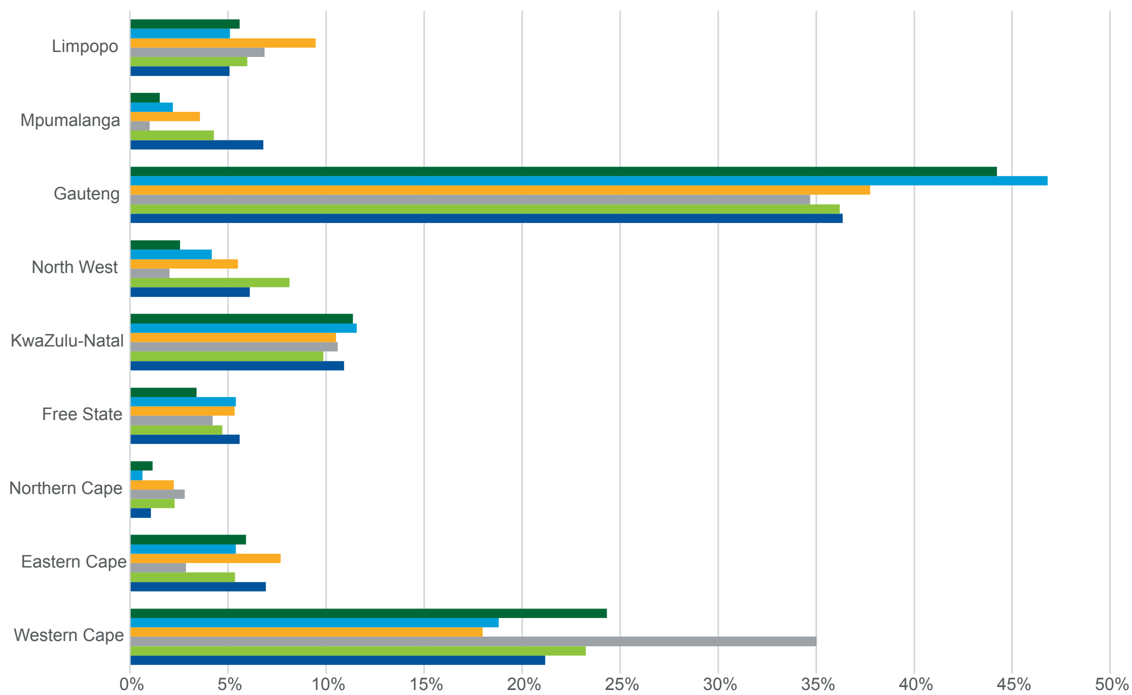


Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Note: Life Sciences=Life Sciences + Physical Sciences, Agriculture=Agriculture + Agricultural Operations and Related Sciences, Math Stats=Mathematics + Statistics

In looking at which provinces natural scientists reside in, Figure 10 shows that consistently across the years Gauteng registers a larger proportion of scientists, which has also been growing steadily, from 36% in 2013 to 44% in 2018. Some small but significant shares are also reported for the Western Cape and KwaZulu-Natal. Shares of scientists in the Eastern Cape, Free State, North West, Mpumalanga and Limpopo have remained unchanged across the six-year period.

Figure 10: Distribution of natural scientists by province, 2013–2018



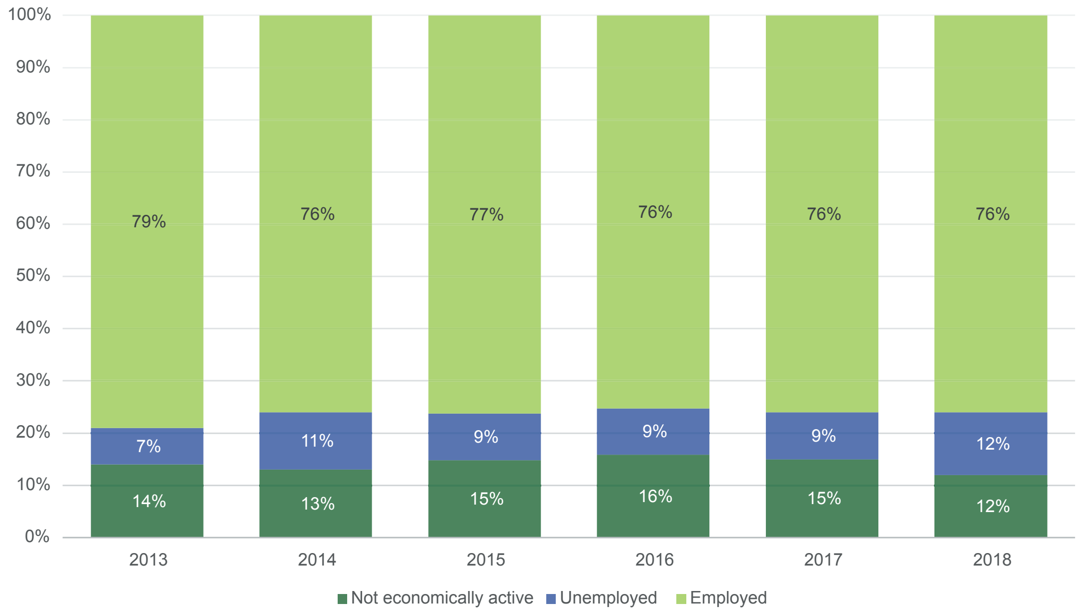
	Western Cape	Eastern Cape	Northern Cape	Free State	KwaZulu-Natal	North West	Gauteng	Mpumalanga	Limpopo
2018	24%	6%	1%	3%	11%	3%	44%	2%	6%
2017	19%	5%	1%	5%	12%	4%	47%	2%	5%
2016	18%	8%	2%	5%	10%	6%	38%	4%	9%
2015	35%	3%	3%	4%	11%	2%	35%	1%	7%
2014	23%	5%	2%	5%	10%	8%	36%	4%	6%
2013	21%	7%	1%	6%	11%	6%	36%	7%	5%

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.4 Mapping the labour market destinations of natural science graduates

Figure 11 begins to examine the current labour market destinations of natural science graduates between 2013 and 2018. During this period, patterns of labour market participation of scientists have basically remained unchanged. The proportion of those in employment has decreased slightly, from 79% in 2013 to 76% in 2018. Similarly, the numbers of those unemployed has remained fairly the same across the years at between 7% and 12%. The trend of natural science graduates who are not economically active is, however, gradually declining, from 14% in 2013 to 12% in 2018.

Figure 11: Percentage of natural science graduates employed, unemployed and economically inactive (2013–2018)



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Likewise, although there is already a very small proportion of natural science graduates who are in employment and can be identified as underemployed (between one and two percent), their proportion is also reducing over time (Table 4). This is a surprising finding, considering that globally the phenomenon of underemployment has been steadily gaining currency, with a rising share of workers expressing willingness to work extra hours.

Table 4: Percentage employed graduates who are underemployed (2013–2018)

Year	2013	2014	2015	2016	2017	2018
Underemployed	0%	1%	1%	2%	2%	1%
Not underemployed	100%	99%	99%	98%	98%	99%

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.4.1 Characteristics of natural science graduates

This section gives a broad overview of natural scientists that are in the labour force and described as either employed or unemployed. We will examine the relationship or correlation between an individual employment outcome and their personal profiling characteristics, such as gender, population group, age, educational attainment and province.

Several policies have explicitly expressed commitment to advancing participation of women in science- and engineering-related fields (Ngila et al., 2017). In 2004 the National Advisory Council on Innovation released a report which indicated that participation in work in SET sectors was very weak. This was subsequently followed by the development of a monitoring and evaluation framework, which sought to benchmark the performance of women in SET fields. The follow-up report of 2009 began to show some significant advancement in women's participation. It has consistently been shown that persisting gender inequality often limits women scientists from achieving their potential and effectively contributing to the continent's developmental challenges (World Health Organization, 2013). Women's underrepresentation in science not only has negative results for development, but also for research. For instance, in the area of infectious diseases, which largely affect women – with few women occupying decision-making positions in academic and research institutions, their scientific role in prioritising research agendas is severely circumscribed. This has potentially adverse implications for addressing and eliminating infectious diseases (World Health Organization, 2013).

Table 5: Profile of employed natural scientists by demographic characteristics (2013–2018)

Category	2013	2014	2015	2016	2017	2018
Gender						
Male	54	65	68	62	59	63
Female	46	35	32	38	41	37
Population group						
African/Black	45	45	33	43	53	42
Coloured	4	4	3	4	3	7
Indian/Asian	5	9	2	4	7	3
White	45	42	63	49	37	47
Age						
20-29	20	11	18	11	24	20
30-39	30	33	26	32	27	37
40-49	33	38	25	30	22	20
50-59	13	13	24	19	22	21
60+	4	4	7	8	6	3
Education						
Bachelor's degree	53	49	38	30	11	45
Bachelor's degree and Postgrad Diploma	9	8	14	38	58	11
Honours degree	18	19	29	10	7	22
Master or PhD	20	24	18	22	24	21
Province						
Western Cape	22	21	31	15	19	27
Eastern Cape	7	7	4	7	7	5
Northern Cape	1	3	3	3	1	2
Free State	7	3	4	3	5	3
KwaZulu-Natal	12	10	10	13	12	14
North West	5	8	2	7	4	3
Gauteng	32	40	38	37	45	41
Mpumalanga	8	4	1	5	2	2
Limpopo	6	4	7	10	4	4

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Findings as depicted in Table 5 reveal stark gendered patterns of employment participation, with more male than female natural scientists being in employment across the years. A negative trend is evident, where the proportion of females has been decreasing over time, from 46% in 2013 to 37% in 2018. The main area of interest is, however, in the actual activities undertaken by women scientists, considering observations that women scientists primarily work for academic and government institutions while their male counterparts are engaged more in the private sector where they enjoy better pay and opportunities (Mcunu, 2018; World Health Organization, 2013) including pushing the envelope on gender equality, one of the 17 Sustainable Development Goals (SDGs).

Employment rates of young natural scientists are declining across the years. Fluctuations have been observed in all age groups between 2013 and 2018; however, when comparing 2013 to 2018 the percentage of science graduates in the age category 20 to 29 years has remained consistent at 20% (Table 4). The percentage of graduates in the age category 30 to 39 years has increased from 30% to 37% between 2013 and 2018. A decrease was observed in the 40 to 49 years as well as the 60 years and older category. Therefore, most scientists in employment are between the ages of 30 and 49 years. Amongst other things, this might suggest that very few young natural scientists are being absorbed into natural science jobs, or over time, or might be pointing to employer preference for more experienced workers in their prime ages, that is, those between the ages of 25 and 54 years.

From 2013 to 2018 the shares of the employed African population have generally remained constant at between 42% and 45%. The percentage of employed graduates has remained constant over time, with most natural scientists employed in Gauteng (38% on average) followed by the Western Cape (23% on average) and KwaZulu-Natal (12% on average). The average percentage in the remaining provinces was consistently below 10% across the years.

4.4.2 Share of employed natural scientists by main industry, 2013–2018

Next, the focus is on the industrial sector where individuals with a natural science qualification work. This is important as it provides signals in terms of the alignment between field of study and industry, to provide insight into the extent to which they work in industries linked to their qualifications. Furthermore, the changing structure of the economy is contributing to the allocation of natural scientists in more service-oriented sectors, due to the growth of these sectors.

Table 6 shows the distribution of scientists across the various sectors of the economy, and shows that consistently across the years, the biggest two employers of the scientists remain the financial sector and the community sector. Shares of scientists joining the community sector have increased over time, from 41% in 2013 to 44% in 2018, with decreases observed in the financial sector, from 29% in 2013 to 25% in 2018. Shares of scientists in the primary sector show increases over time in the agriculture, hunting and forestry sector, from three percent in 2013 to 11% in 2018. However, the share in mining and quarrying has remained unchanged across the years. As far as the secondary sector is concerned, manufacturing and construction experienced slight declines in the shares of scientists, whilst the electricity and gas sector remained constant. Notably, shares of scientists working in the wholesale sector have in general decreased slightly across years, from four percent in 2013 to two percent in 2018. Shares of scientists in the transport and storage sector decreased from six percent in 2013 to one percent in 2018.

Table 6: Distribution of natural scientists by main industry, 2013-2018

Occupational category	Number of scientists						Percent of scientists					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Primary sector												
Agriculture; hunting; forestry and fishing	19	32	26	37	23	31	3	9	11	14	7	11
Mining and quarrying	3	11	4	1	0	1	2	5	2	1	0	1
Secondary sector												
Manufacturing	30	22	21	18	20	29	11	10	11	9	12	14
Electricity; gas and water supply	3	0	0	1	3	5	2	0	0	1	1	2
Construction	5	0	4	7	3	1	2	0	2	3	1	1
Tertiary sector												
Wholesale and retail trade	13	18	19	9	17	6	4	6	9	4	7	2
Transport; storage and communication	10	7	5	6	4	1	6	4	3	3	2	1
Financial intermediation; insurance; real estate and business	74	42	48	38	37	55	29	22	26	17	18	25
Community; social and personal services	111	91	72	116	103	117	41	43	35	50	52	44

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.4.3 Share of employed university and TVET college natural scientists by field of study and main industry, 2018.

The next table (Table 7) looks at the specific natural science fields against the sectors where the natural scientists are working. Within the mathematics and statistics field, most of the science graduates are in the financial sector (45%) as well as the community sector (49%), with only six percent in the manufacturing sector. The life skills field shows three dominant sectors – the community (46%), financial (28%) and manufacturing (16%) sectors – with small percentages found in the remaining sectors (<10%). Science graduates in the field of agriculture are predominantly found in one of four sectors: community (40%), agriculture (29%), manufacturing (14%) and financial (13%).

Table 7: Field of study by main industry, 2018

Industry	Agriculture, Agricultural Operations and Related Sciences	Life Sciences	Mathematics and Statistics
Agriculture; hunting; forestry and fishing	29%	1%	
Mining and quarrying		1%	
Manufacturing	14%	16%	6%
Electricity; gas and water supply	1%	3%	
Construction		2%	
Wholesale and retail trade	3%	2%	
Transport; storage and communication		1%	
Financial intermediation; insurance; real estate and business	13%	28%	45%
Community; social and personal services	40%	46%	49%

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Table 8: Distribution of employed natural scientists by occupation level, 2013–2018 shows that across the years over two-thirds of graduates occupied higher skilled occupations. Most of them were professionals (47% on average), managers (21% on average) or technicians and associate professionals (26% on average), which have been consistent trends between 2013 and 2018. Notably, shares of scientists employed as managers increased slightly from 24% in 2013 to 29% in 2018. Shares of technicians and associate professionals have fluctuated over time, with a decrease observed between 2013 (17%) and 2018 (11%), whilst the professional category shrank by one percent from 44% in 2013 to 43% in 2018.

Table 8: Distribution of employed natural scientists by occupation level, 2013–2018

	Number of scientists						Percent of scientists					
Occupational category	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Managers	74	63	48	72	43	70	24	27	22	31	22	29
Professionals	110	106	98	93	93	105	44	53	53	41	50	43
Technicians & Associate Professionals	42	25	25	25	35	27	17	9	13	9	13	11
Clerical Support Workers	19	9	10	11	14	14	7	4	5	5	7	5
Service and Sales Workers	4	8	5	5	5	10	2	4	3	2	2	4
Skilled Agricultural, Forestry, Fishery, Craft and Related Trades Workers	11	10	10	18	11	13	3	3	4	9	3	6
Plant and Machine Operators, and Assemblers	2	0	3	5	4	3	1	0	1	2	1	1
Elementary occupations	6	2	1	4	5	4	3	0	0	1	2	2
Total	*268*	*223*	*200*	*233*	*210*	*246*	*100*	*100*	*100*	*100*	*100*	*100*

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

Very low percentages of graduates are engaged in low-skill occupations. We also see from Figure 12 that approximately 6% are in the elementary occupations (only within the Agriculture field), skilled agricultural, forestry, fishery, craft and related trades (5% on average), plant and machine operators, and assemblers (2% on average) occupations. This suggests that these scientists might be in positions not appropriate for their qualifications, where they are not yet fully utilising their skills. This occupational pattern is, however, also consistent with the South African labour market participation patterns, where one might compromise to find lower-skilled jobs, to avoid joining long queues in unemployment.

Table 9 shows the distribution by specific natural science field and occupational level. Science graduates in the field of mathematics and statistics are predominantly employed as professionals (69%) and managers (26%), with only 5% employed as clerical support workers. Life science graduates are predominantly employed as professionals (48%), managers (26%) and technicians and associate professionals (11%), with less than 6% in the remaining occupational categories. The agricultural field showed more of a spread where the various occupational categories were concerned, with managers (34%), professionals (26%) and skilled agricultural, forestry, fishery, craft and related trade workers (13%). Six percent of agriculture graduates are in elementary occupations.

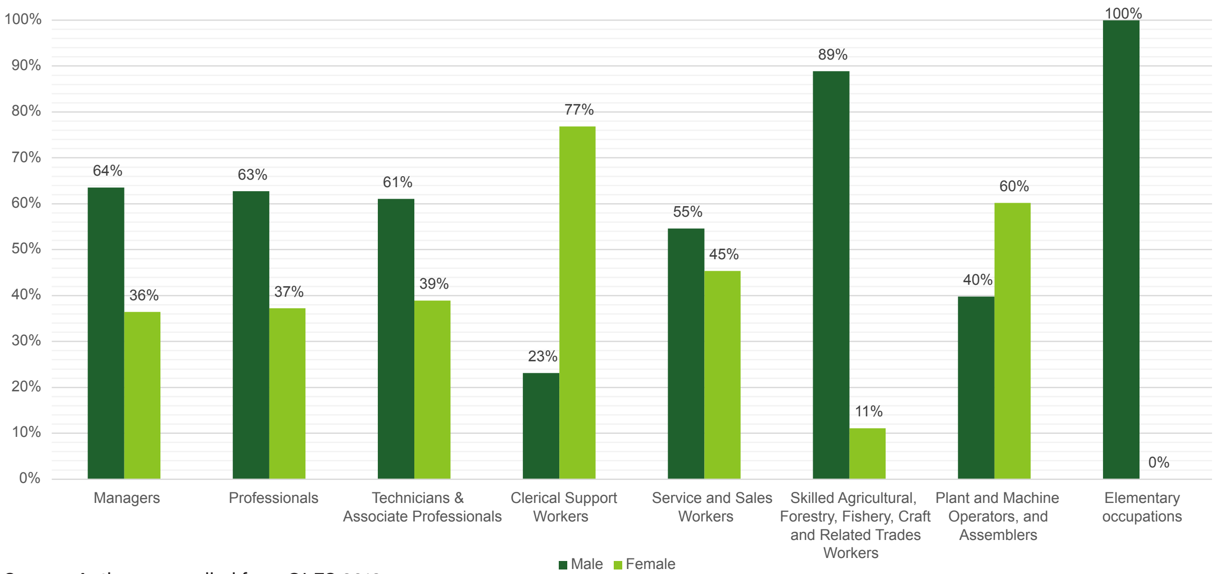
Table 9: Distribution of natural scientists by field of study and occupational level, 2018

Occupation	Agriculture, Agricultural Operations and Related Sciences	Life Sciences	Mathematics and Statistics
Managers	34%	26%	26%
Professionals	26%	48%	69%
Technicians & associate professionals	16%	11%	
Clerical support workers	2%	6%	5%
Service and sales workers	3%	5%	
Skilled agricultural, forestry, fishery, craft and related trades workers	13%	2%	
Plant and machine operators, and assemblers	1%	2%	
Elementary occupations	6%		

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

There is mounting evidence showing that women tend to be more overrepresented in occupations perceived as unskilled and of low value, particularly in care jobs. To explore this possible occupational segregation, we looked at the latest data (2018) on gender and occupational level. Figure 12 shows that male scientists are far more likely to occupy senior management positions compared to females. More females than males occupy clerical support positions (77%), and plant and machine operator positions (60%) although they also hold a natural science qualification.

Figure 12: Distribution of natural scientists by gender and occupational level, 2018



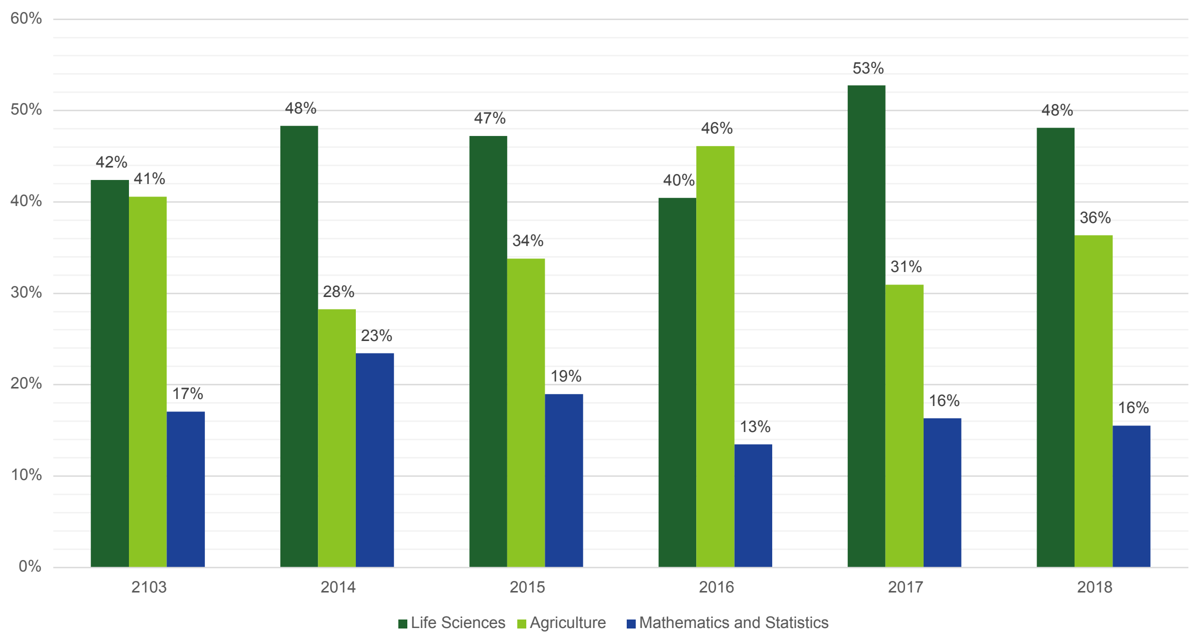
Source: Authors, compiled from QLFS 2018

Women scientists are overrepresented in administratively inclined jobs, such as clerical and service type jobs. Very few female scientists occupy jobs as agricultural or fishery workers.

4.4.4 Shares of employed natural scientists by science field of study, 2013–2018

Across all years there were more graduates in the field of life sciences than in both agriculture and mathematics and statistics, accept in 2016 where there were more graduates from the agriculture field (Figure 13). The percentage of graduates in the life sciences field has remained consistent over time, with 46% on average. Percentages in the agricultural field fluctuated over time, with decreases observed between 2013 and 2015 followed by an increase in 2016 and then a decrease in 2017. The percentage of graduates in the field of mathematics remained consistent over time and lower than both life sciences and agriculture, with an average of 17% over time.

Figure 13: Shares of employed natural scientists by science field, 2013–2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018
Note: Life Sciences=Life Sciences + Phys Sciences=Physical Sciences, Agriculture=Agriculture, Agricultural Operations and Related Sciences, Math Stats=Mathematics + Statistics

4.4.5 Characteristics of the natural sciences unemployed graduates

Several studies have found that spells of unemployment experienced during one's early career have profound effects on future labour market outcomes and earnings. It has been indicated that youth unemployment both reduces the probability of future employment, as well as lowers wages throughout later work careers (Viitanen, 2014). According to the dual labour market theory, early experiences of unemployment may lead to poor work habits and a weaker labour market attachment. Experience of unemployment may alter attitudes of the young as they become discouraged about chances of finding work and job search behaviour may be affected negatively. It is therefore important to be aware of determinants of unemployment, particularly for policy considerations. This section first focuses on the demographic characteristics of the unemployed natural scientists. This is followed by an investigation into their job search activities. There are arguments that unemployed graduates represent spare capacity in the labour market that could be engaged.

Over the 2013–2018 period, Table 10 shows that on average more males (51%) than females (49%) were unemployed, with percentages for males increasing over time and the opposite being true in the case of females. However, 2016 shows a significantly high percentages of unemployed females. A large majority of the unemployed natural scientists also came from the Black African population group across the years, with smaller proportions coming from other population groups.

Table 10 also shows the unemployment patterns by age. Approximately 70% of scientists in unemployment across the years were less than 39 years old. This is of policy concern, since early unemployment increases the likelihood of subsequent unemployment. The proportion of unemployed scientists between the ages of 20 and 29 years almost doubled between 2013 and 2018 (31% to 64%). The numbers have consistently increased within the 30 to 39 age group from 2013 (14%) to 2018 (33%). Older natural scientists (above 40 years) seem to experience better employment outcomes. A decrease in the proportion of those in unemployment in this group was observed between 2013 and 2018.

The provinces with the highest percentage of unemployed natural science graduates are Gauteng (35% on average) followed by the Western Cape (25% on average) and Limpopo with 11% on average. The Northern Cape has the lowest percentage of unemployed graduates (2% on average) followed by the Free State and the North West with 6% each. The unemployment percentages have fluctuated across the years.

Table 10: Profile of unemployed natural scientists by demographic characteristics (%)

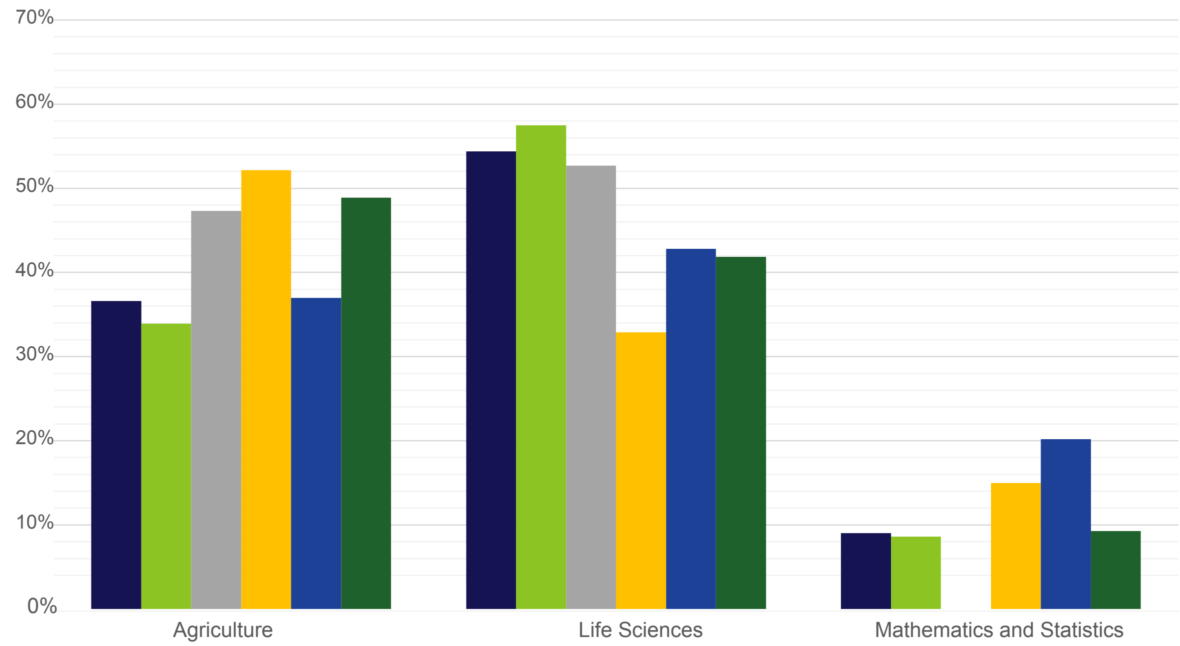
	2013	2014	2015	2016	2017	2018
By gender						
Male	51	51	55	43	53	57
Female	49	49	45	57	47	43
By race category						
African/Black	68	88	64	57	69	63
Coloured	3	5	3	0	7	2
Indian/Asian	24	0	0	13	13	12
White	6	6	32	30	11	22
By age category						
20-29	31	54	61	75	64	58
30-39	14	15	21	20	32	33
40-49	20	25	12	4	4	2
50-59	36	6	0	1	0	7
60+	0	0	6	0	0	0
By highest level of education						
Bachelor's degree	75	39	32	38	0	61
Bachelor's degree and postgrad diploma	0	27	35	30	62	13
Honours degree	25	27	28	6	13	14
Master's or PhD	0	6	5	26	25	12
By province						
Western Cape	21	33	52	14	11	17
Eastern Cape	9	1	0	18	0	15
Northern Cape	4	2	2	1	0	0
Free State	0	0	0	20	11	3
KwaZulu-Natal	7	18	14	0	0	4
North West	14	7	0	3	10	0
Gauteng	36	29	20	26	52	48
Mpumalanga	7	5	0	0	0	0
Limpopo	3	5	13	18	16	12

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.4.6 Shares of unemployed natural scientists by science field of study, 2013–2018

The number of unemployed scientists in the agricultural field fluctuates over time with on average 43% of the scientists being unemployed. The Life Sciences field decreased from 54% in 2013 to 42% mathematics and statistics field has considerably lower unemployment number than both agriculture and life science with an average of 12% over time, see Figure 14.

Figure 14: Percentage unemployed graduates by field of study (2013–2018)



	Agriculture	Life Sciences	Mathematics and Statistics
2013	37%	54%	9%
2014	34%	57%	9%
2015	47%	53%	0%
2016	52%	33%	15%
2017	37%	43%	20%
2018	49%	42%	9%

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018
Note: Agriculture=Agriculture, Agricultural Operations and Related Sciences, Life Sciences=Life Sciences + Phys Sciences=Physical Sciences, Math Stats=Mathematics + Statistics

4.4.7 Characteristics of the inactive natural science graduates

The numbers of inactive natural scientists fluctuated considerably between 2013 and 2018 for both males and females (Table 11). A large majority of inactive scientists are female (65% on average), which is a phenomenon that has been consistent over time. Most inactive science graduates are either White (56% on average) or African (27% on average), with Coloured and Indian/Asian being 5% and 12% respectively. The provinces with the highest percentages of inactive natural science graduates are Gauteng (45% on average) followed by Western Cape (27% on average), KwaZulu-Natal (8% on average) and Limpopo (6% on average). The percentage of inactive natural scientists fluctuated across the years.

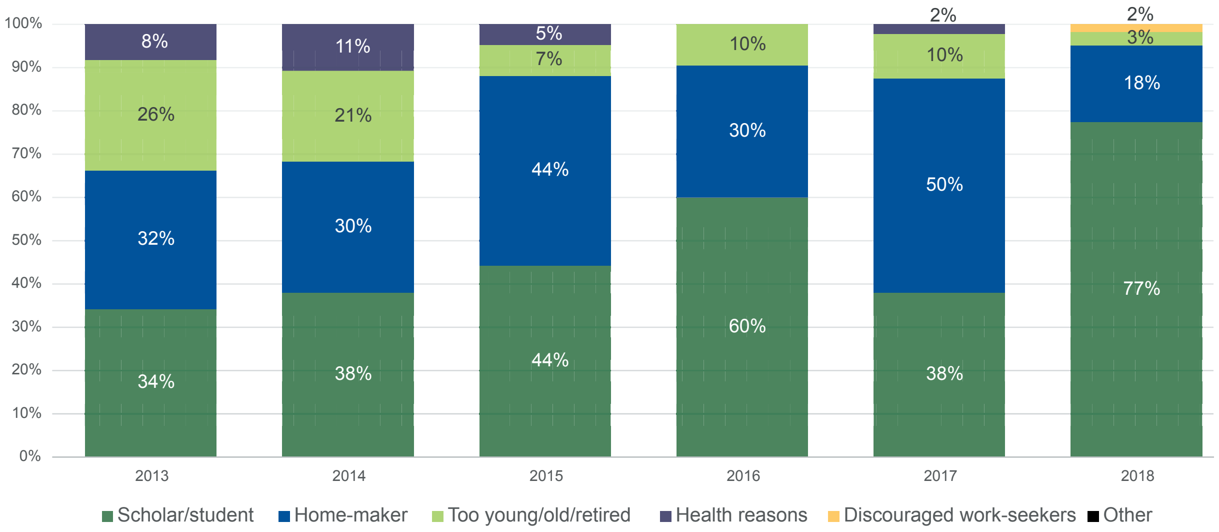
Table 11: Profile of inactive natural scientists by demographic characteristics

	2013	2014	2015	2016	2017	2018
By gender						
Male	38	30	39	46	14	46
Female	62	70	61	54	86	54
By race category						
African/Black	14	33	21	28	10	59
Coloured	5	5	5	5	7	0
Indian/Asian	0	4	18	20	11	17
White	81	58	55	47	72	25
By age category						
20-29	36	39	35	51	48	68
30-39	7	2	17	18	15	26
40-49	6	21	20	8	22	2
50-59	17	27	19	15	4	4
60+	34	10	10	8	12	1
By highest level of education						
Bachelor's degree	50	27	32	44	9	54
Bachelor's degree and postgrad diploma	16	16	19	12	36	18
Honours degree	27	41	30	26	24	16
Master's or PhD	7	17	19	18	31	12
By province						
Western Cape	18	25	48	33	24	13
Eastern Cape	3	0	0	5	2	1
Northern Cape	0	0	1	1	0	0
Free State	3	19	6	6	2	5
KwaZulu-Natal	7	3	12	6	14	4
North West	8	9	1	2	2	2
Gauteng	59	19	27	47	51	64
Mpumalanga	2	6	2	0	2	0
Limpopo	0	18	3	0	1	12

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

The most common reason for inactivity provided by graduates (Figure 15) was that they were a student (49% on average), a homemaker (34% on average) or that they were too young, old or retired (13% on average). This phenomenon was observed between 2013 and 2018. The percentage of inactive scholars increased from 34% in 2013 to 77% in 2018, with the percentage of homemakers decreasing. Research has shown that some young people may be more likely to opt to continue their education if the probability of finding work is low (Dhillon and Cassidy, 2018).

Figure 15: Reasons provided for inactivity (2013–2018)



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

4.5 Concluding comments

Consistent with expectations, and earlier statistics, gender plays a significant role in the employment outcomes. Young women face significantly less probability of being employed than men. This observation is even more the case for younger people, with youth facing more likelihood of unemployability than older people. While vulnerable employment is widespread for both men and women, women tend to be overrepresented in certain types of vulnerable jobs.

Underutilisation of youth can incur economic costs, as the national workforce is not used to its full potential. While young people are said to be more dynamic and often have higher educational levels than their parents, they are less likely to be employed and hence more likely to migrate, enhancing notions of skills shortage through a brain drain. Such underutilisation can also trigger a vicious cycle of intergenerational poverty and social exclusion.

5

Factors influencing labour market outcome: A multinomial logistics regression

Catherine Namome

Regression models were developed to identify some of the determinants of transitions into the labour market. In the current analysis the transitions were defined as employed, unemployed and not economically active, and these were treated as dependent variables. Binary logistic regression was applied in this instance. This form of regression is used when the outcome variable has two discrete responses, typically yes/no. The predictors or independent variables used in the analysis were age, education, science field, gender, race, location and province.

For ease of interpretation, predicted probabilities are used, which are the probabilities calculated from the available data of falling into any of the possible outcomes (Cameron and Trivedi, 2005). As such, predicted probabilities of the three outcome variables were obtained. (Table 9: Characteristics associated with employment status in the employed logistic regression model; see appendix). Only significant variables are presented. The results are presented under four themes in terms of how they influence an individual's employment status[6]: effects of background characteristics (demographic characteristics), science education fields, geographical location and provincial distribution.

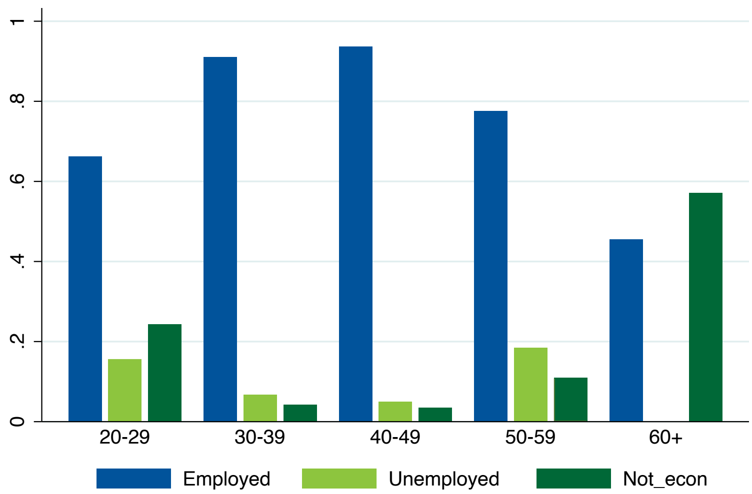
5.1 Demographic characteristics

Four variables were used to represent different aspects of the background characteristics related to the participants' employment status.

5.1.1 Age

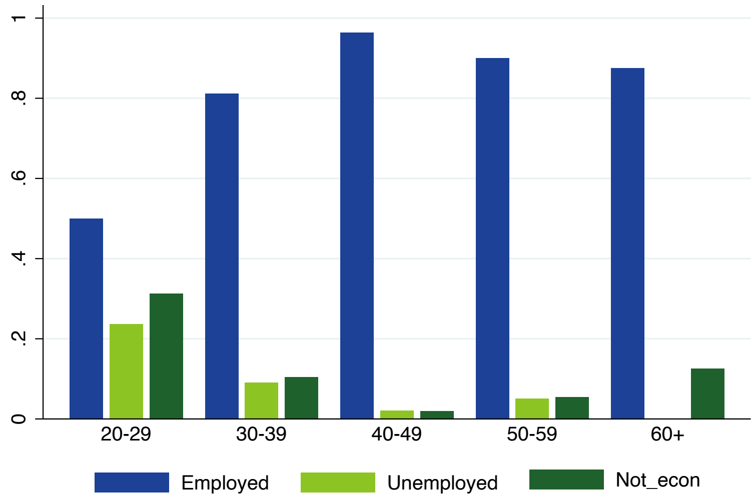
The following figures, below, displays the age-specific employment probabilities for the 2013 and 2018 data. The figure shows that the probability of being employed increased with age in both years, while the situation was the opposite for the unemployed graduates. In 2013 young scientists were more likely to be employed when compared to 2018; at the same time they were mostly inactive compared to older scientists in 2018.

Figure 16: In-sample predicted probabilities, by age for 2013



6 The analysis by university types will be done in the online survey of 14 000 natural scientists which is under way.

Figure 17: In-sample predicted probabilities, by age for 2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018

The margin results from the logistic regression confirm that the labour market absorbed older science graduates more than younger graduates. This pattern was witnessed from 2013 to 2018, showing that the younger age category had an increased predicted probability of unemployability of 0.08% in 2013 and 0.17% in 2018. This implies that older individuals have higher probabilities of being in employment, and such a finding might demonstrate employer preference for individuals with practical workplace skills and experience, which in most cases are older individuals. Figure 16 shows that scientists younger than 30 years and above 60 years seem more likely to be economically inactive compared to their middle-aged counterparts. On average, older people had a two percentage points higher chance of being economically inactive. Younger scientists (less than 30 years) also had a higher probability of being economically not active. This can be linked to them largely still being in some form of studies. Though the extent changed slightly in 2018, the broad trend patterns remained. Hence, the result implies that the probability for young science graduates being economically not active was higher. The result was different for those above 60, where the probability of being economically inactive decreased significantly in 2018. Van den Berg and Van Broekhuizen (2013) confirm that graduate unemployment reduces with age, with older graduates being more employable. They suggest that this is because some of the younger age cohort (20–29 years) might still be involved in further studies, compared to the older age cohorts who are more likely to have completed their studies.

5.1.2 Level of education

In the analysis the reference category for the education variable was: secondary not completed. Figure 18 and Figure 19 shows the predicted probabilities for education categories in the 2013 and 2018 data. In 2013, it is seen that graduates with Bachelor's degrees were more employable compared to those with Honours degrees. This trend changed considerably in 2018, where graduates with an Honours qualification were more likely to be employed compared to those with Bachelor qualifications. The predicted probabilities of employment for Master's and PhD graduates changed between 2013 and 2018. In 2018 the probability of being employed increased for Master's and PhD graduate compared to the other two categories.

The predicated probabilities for unemployed and not economically active graduates changed slightly over the years. In the 2013 sample those with a Bachelor's and Honours education level were more likely to be economically inactive. However, over time this changed, showing a reduced predicted probability for economically inactive graduates. In particular, in 2018 graduates with an Honours degree were less likely to be economically inactive compared to graduates with a Bachelor's degree. With an Honours degree the required level for registration as a professional scientist, graduates and universities have tried to provide graduates with opportunities to register as professionals, which boosts their employment outcomes. As shown in section seven below, some universities have launched initiatives to support graduates to enter into relevant science fields and Honours programmes, which has enhanced the employment outcomes of graduates.

Figure 18: In-sample predicted probabilities by education for 2013

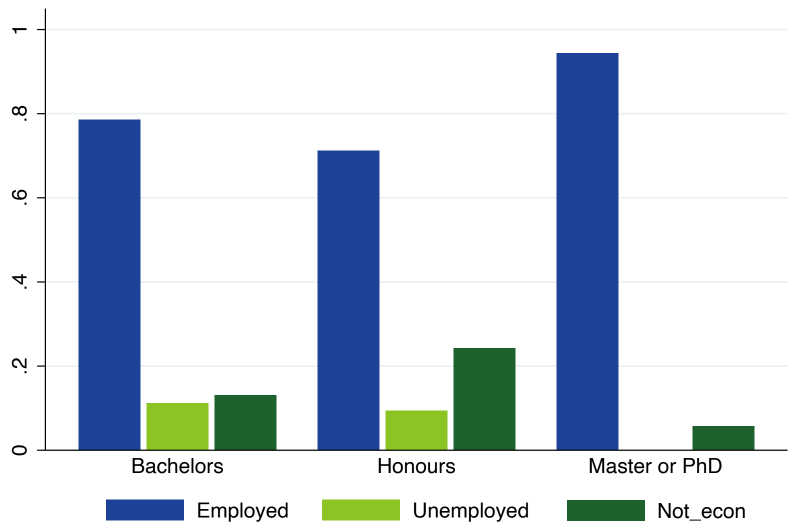
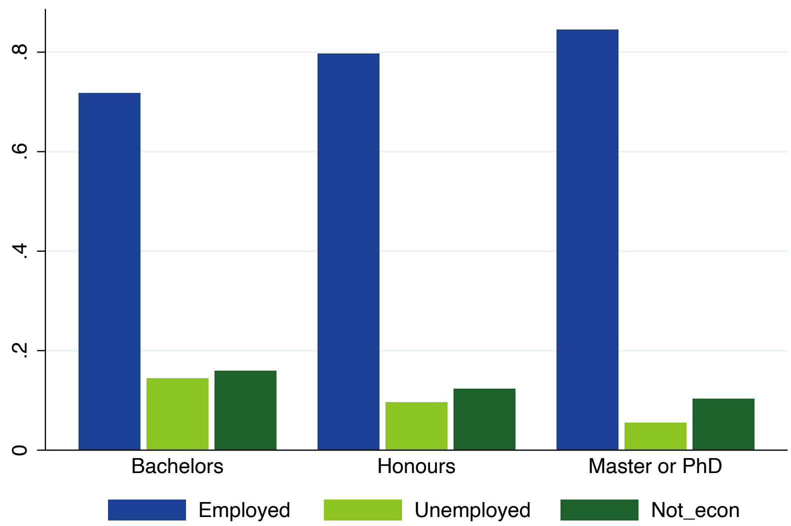


Figure 19: In-sample predicted probabilities by education for 2018



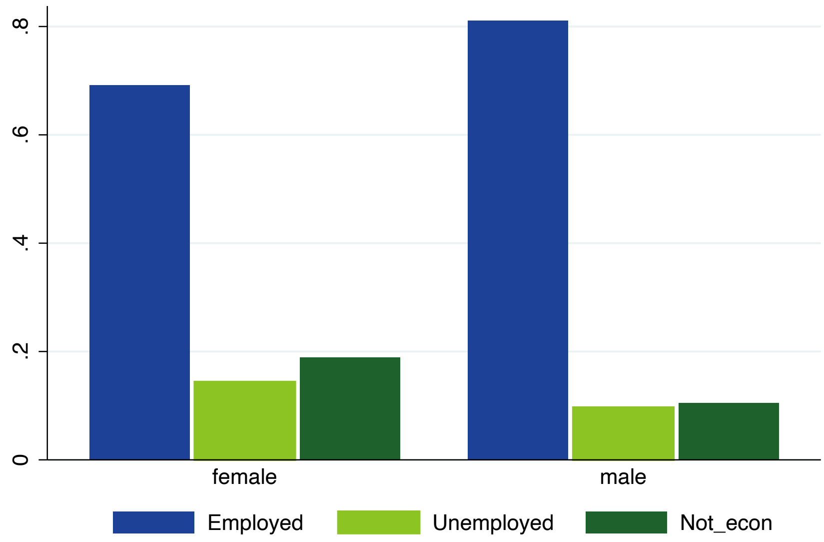
Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018. Not_econ = not economically active.

Due to the current national unemployment rate of 30.1% (Stats SA, 2020), individuals with lower qualifications and possibly lower expertise have a higher probability of being unemployed. Hence, we see the unemployed line graph moving slightly above the employment graph. More detailed analysis of the role of higher levels of education (master's, doctoral and other certifications) will be provided from the online survey of 14 000 natural scientists.

5.1.3 Gender

Figure 20 illustrates the influence of the gender variable on employment, unemployment and not economically active statuses amongst science graduates. The graphs showing the predicted probabilities for the 2013 and 2018 datasets were quite similar, and hence only the graph for the latest data has been depicted. Results indicate that male scientist graduates are more likely to be employed than females. However, the difference in predicted probabilities for employment status is only slightly higher for males than for females, as shown on the figure. Females are also more likely to be economically inactive compared to their male counterparts.

Figure 20: In-sample predicted probabilities by gender for 2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018. Not_econ = not economically active.

The probability of being employed rather than being unemployed is 0.78% lower for female graduates than their male counterparts. The intensity of unemployment amongst female individuals is further shown in the not economically active model. The trend for gender shows that there has been a higher probability for female graduates to be economically not active when compared to male graduates. Female graduates could be preoccupied with other forms of activities other than career-based employment, while cultural and societal obligations and responsibilities hold that females seem to get more involved in care-giving and child-rearing activities compared to males.

5.1.4 Race

In 2013 Indian and White graduates were more likely to be employed compared to other race groups, with Coloured graduates having the highest probability of being economically inactive. Overall, all race groups were more likely to be employed, each with a predicted probability above 0.7. The results also indicate that Indian and African graduates were more likely to experience unemployment compared to their Coloured and White counterparts.

Figure 21: In-sample predicted probabilities by race for 2013

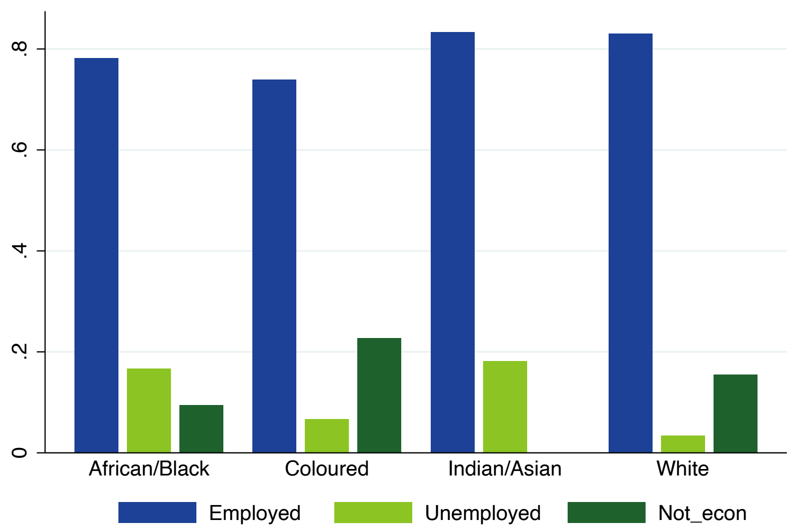
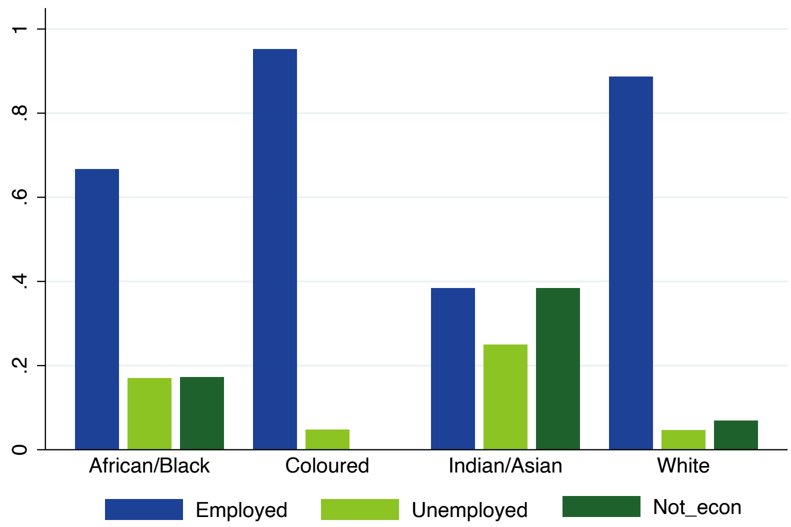


Figure 22: In-sample predicted probabilities by race for 2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018. Not_econ = not economically active.

This trend changed considerably in 2018. The results suggest that Coloured graduates were more likely to be employed, followed by White and then African graduates. Indian graduates were less likely to be employed. African graduates had similar predicted probabilities for unemployment and being economically inactive. Coloured and White graduates were less likely to be unemployed and economically inactive. Previous research has attributed this observation to other social factors, such as social capital and networks which White graduates have better access to compared to the other population groups (CHEC, 2013).

5.2 Science education fields

With respect to the different science fields, controlling for all other variables including race, geography and educational level, we notice that in 2013 science graduates who had majors in Agriculture had higher predicted probabilities of above 0.8 percentage points for employment when compared to other categories of science fields. Life sciences and mathematics graduates at 0.77 percentage points showed a lower predicted probability of being employed. Graduates in life sciences and mathematics were also likely to be not economically active in 2013.

Figure 23: In-sample predicted probabilities by science fields for 2013

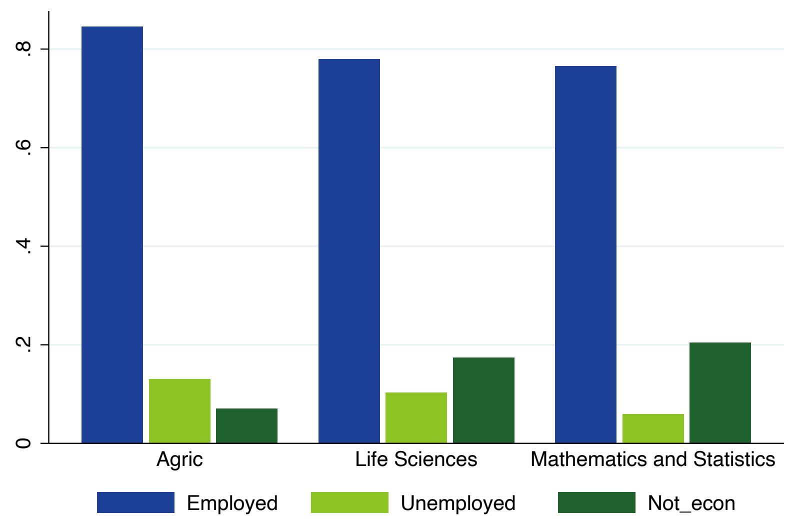
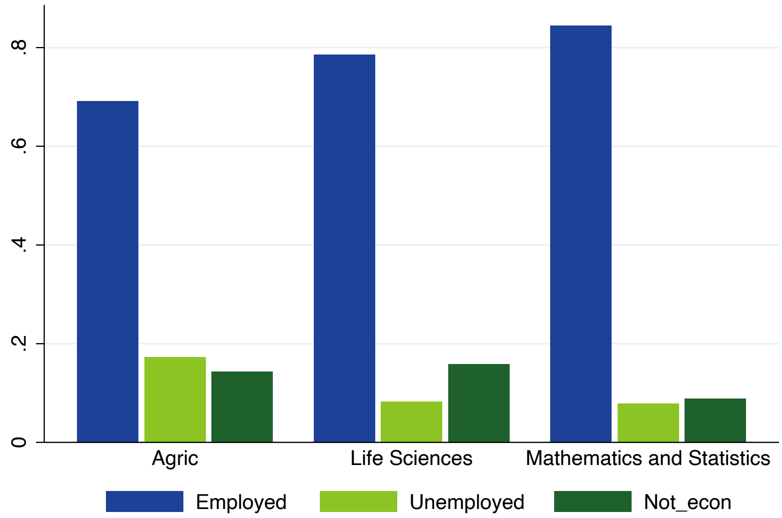


Figure 24: In-sample predicted probabilities by science fields for 2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2013. Not_econ = not economically active.

In 2018 this trend changed, with the analysis showing that graduates in mathematics and life sciences had at least 0.75 percentage points higher probability for being employed. Graduates in agricultural sciences were less likely to be employed, with a predicted probability of 0.65. This was further shown in the predicted probabilities of unemployment, where graduates in agricultural sciences were more likely to be unemployed and not economically active. This result corresponds to the agricultural outlook in 2018. The effects of the severe drought of 2016/17 are beginning to have an impact on the employment capacity of the agriculture sector, with a drop in employment in the sector from 5.61% of total employment in 2015 to 4.99% in 2020 (Stats SA, 2020). Furthermore, local policy uncertainties such as land redistribution policies are possible contributors to the decline in economic activity of the agricultural sector. Since the South African agricultural sector is export driven, foreign trade policies and global challenges such as the COVID-19 pandemic also impact on employment opportunities in the sector.

The rapid rise in new applied fields such as nanotechnology, which employs life science graduates, can be attributed to the perceived enhanced employment outlook of life science graduates compared to graduates with agriculture-related degrees.

With the growth in computer-related applications and in the information and communication technology (ICT) sector, including data science and data management, graduates from Mathematics- and Statistics-related fields seem to have better employment outlooks. According to the United States Bureau of Labour Statistics (2020), overall employment of mathematicians and statisticians is projected to grow 33% from 2019 to 2029, much faster than the average for all occupations. Businesses will need these workers to analyse the increasing volume of digital and electronic data (US Department of Labor, 2020). This is also perceived to be the trend in South Africa. Furthermore, as shown by Shay (2020) the declining performance of young people in mathematics and statistics throughout the schooling and post-schooling system further enhances the outlook of the few who perform. Shay shows that unless a student achieved a distinction for mathematics at school level, they are at risk of failing it at university level. The Trends in International Mathematics and Science Studies (TIMSS) show that South Africa continues to be amongst the low-performing countries in school mathematics, albeit its significant progress in the last surveys (Reddy et al., 2016)

5.3 Geographical location effect

From 2013 to 2015 the location variable was categorised as urban formal, urban informal, tribal areas and rural formal, but this changed in 2017–2018, when the variable was categorised as urban, traditional and farms. In Figure 21 we merge the urban formal and urban informal to create urban, traditional and farms as non-urban areas. The location variable in 2013 showed that graduates who were located in non-urban areas were slightly more likely to be employed, although they were also likely to be unemployed when compared to graduates who lived in urban settings.

Figure 25: Effect of geographical location on employment status for 2013

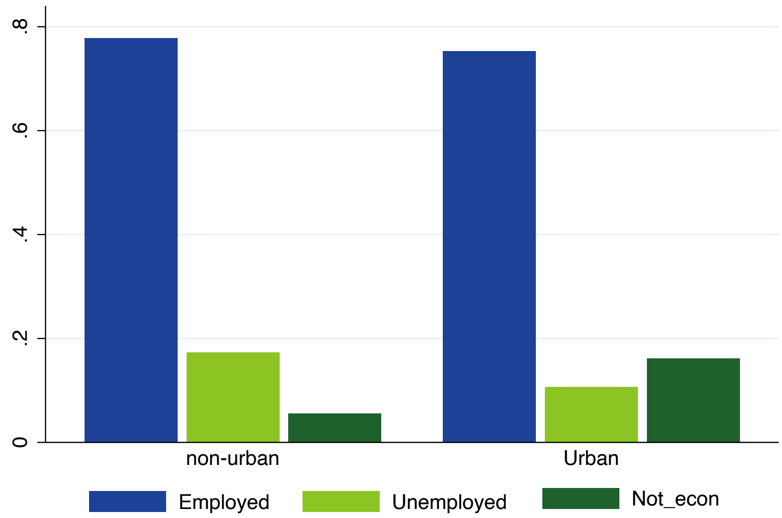
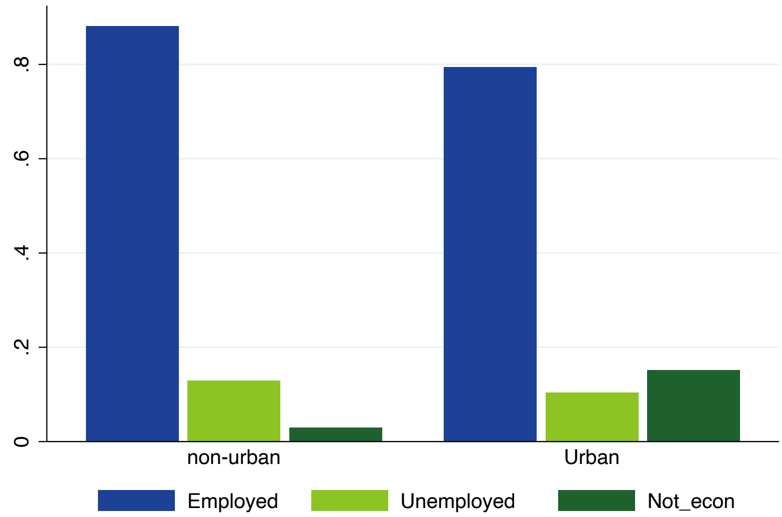


Figure 26: Effect of geographical location on employment status for 2018



Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018. Not-econ = not economically active.

In 2018 the trend between the location variable and employment, unemployment and economically inactive status changed slightly. Graduates in non-urban areas were less likely to be economically inactive when compared to graduates in urban settings. Unemployment for both sets of graduates was similar. However, graduates in urban settings were more likely to be not economically active. This result could indicate the high migration rates of graduates from non-urban areas to urban areas in search of better economic opportunities, which may not necessarily result in actual employment.

5.4 Provincial or geographical effect

The province variable in the employment model suggests that graduates in North West Province were less likely to be employed when compared with graduates in other provinces. Graduates from the Free State Province were more likely to be employed. Graduates from Limpopo, Northern Cape, Western Cape and KwaZulu-Natal Provinces were also more likely to be employed in 2013, as shown below in Figure 22.

Figure 27: Employment status by province for 2013

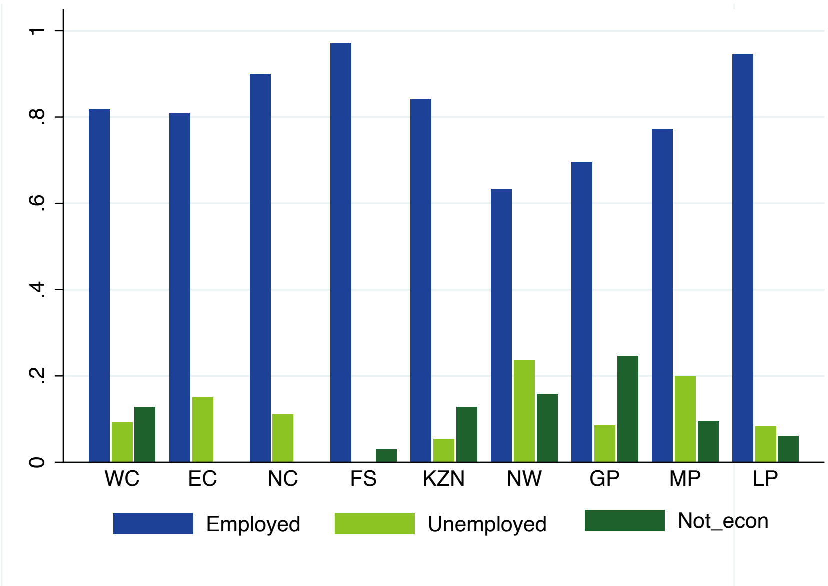


Figure 28: Employment status by province for 2018

Source: Authors, compiled from LMDS, 2013-2018; QLFS 2018. Not_econ = not economically active.

Given that in 2014 mining and quarrying was the biggest economic sector, contributing 26.5% to the Provincial gross domestic product, it is likely that most informal and formal sectors did not absorb a significant number of science graduates in North West Province. A similar result is picked up in Mpumalanga for the same year.

However, this trend changed for most provinces in 2018, and we notice that individuals from the Western Cape had a higher probability of being employed compared to individuals from less economically endowed provinces such as Limpopo. Despite the strong economy in the Western Cape, the predicted probability of employment in the province is relatively weak, with observably higher levels of economically inactive graduates and those still unemployed. This could be due to the negative outlook of the agricultural sector since agricultural production contributes greatly to the labour market of the Western Cape. Other factors could be higher immigration into the economically stronger provinces (Western Cape and Gauteng) by residents from other provinces.

5.5 Conclusion

This section has described and accounted for intracohort growth in the different employment statuses for science graduates by focusing on the linkages of employment to their demographic characteristics, study fields and geographical location. The findings within the demographic factors suggest that a substantial part of measured unemployment results from the absence of the youth – whose employment prospects are not good – from the labour market. Qualified and more experienced graduates are more easily absorbed into the labour market. The results highlight a clear gap that has existed and that continues to exist – new graduates are not readily absorbed by the labour market. Educational qualification remains a strong determinant of labour market absorption, with post-graduates being more readily employed. Graduates who are employed are more than likely to be Coloured or White older males with postgraduate qualifications in a field other than agriculture. Graduates who are not economically active will most likely be graduates who are young African females with a secondary or lower qualification and are more likely to be from the North West Province.

6

The 2020 Survey of Natural Science Graduates

Bongiwe Mncwango and Stewart Ngandu

Sections 4 and 5 of this report provide the analysis of labour market destinations of natural scientists, and further demonstrate estimates of determinants of employment, unemployment, and inactivity. Data for the analysis were at national level, having been extracted from QLFS 2013–2018. However, such sources which represent national labour market information do not allow for asking specific subjective questions pertaining to the experience of work and expectations. For SACNASP to make a meaningful contribution towards enhancing the employment outcomes of its members, a thorough understanding of the profile and determinants of the various labour market destinations, i.e. employment, unemployment, underemployment, or inactivity at the field of study level, subjective experience of work and scientists' perceptions towards their work, is needed in to come up with appropriate policy responses. This requires an analysis which will draw from an adequate sample of natural scientists. Therefore, building from the shortcomings of the national level labour market data, for the first time in the country a survey of natural scientists was launched to provide evidence on the state of the natural sciences graduate labour market.

Understanding patterns of education to work transitions and pathways pursued is integral to the task of understanding labour market destinations of science graduates. As will be presented in this chapter, the survey aimed at collecting a wide range of information of personal, employment and skills development related issues. This includes information related to type of institutions of higher education attended, i.e. universities and colleges, and exploring postgraduation employment patterns, including further study. The survey thus allowed for capturing the voices of different cohorts of natural scientists, to share their employment experiences and analyse some of the factors influencing their career pathways. Four possible destinations were explored: employment, unemployment, studying or self-employment. Therefore, on the one hand the study will investigate the process of transitioning into the world of work where graduates land in the various labour market destinations, and on the other it will study the experiences of scientists in these destinations.

Apart from the providing the labour force breakdown, the survey also thus captured information on how graduates are doing in the labour market, including the types and location of employment, employment conditions (sector of employment; employment conditions: contractual arrangements, salary ranges, number of days worked; employment quality: alignment between education qualifications and current employment; job satisfaction) for those natural scientists who are employed. Furthermore, the survey also allowed for probing the experiences of those natural scientists who are without work, in terms of perceived barriers to finding work, how long they have been without work, job search methods used, socioeconomic support, and type of work preferred.

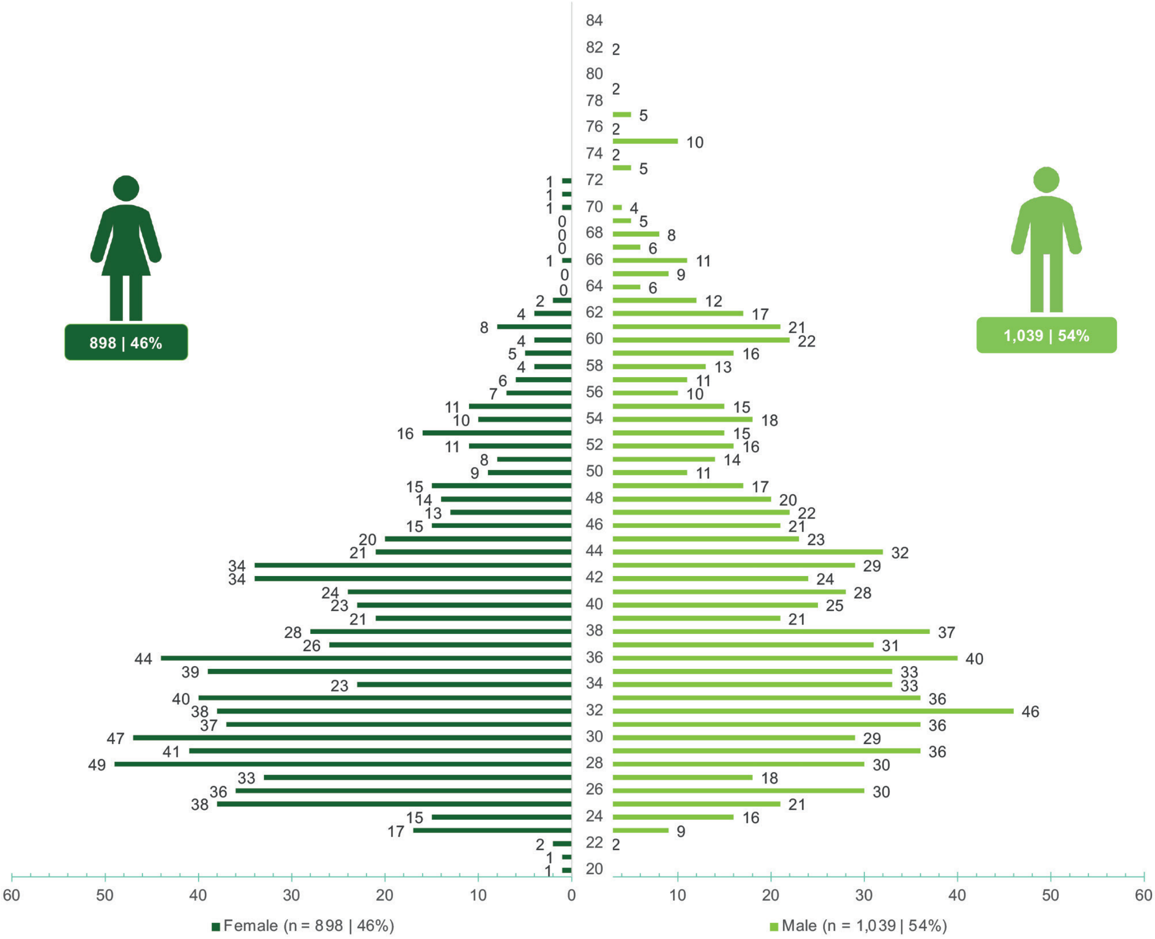
6.1 Profiling the natural science graduates of South Africa

It is important to get a sense of the demographic structure of natural science graduates of South Africa before analysis of their labour market destinations. This section provides information on their socioeconomic characteristics, including population group, gender, disability status, parental education, mobility, and educational attainment.

6.1.1 Demographic structure of natural science graduates

The demographic structure of the general population is the outcome of genetic variations that are driven by a number of biological factors, such as genetic drift, and changes and shifts in demographic structure over time. The population structure of a profession is shaped by a combination of factors that influence the propensity of individuals to pursue a career in, for example, the natural sciences. The population structure of natural scientists allows us to explore systematic differences across subgroups. The access and participation of previously disadvantaged groups will influence the racial profile of the profession, whilst the overall shape of the demographic pyramid reveals key characteristics of its demographic state. Figure 29 shows the demographic pyramid for natural scientists, which reveals marked differences between males and females. It has an asymmetric shape which shows women concentrated at the base, relative to men who are spread across the pyramid, albeit tapering at the top.

Figure 29: SACNASP demographic pyramid (n = 1,937)



Source: HSRC-SACNASP Track and Trace Survey, 2021

Figure 29 also shows that there are more male natural scientists, 54%, relative to females, 46%. However, there are disproportionately more women (14% more) in the 20–34 age group. Whilst this data only shows us a single point in time, the large drop of 29% in the number of female natural scientists between the 35–49 and 50–65 age cohorts might suggest that women exit the profession in later stages of their professional life. This trend can be attributed to other commitments such as care-giving or linked to the challenging male-dominated nature of most natural science occupations. This is more apparent in Table 12 below, which shows that male natural scientists are on average much older that their female counterparts, with mean ages (43 vs. 37) and a median (40 vs. 35) that are much higher, albeit with a larger variance.

The interquartile range is the difference between the 1st and 3rd quartile and the results show that 50% of males are between the ages of 32 and 52 (that is, within a 20-year band). The band for females is much tighter (14 years), with 50% of them falling within the 29 to 43 years age range. Half of all males are below the age of 40, with the same percentage of females falling below the age of 35.

Table 12: Key summary demographic statistics

Statistics & indicator	Male (n = 1,039)	Female (n = 898)	Total (n = 1,937)
Mean age	42.9	37.0	40.1
Median age	40.0	35.0	37.0
Minimum	22	20	
Maximum	85	72	
Range	63	52	
Standard deviation	13.3	9.7	
1st quartile	32	29	
3rd quartile	52	43	
Interquartile range	20	14	
Gender ratio			1.16:1
Aging index (%)	7.4	0.4	4.2
20–34	33%	47%	39%
35–49	39%	41%	74%
50–64	21%	12%	36%
65+	7%	0%	0%

Source: HSRC-SACNASP Track and Trace Survey, 2021

The gender ratio shows that there are 116 males to 100 females in the sample (that is, a ratio of 1.16:1). The human gender ratio is generally close to 1:1; as such the gender imbalance amongst natural scientists can potentially be explained by several factors, such as the known bias towards males in STEM-related occupations.

As mentioned above, the population pyramid suggests that they are factors that might be influencing the participation, in terms of exit, of female natural scientists in the labour market. These could be linked to the fact that women tend to play a 'matriarchal' role in the household, acting as the centre of all household life. Elements of this can be observed in the broader literature which concurs that there are significantly more male South African natural scientists who are currently working outside the country. This suggests that males tend to be more mobile than their female counterparts, who remain tethered to the home and are expected to fulfil other responsibilities on top of pursuing a lifelong career. The potential role of 'maternal' responsibilities is contextualised according to Sanday's (2003) anthropological framing, where matriarchy "emphasises maternal meanings where maternal symbols are linked to social practices influencing the lives of both gender, and where women play a central role in these practices" (Peoples and Bailey, 2012, p. 258).

Whilst these cross-sectional data do not allow us to say anything about changes in the demographic population, some observations can be made with the understanding that these might bring to the surface potential issues that are worth noting. As such, this survey can be seen as a baseline that will allow for a better understanding of some demographic changes in the next round of the survey.

The following insights are based on a few observations. The first has already been discussed and speaks to what appears to be a premature taper for female natural scientists in their demographic structure. The second is the presence of older males on the SACNASP database. Of the 81 (77 males and 4 females) scientists above the age of 64 years, 72 responded to the question on what their professional registration status was at the time of the survey. Sixty-five of the 72 indicated that they were still registered. The presence of older males above the age of 64 indicates that this demographic subgroup has a high aging index (7.4 relative to 0.4). Whilst the implications of a certain age ratio have a given meaning in the general population, at a profession level it might be worth our while to explore what these findings mean for the profession of natural scientists.

Whilst the demographic literature is often concerned with the challenges that arise from an aging population, these findings show that these concerns are not present in this population – which is a sign of a profession in its early stages of development. Nonetheless, there is a view that as life expectancies increase, there is a need for people to remain actively engaged in the labour market, to allow them to continue to contribute to their health, independence and possibly to the profession itself. Professions that can offer people opportunities for productive effort as they get older could be seen as progressive occupations that can cater for the wellbeing of people throughout their entire life (Zaidi, 2015).

While this might represent a peripheral point, it does have an important corollary that is related to the loss of experienced scientists from a profession where it takes a lengthy period to produce seasoned scientists with the requisite experience to make impactful contributions. The idea of retaining experienced scientific capacity with the goal of mentoring younger and mid-career science researchers is not new. Realising that there was an aging generation of seasoned research scientists, the then Department of Science and Technology (DST) (now the Department of Science and Innovation or DSI) and the National Research Foundation (NRF) created the South African Research Chairs Initiative (SARChI) in 2006. The SARChI intervention was:

> designed to attract and retain excellence in research and innovation at South African public universities, through the establishment of Research Chairs at public universities in South Africa with a long-term investment trajectory of up to fifteen years. (NRF, 2020, p. 6)

Some of its key objectives were to

> Attract and retain excellent researchers and scientists and create research career pathways for young and mid-career researchers, with a strong research, innovation and human capital development output trajectory. (NRF, 2020, p. 6)

The SARChI research chair programme is predicated on the understanding that the quantum of experience gained by a scientist should not be lost through attrition but should be retained for the purpose of mentoring and grooming the next generation of scientists. This is more so in the natural sciences, where it is inconceivable that a seasoned natural scientist could ever displace a young emerging scientist. The experience and knowledge gap is too large to make this an opportunity- constraining factor for young scientists, who in the final analysis stand to benefit from the mentorship and supervision by seasoned scientists.

If the idea that knowledge and experience acquisition in the natural sciences involves a lengthy, steady, and incremental endeavour, then the premature exit of female natural scientists before the national age of retirement is cause for concern. Whilst the foregoing has speculated on what those reasons for exit might be, it is incumbent on SACNASP to take a deep dive into understanding the reasons that drive this trend, above and beyond those attributable to natural/health-related causes. If it turns out that the drop-off represents female natural scientists prematurely exiting the labour market, and in as far as this figure is representative of the larger population, this means that there is a potential drop-off from the labour market of approximately 4060 female natural scientists per year. This number is too large a loss in the cumulative experience of the profession and more so for women who are needed to serve as mentors and role models for the next generation of female natural scientists.

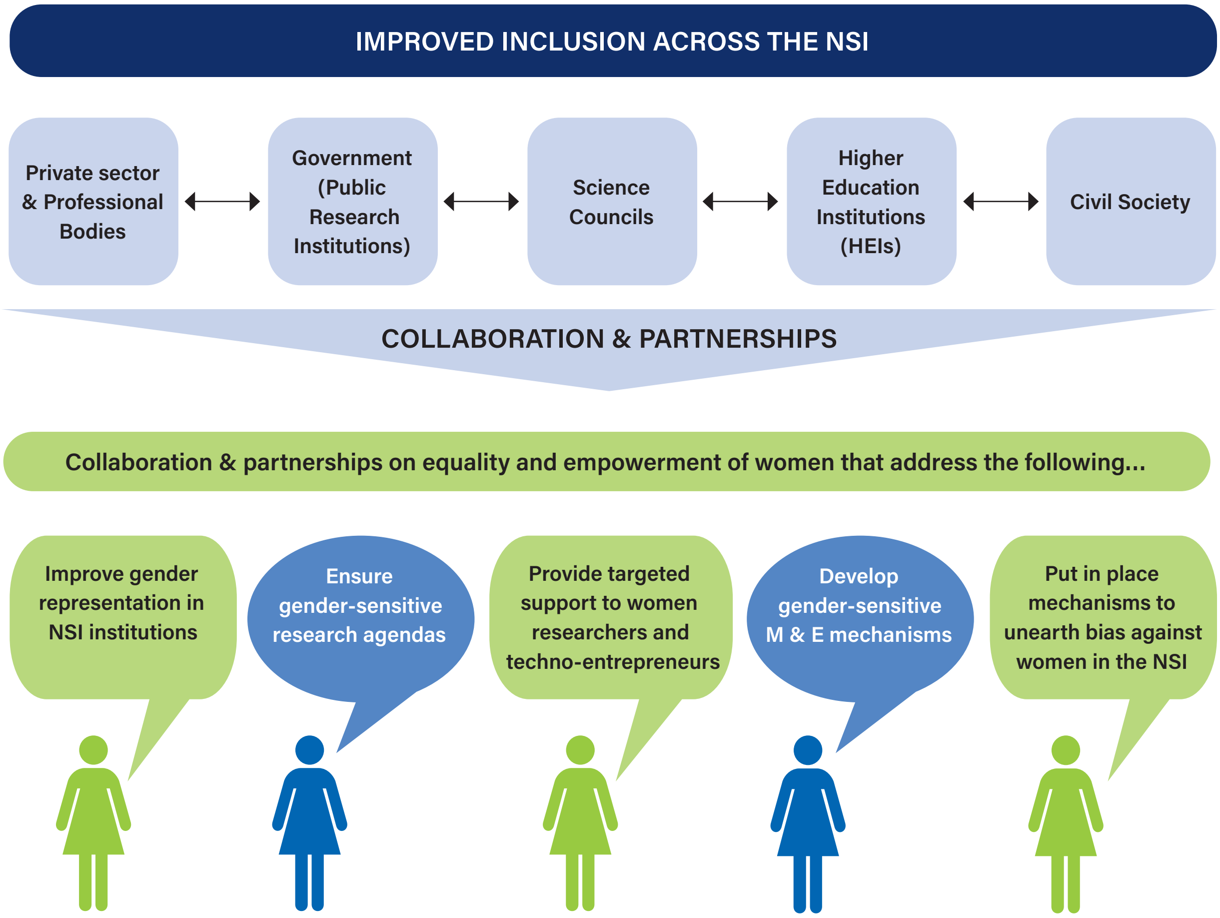
In view of the implications of the latter, SACNASP can play a role by contributing to the policy intents of the STI White Paper (DST, 2019), which focuses on the need to *Transform the Profile of the Researcher Base*. The intent around transformational policy targets that speak to *"the development of … women researchers at emerging researcher level (with a specific focus on African women)" (p. 48)* means that the potential attrition in these findings implies that women could be exiting the labour market just after transitioning from emerging scientist.

Figure 30 shows the inclusivity imperatives in the STI White Paper, and it is not difficult to envisage professional bodies such as SACNASP also contributing to improved inclusion across the National System of Innovation. This contribution need not lead to activities that go beyond the mandate of the professional body, as it could be ongoing research efforts, such as this track and trace study, that illuminate the previous patterns regarding gender imbalances in the profession. It is difficult to fix what is not known.

6.1.2 Population group

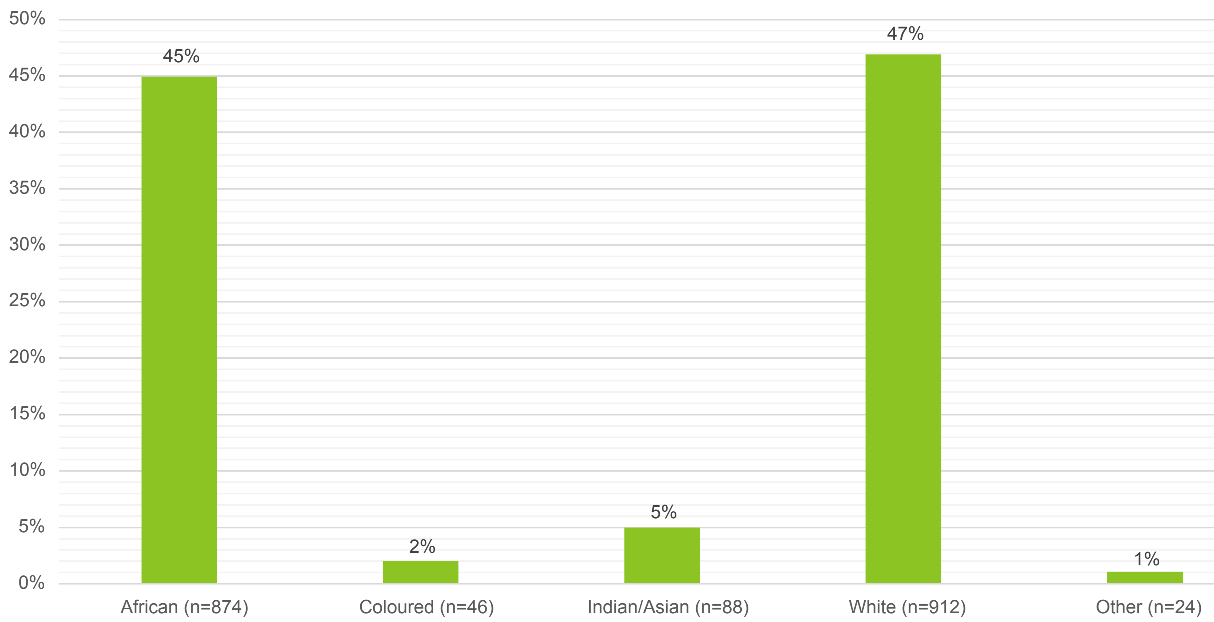
There were slightly more White natural scientists in the survey sample, at 47%. This was followed by African natural scientists, 45%, and very low proportions of Indian (5%) and Coloured (2%) natural scientists. A negligible proportion of scientists (1%) did not specify their race group. Natural scientists in South Africa have historically been disproportionally White, but the proportion of African natural scientists has steadily increased over the past decade.

FIGURE 30: The STI White Paper Gender Inclusivity Policy Intent



Source: Authors from STI White Paper (DST, 2019)

Figure 31: Population group of natural scientists, 2020 (n = 1,944)



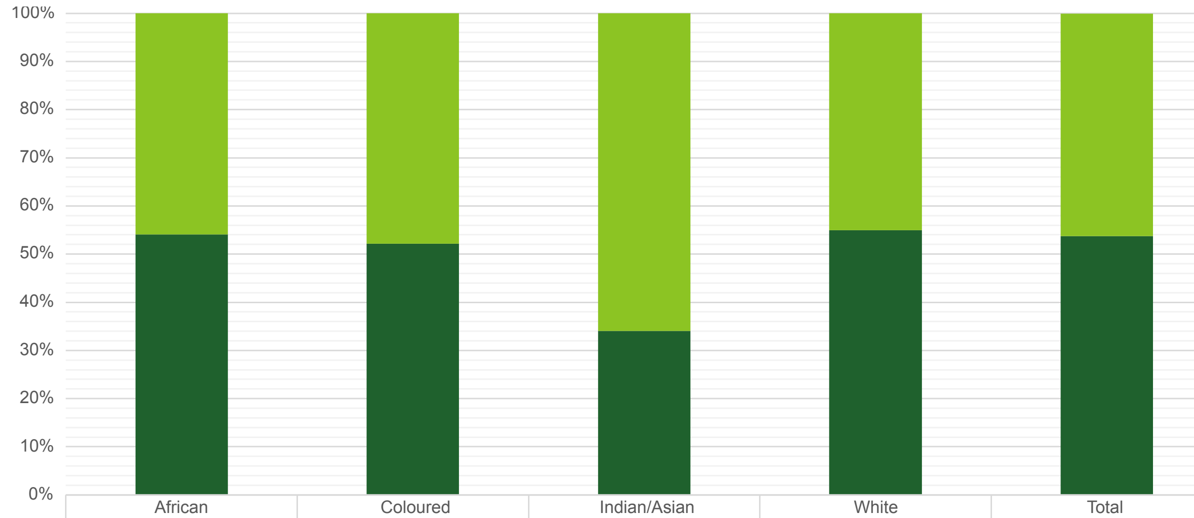
Source: HSRC-SACNASP Track and Trace Survey 2021

As observed from Figure 31, the LMDS and QLFS show a steadying from between 42% Africans and 47% Whites in 2013 to 47% Africans and 42% Whites in 2018, which is consistent with the online survey presented in. Similarly, the national level analysis also showed at that about 6% of scientists were Indian, and 5% were Coloured. From a national population dynamic with Indians (Asians) making only 2.6% of the national population, it suggests Indians are well represented within natural science professions. However, Africans who make up about 80% of the population continue to be very poor represented while Whites who contribute just 8% to the national population are very highly represented contributing about half of natural science professionals. Coloureds are also not equitably represented considering that they contribute close to 9% of the national population.

6.1.3 Gender

As presented already in the population pyramid Figure 32, a general trend of the entire sample is that males dominate within the natural science professions. The only exception is within the Indian population group, where women constitute the majority.

Figure 32: Distribution of natural scientists by population group and gender, 2020 (n = 1,951)



	African	Coloured	Indian/Asian	White	Total
Female	46%	48%	66%	45%	46%
Male	54%	52%	34%	55%	54%

Source: HSRC-SACNASP Track and Trace Survey 2021

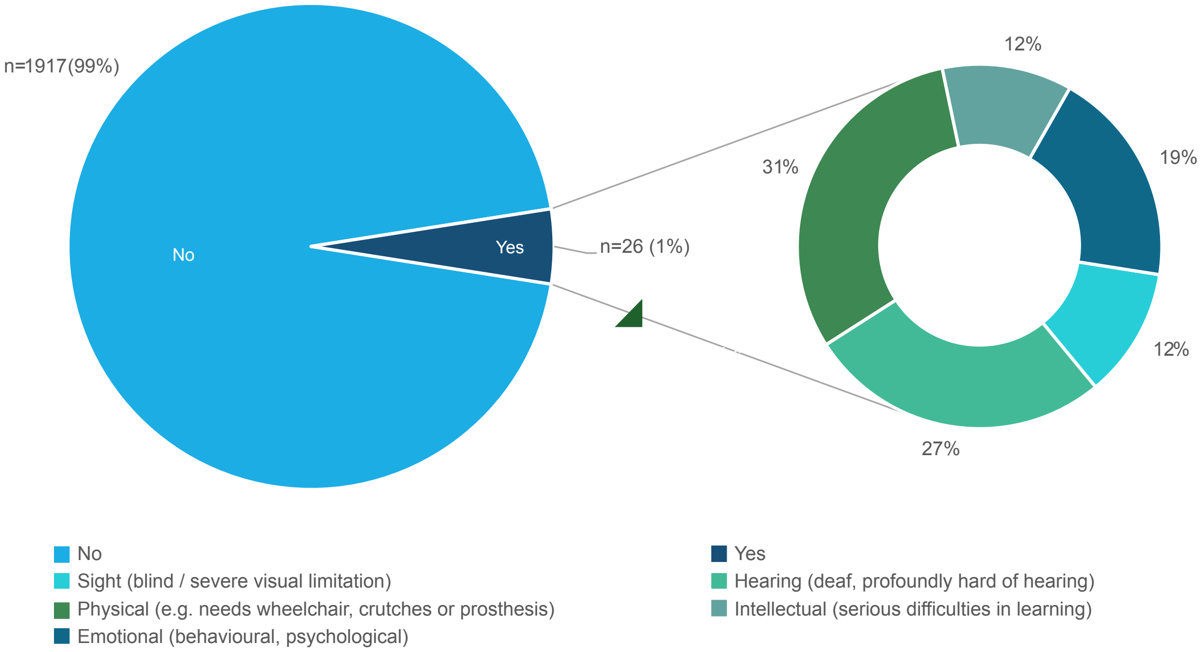
6.1.4 Disability status

Figure 33 shows the number and percentages of scientists by disability status; only 1% (N= 26) of the natural scientists indicated that they have some disability. This included scientists with physical, emotional, hearing, and intellectual disabilities. Further analysis of the data shows that of the 17 scientists that specified their disability, 10 worked full time, 4 were self-employed and the rest either worked part time or were unemployed.

6.1.5 Parental education

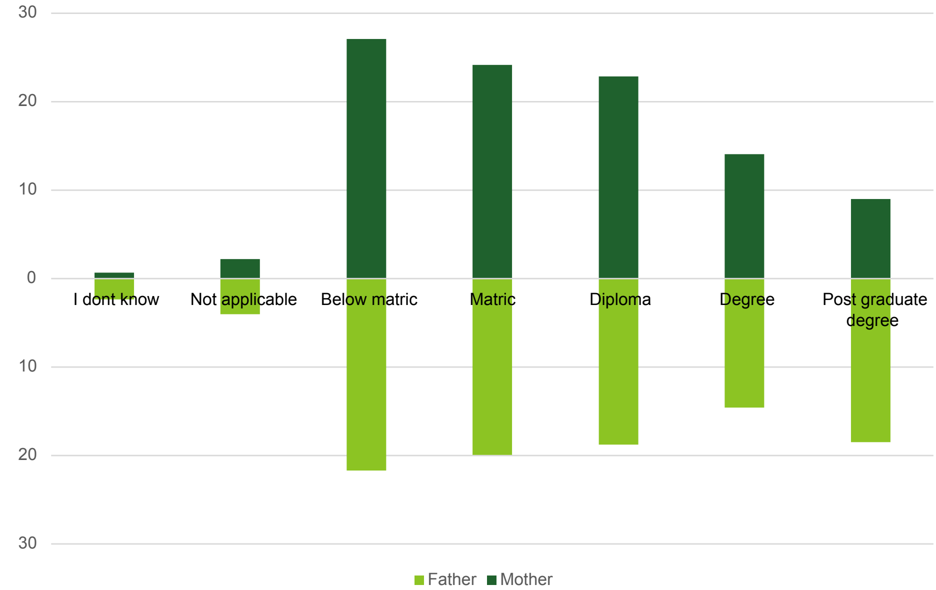
Existing research has found that parents' education levels significantly affect children's academic achievement, even more so than schools and communities. Taken as a proxy of the family socio-economic status, the expectation is that parents with higher educational status tend to have higher educational expectations of their children's educational performance and invest more in educational- related activities (Li and Qiu, 2018)it is necessary to examine how family background affects children's academic achievement at an early stage. Through analysis of data from the Chinese Family Panel Study in 2010(CFPS2010. Furthermore, social class has also been found to significantly affect individual career aspirations, trajectories, and achievement.

Figure 33: Distribution of natural scientists by disability status (n = 1,943)



Source: HSRC-SACNASP Track and Trace Survey 2021

Figure 34: Parental education



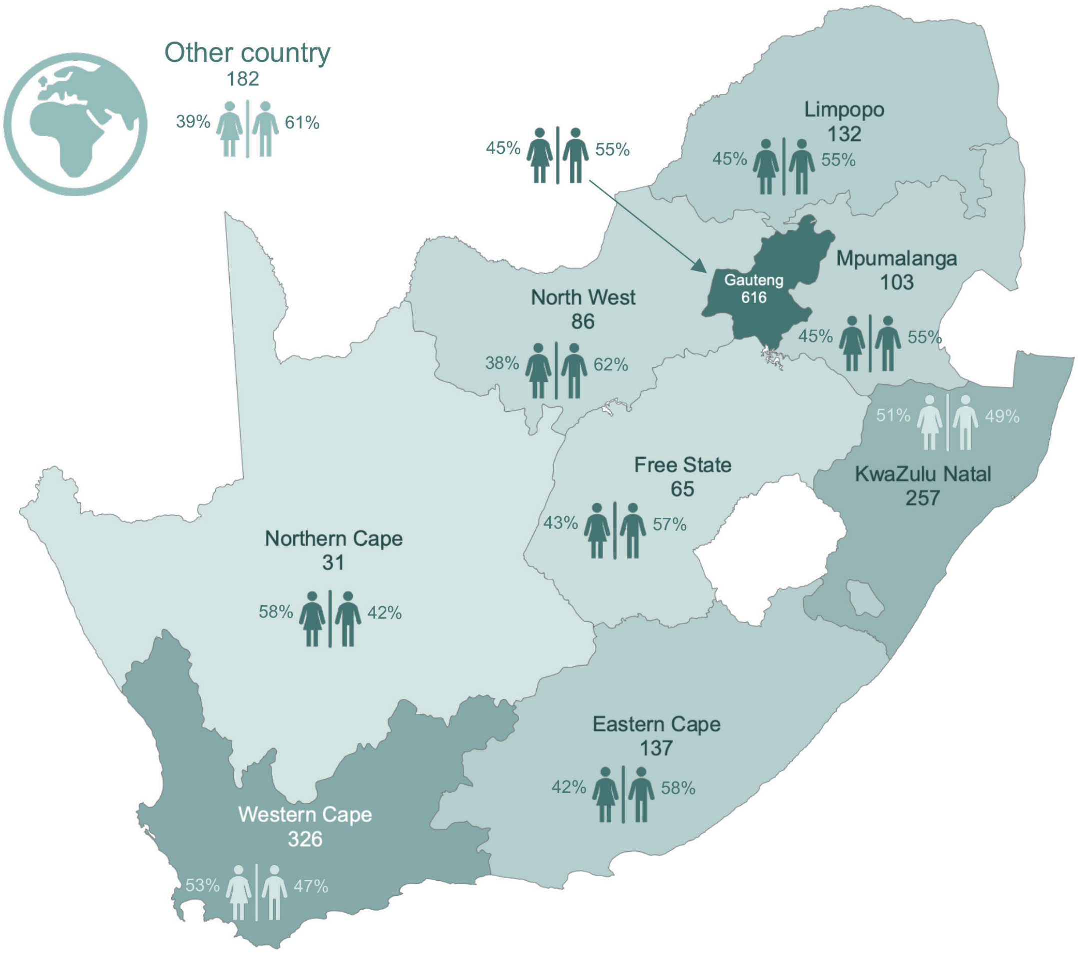
Source: HSRC-SACNASP Track and Trace Survey 2021

To identify parental education, respondents were asked to indicate the highest level of education completed by their parents or guardians. The share of mothers of the surveyed scientist who attained a matric or diploma was significantly higher than that of the fathers; however, these proportions were almost even for degrees. The results revealed that about 22% of the fathers had an education below matric level, 20% had a matric, 19% possessed a diploma, 15% had a degree, whilst 19% were postgraduates. Of the mothers, 27% did not have matric, whilst a further 24% obtained a matric certificate, 23% had a diploma, with about 14% achieving a degree and only 9% holding a postgraduate degree, which is half the proportion of the fathers who did so.

6.1.6 Migration patterns of natural science graduates

Figure 35 shows the province where natural scientists are currently working, by gender. Gauteng has the highest concentration of 616, followed by the Western Cape (326) and KwaZulu-Natal (257). The figure also shows that there are 182 scientists currently working outside the country. Generally, there are more males in each province, with the exception of the Western Cape (53% females vs. 47% males) and KwaZulu-Natal (51% females vs. 49% males), with the highest percentage being in the Northern Cape (58% females vs. 42% males).

Figure 35: Province where you currently work



Source: HSRC-SACNASP Track and Trace Survey 2021

6.1.7 Highest natural science qualification completed

Master of Science degree holders form the largest proportion of natural scientists in the sample (635), representing 35% of the total sample population. This is followed by those who have completed an Honours degree which is the qualification required to register as Professional Natural Scientist, who make up 30% (535), with PhD graduates at 18% (326). Some small proportions with less than 10% came from BSc (7%), BTech (6%), two- and three-year diplomas and DTech contributing the remaining 4% of respondents. The results for highest qualification completed are highly gendered and racially stratified.

Table 13: Highest qualification by race (n = 1,802)

	PhD/ DPhil	DTech	MSc	MTech	BSc Hons	BTech	3-year BSc	3-year Nat. Dip.	2-year Dip	Total
n	326	3	635	19	535	106	123	47	8	1802
	Column % Qualification across race (Down the column)									
African	24%	33%	33%	74%	51%	79%	70%	64%	25%	**43%**
Coloured	2%	0%	3%	5%	1%	2%	2%	2%	0%	**2%**
Indian/Asian	5%	33%	4%	0%	7%	3%	2%	0%	0%	**5%**
White	66%	33%	59%	21%	40%	16%	27%	34%	75%	**49%**
Other	3%	0%	1%	0%	1%	0%	0%	0%	0%	**1%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Row % Race across qualification (Across the row)									
African	10%	0%	27%	2%	35%	11%	11%	4%	0%	**100%**
Coloured	17%	0%	44%	3%	22%	6%	6%	3%	0%	**100%**
Indian/Asian	20%	1%	33%	0%	41%	3%	2%	0%	0%	**100%**
White	24%	0%	43%	0%	24%	2%	4%	2%	1%	**100%**
Other	45%	0%	40%	0%	15%	0%	0%	0%	0%	**100%**
Total	**18%**	**0%**	**35%**	**1%**	**30%**	**6%**	**7%**	**3%**	**0%**	**100%**

Source: HSRC-SACNASP Track and Trace Survey 2021. Largest percentage in category and second largest.

When these qualification patterns are scrutinised across population groups, about three interesting observations can be made. Firstly, about two-thirds (66%) of all PhD graduates are white, with only 24% of PhD holders being African. A second point of note is the variation in the type of qualifications by race. More Africans seem to be completing their doctoral degrees with universities of technology, representing 33% of DTech graduates being African and equal to the Whites and Coloureds within the category. This pattern continues to the MTech and BTech level, where more African scientists seem to have earned their Master's and Honours qualifications from universities of technology (74% and 79% respectively). In contrast, most White graduates have a Master's degree (MSc) from traditional universities (59%).

A third point worth noting is that there is a relatively high number of White professionals with two-year diplomas. Whilst this can be linked to historical patterns of access, more empirical work is needed to understand how these patterns play out within the current higher education context of access and success.

Table 14: Highest qualification and gender (n = 1,802)

	PhD/ DPhil	DTech	MSc	MTech	BSc Hons	BTech	3-year BSc	3-year Nat. Dip.	2-year Dip	Total
	18%	0.2%	35%	1%	30%	6%	7%	3%	0.4%	100%
n	326	3	635	19	535	106	123	47	8	1,802
	Column % Qualification across gender (Down the column)									
Male	63%	33%	49%	53%	55%	55%	52%	53%	63%	54%
Female	37%	67%	51%	47%	45%	45%	48%	47%		46%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Row % Gender across qualification (Across the row)									
Male	21%	0%	32%	1%	30%	6%	7%	3%	1%	100%
Female	14%	0%	39%	1%	29%	6%	7%	3%	0%	100%
Other	50%	0%	0%	0%	50%	0%	0%	0%	0%	100%
Total	18%	0%	35%	1%	30%	6%	7%	3%	0%	100%

Source: HSRC-SACNASP Track and Trace Survey 2021. Largest percentage in category and second largest.

When natural scientists' qualifications are analysed by gender, again very stark differences emerge in the distribution of males and females across most of the qualification categories. Notably, about 63% of males (almost double the proportion of females) versus 37% of females hold PhDs. What is surprising is that there are comparable percentages of male and female scientists with an MSc degree (49% and 51%). In fact, the within-gender analysis shows that almost two-fifths (40%) of females achieved an MSc, compared to 32% of males. In the presence of this healthy pipeline, the question then becomes what barriers are making it difficult for women to advance in their academic careers or to reach doctoral level?

6.2 Transitions from school to various labour market destinations

Section 6.1. has provided a demographic breakdown of the natural scientists. The current section now seeks to offer an understanding of the scientists' transition outcomes from education to the world of work. These would be measured against the following indicators: employment, time taken to find work, quality of employment, and extent to which labour market outcomes meet the workers' aspirations.

6.2.1 Current activity status of natural scientists

One of the key research objectives was to determine labour market destinations of natural science graduates. To do this, scientists were asked to indicate their current employment status, whether they are in employment (full time or part time), self-employed, studying full time or unemployed. This important indicator provides evidence of the economic activities of the scientists.

Table 15: Labour market destinations of natural science professionals

	Full-time employed	Part-time employed*	Self-employed⁺	Full-time Studying	Unemployed˙	Total
%	**70%**	**5%**	**17%**	**3%**	**5%**	**100%**
n	**980**	**71**	**236**	**47**	**68**	**1,402**
Gender	**Column % employment status across gender (Down the column)**					
Male	53%	56%	60%	47%	50%	54%
Female	47%	44%	40%	53%	50%	46%
Total	100%	100%	100%	100%	100%	100%
Gender	**Row % gender across employment status (Across the row)**					
Male	69%	5%	19%	3%	4%	100%
Female	71%	5%	15%	4%	5%	100%
Total	70%	5%	17%	3%	5%	100%
Race	**Column % employment status across race (Down the column)**					
African	40%	51%	15%	79%	65%	39%
Coloured	2%	0%	1%	2%	1%	2%
Indian/Asian	6%	4%	3%	2%	4%	5%
White	51%	44%	80%	17%	29%	53%
Other	1%	1%	1%	0%	0%	1%
Total	100%	100%	100%	100%	100%	100%
Race	**Row % race across employment status (Across the row)**					
African	72%	7%	6%	7%	8%	100%
Coloured	85%	0%	8%	4%	4%	100%
Indian/Asian	80%	4%	10%	1%	4%	100%
White	67%	4%	25%	1%	3%	100%
Other	75%	6%	19%	0%	0%	100%
Total	70%	5%	17%	3%	5%	100%

Table 15 (*continued*)

	Full-time employed	Part-time employed*	Self-employed+	Full-time Studying	Unemployed˙	Total
%	70%	5%	17%	3%	5%	100%
n	980	71	236	47	68	1,402
Age	**Column % employment status across age cohorts (Down the column)**					
20 - 34	37%	51%	13%	77%	68%	36%
35 - 65	63%	35%	76%	23%	24%	60%
66 +	1%	14%	11%	0%	9%	3%
Total	100%	100%	100%	100%	100%	100%
Age	**Row % race across employment status (Across the row)**					
20 - 34	71%	7%	6%	7%	9%	100%
35 - 65	73%	3%	21%	1%	2%	100%
66 +	11%	21%	55%	0%	13%	100%
Total	70%	5%	17%	3%	5%	100%

Source: HSRC-SACNASP Track and Trace Survey 2021. NB: *Includes retired and working for any form of income; + E.g. consultant, ˙ Retired and not working, career break. Largest percentage in category

Four key findings can be drawn from the analysis in Table 15.

1. The majority of natural scientists are in full-time employment.

Most of natural scientists, 70%, are working for wages or salaries. About 5% of the scientists are employed on a part-time basis. A full-time employee typically works an average of 30–40 hours a week and typically receives a steady income, whilst a part-time employed employee will work a minimum of 20 hours a week, and many may not be entitled to the same benefits as their full-time co-workers. More males were found to be in full-time and part-time employment (54% and 56%) compared to their female counterparts (47% and 48%). Notably, within the female group a high percentage of 71% are employed full time.

Over half of scientists in employment are white (51%). About 40% are African, 6% Indian/Asian and 2% Coloured. Scientists in part-time employment were predominantly African (51%), with 44% being White and 4% being Indian/Asian. Furthermore, the category of the employed scientists was largely made up of individuals aged 35–65 (63%). About 37% were aged between 20 and 35, whilst a percentage was aged 66 and above. Most of the young cohort are in part-time employment (51%), which is often associated with some level of precariousness.

2. There is sizeable proportion of natural scientists who are self-employed.

A substantial proportion of 17% are self-employed, and this proportion includes natural scientists working as consultants. Male scientists are more likely to be self-employed (60%) than female scientists (40%). This category also largely constitutes White scientists (80%) and scientists aged between 35 and 65 (76%).

3. More female scientists are engaged in further studies than males.

Although in general there is a smaller proportion of scientists who are engaged in full-time studies (3%), the analysis shows that females are overly represented amongst this group (53% compared to 47% males). This category is also mainly constituted by African (79%) and younger natural scientists.

4. Only a small proportion of natural scientists are unemployed.

Only 5% of natural scientists are unemployed. This category included all those who are out of the labour market, as well as those who are retired. There is an equal split of male and female scientists in unemployment. The unemployed scientists were also more likely to be African (65%) and young, aged 20–34 years (68%).

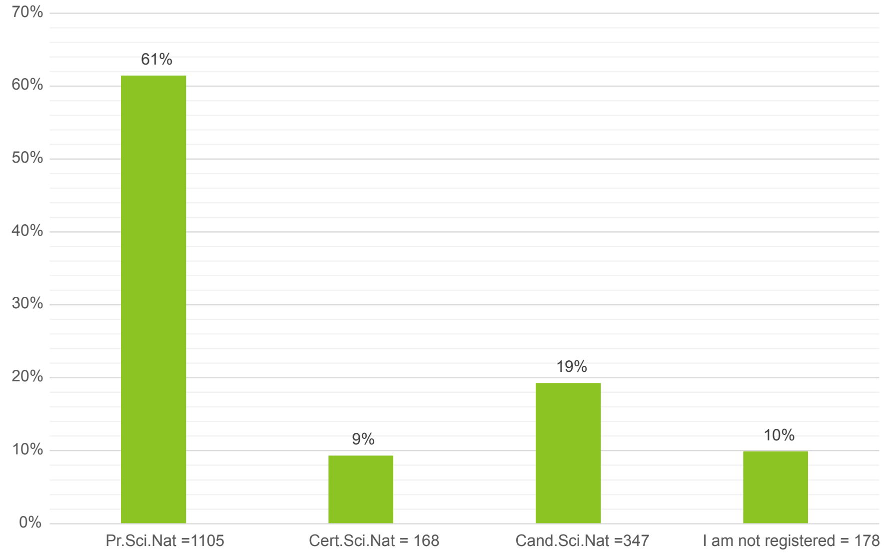
Strong gender variations emerge in the labour market states of natural scientists, showing that even though more female scientists are engaged in further education, males have better labour market outcomes than females. More males are in full-time and part-time employment and more likely to be self-employed than female scientists. Furthermore, White scientists were predominately found in full- time and self-employment, whilst African scientists dominate the part-time employment, full-time study and unemployment.

6.2.2 Registration category of scientists

As per the Natural Scientific Professions Act 27 of 2003, SACNASP is mandated to register scientists in different categories and fields of practice. There are three categories of registration, with varied work experience and educational qualifications requirements. These are the Professional Natural Scientist (Pr.Sci.Nat), Certificated Natural Scientist (Cert.Sci.Nat), and the Candidate Natural Scientist (Cand.Sci. Nat).

Figure 36 shows patterns of registration with SACNASP. From the analysis, about 88% of the scientists who participated in the survey were registered, with 10% indicating that they were not registered with the Council. The analysis further reveals that 61% of the scientists were Pr.Sci.Nat. Almost a fifth (19%) were Candidates, whilst just under a tenth (9%) were Certificated natural scientists.

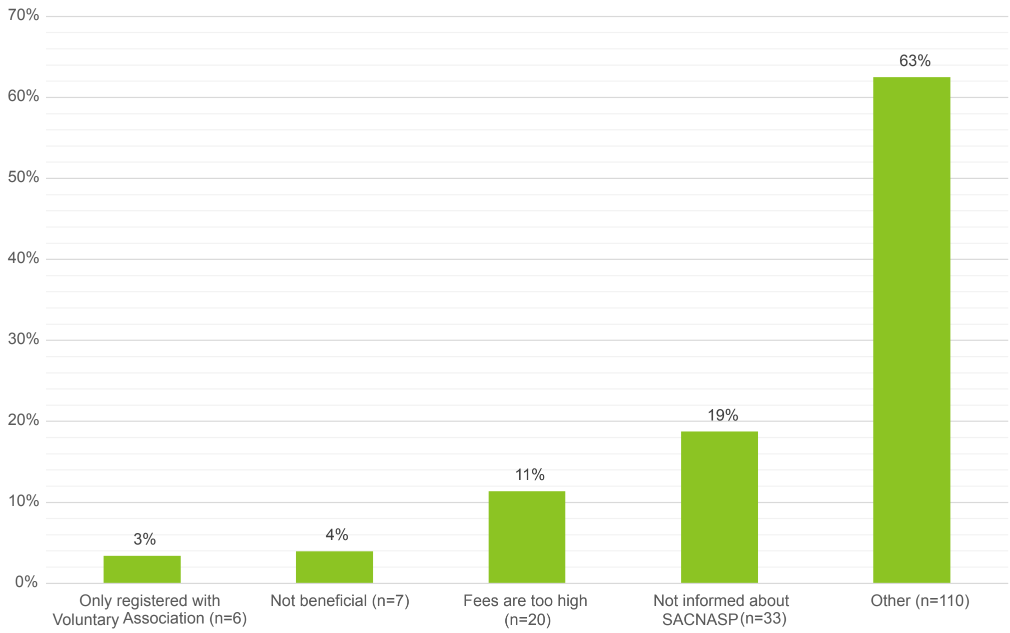
Figure 36: Registration category of natural scientists, 2020 (n = 1,798) (%)



Source: HSRC-SACNASP Track and Trace Survey 2021

Whilst registration and regulation of the natural science professions is a key mandate of the Council, the Natural Scientific Professions Act also requires all scientists to be registered. Although a low percentage of scientists were not registered, it is important to probe further into this 10% to find out reasons for their non-registration.

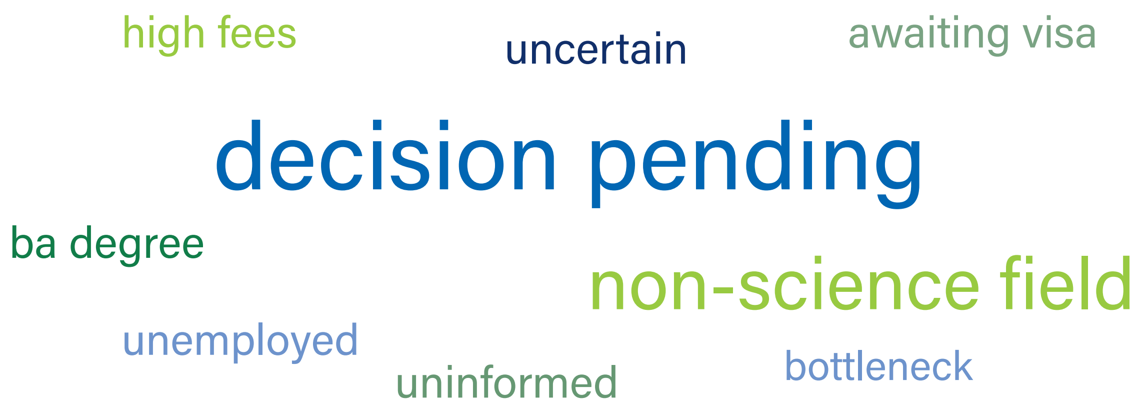
Figure 37: Reasons for not being registered with SACNASP (n = 176)



Source: HSRC-SACNASP Track and Trace Survey 2021

Of those who were not registered with the Council, almost a fifth (19%) said they were not informed about SACNASP, whilst just over a tenth (11%) protested that the fees are too high. Of concern is the marginal 4% who did not perceive registration with the Council as beneficial. About 3% indicated that they are only registered with VAs. Further analysis of the reasons why these respondents have not been registered suggests that most of them members have submitted their applications and they are pending approval (the evaluation process takes between three and six months). Others seem to be practising in non-science fields, while more are in the process of applying. A few are still engaged in further education which they want to complete before registering, while a smaller fraction do not have all the required information.

Figure 38: Word cloud for reasons of not being registered with SACNASP

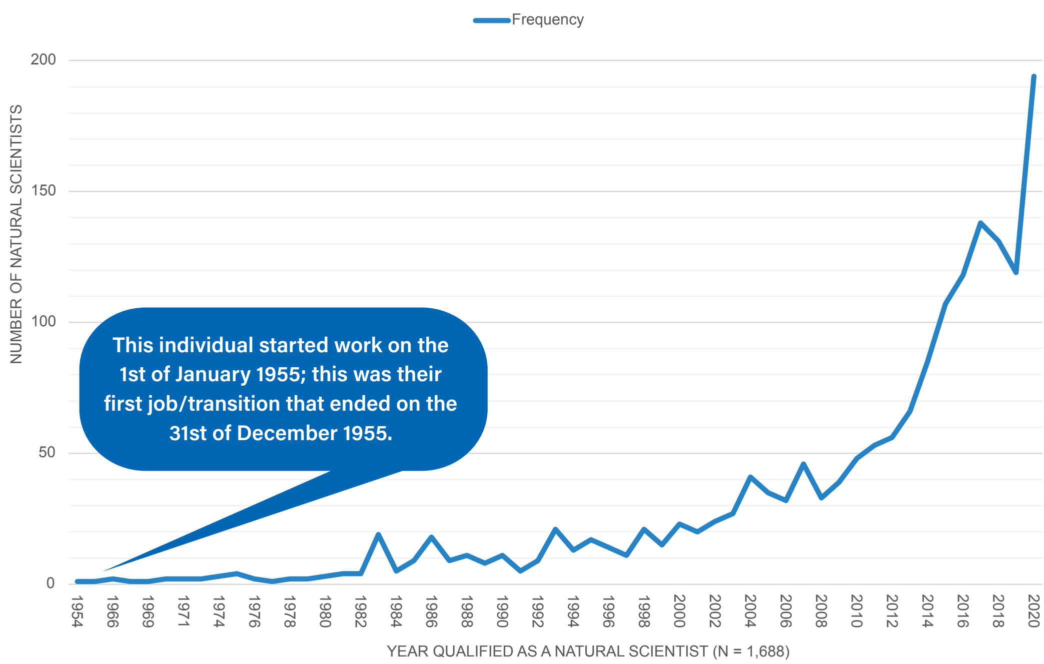


Source: HSRC 2021

6.2.3 Year when qualified as a natural scientist

The discussion above has indicated that natural scientists are mandated by law to register with the Council in order to practise in their respective fields of study. The best way to start investigating career pathways of natural scientists is therefore to look at when they first qualified as natural scientists. The next discussion then shifts to focus on when the natural scientists began their careers as natural scientists.

Figure 39: In what year did you qualify as a natural scientist?



Source: HSRC-SACNASP Track and Trace Survey 2021

Two potentially interesting findings from Figure 39 are, firstly, that after 2010 there has been a significantly high rate of registration with SACNASP. This could be due to better sensitisation, or better management of the SACNASP database to capture membership processes efficiently. A second aspect of interest for SACNASP will be potentially ensuring the sustainability of this momentum and consolidating membership. The sharp decrease in membership observed in 2017 already suggests a need for a more integrated system for managing the membership of new and existing members. The decrease in 2017 was due to the end of the registration of extension scientists as a project. Their registration caused a spike as DAFF conducted a drive for registration.

6.2.3 Total number of jobs in one's lifetime

Table 16 gives a better picture of the number of jobs each scientist had had up until the time of the survey. On average, males have had marginally more job opportunities relative to their female counterparts, 4 vs. 3. When accounting for the greater variability for men, both have a median of 3, and the 50% quartile indicates that 50% of both males and females had had 3 or less jobs. The middle 50% of the distribution had also had 3 jobs for both, which would suggest that there are generally no differences by gender.

The findings by age cohort show the expected pattern, where the mean number of jobs increases as one gets older, 3 for those aged 20–34; 4 for those aged 35–65 and 5 for the 66+ age cohort. Looking at the number of jobs by race reveals that whites have had more jobs relative to the other racial groups. The interquartile range shows that the middle 50% of whites have had 3 jobs, relative to 2 for the other racial groups.

Table 16: Summary statistics for total number of jobs in one's lifetime

	N	Sum	Mean	Median	Min	Max	Range	Inter-quartile Range	50% Quartile	Std Dev
Male	952	3611	4	3	1	50	49	3	3	3
Female	808	2760	3	3	1	15	14	2	3	2
Total	**1760**	**6371**	**4**	**3**	**1**	**50**	**49**	**3**	**3**	**3**
Age										
20 - 34	660	1880	3	3	1	12	11	2	3	2
35 - 65	1038	4164	4	4	1	20	19	3	4	2
66 +	64	332	5	4	1	50	49	2	4	6
Total	**1762**	**6376**	**4**	**3**	**1**	**50**	**49**	**3**	**3**	**3**
Race										
African	749	2322	3	3	1	17	16	2	3	2
Coloured	35	121	3	3	1	9	8	2	3	2
Indian/Asian	86	288	3	3	1	10	9	2	3	2
White	872	3567	4	4	1	50	49	3	4	3
Other	20	78	4	3	1	11	10	2	3	2
Total	**1762**	**6376**	**4**	**3**	**1**	**50**	**49**	**3**	**3**	**3**

Source: HSRC-SACNASP Track and Trace Survey 2021

6.3 Natural scientists in employment

Having determined where natural scientists are in the labour market and established their labour market destinations, the next sections provide a detailed analysis of their work outcomes in the respective four destinations: in employment, unemployment, studying or self-employment. Natural scientists could only select one main destination to avoid double counting.

The discussion begins by focusing on those who are in employment to understand their field of practice, how they found employment, the type of work they do, earnings situation, skills and competencies utilised and satisfactions levels with their work.

6.3.1 Employed natural scientists by field of practice

Table 17 provides the distribution of employed scientists by field of practice. Although scientists in this category of the employed are spread across different fields of practice, it is also evident that they make up significant proportions in the fields of Environmental and Geospatial Sciences (13%). About 8% are in the field of Animal Science, with 6% in Botanical Science.

Table 17: Employed scientists by field of study (n = 976)

#	Field of Study	B-Male	B-Female	W-Male	W-Female	I-Male	I-Female	C-Male	C-Female	Total	%
1.	Agricultural Science	21	21	15	15			1		73	7%
2.	Animal Science	18	13	24	24	1				80	8%
3.	Aquatic Science	1		6	5		2	1		15	2%
4.	Atmospheric Science				1					1	0%
5.	Botanical Science	10	12	15	16	1	2	1	2	59	6%
6.	Chemical Science	14	8	5	9	2	1			39	4%
7.	Conservation Science	4		6	7					17	2%
8.	Earth Science	17	4	26	3			2		40	4%
9.	Ecological Science	3	3	9	5				1	21	2%
10.	Environmental Science	24	30	26	31	4	12	1		128	13%
11.	Extension Science	4	4	1	1					10	1%
12.	Food Science	3	1	1	2		1		1	9	1%
13.	Geospatial Science	25	23	43	22	4	5	1	3	126	13%
14.	Mathematical Science		2		1					3	0%
15.	Microbiological Science	6	10	2	4		1			23	2%
16.	Physical Science	4	1	2	2					9	1%
17	Soil Science	4	8	4	6					22	2%
18.	Statistical Science	1	1	2			1			5	1%
19.	Water Resources Science	9	10	5	5	2	1	2		34	3%
20.	Zoological Science		3	4	7					14	1%
21.	Other	53	20	74	72	15	8	3	3	248	25%
	Grand total	**221**	**174**	**270**	**238**	**29**	**34**	**12**	**10**	**976**	**100%**

Source: HSRC-SACNASP Track and Trace Survey 2021

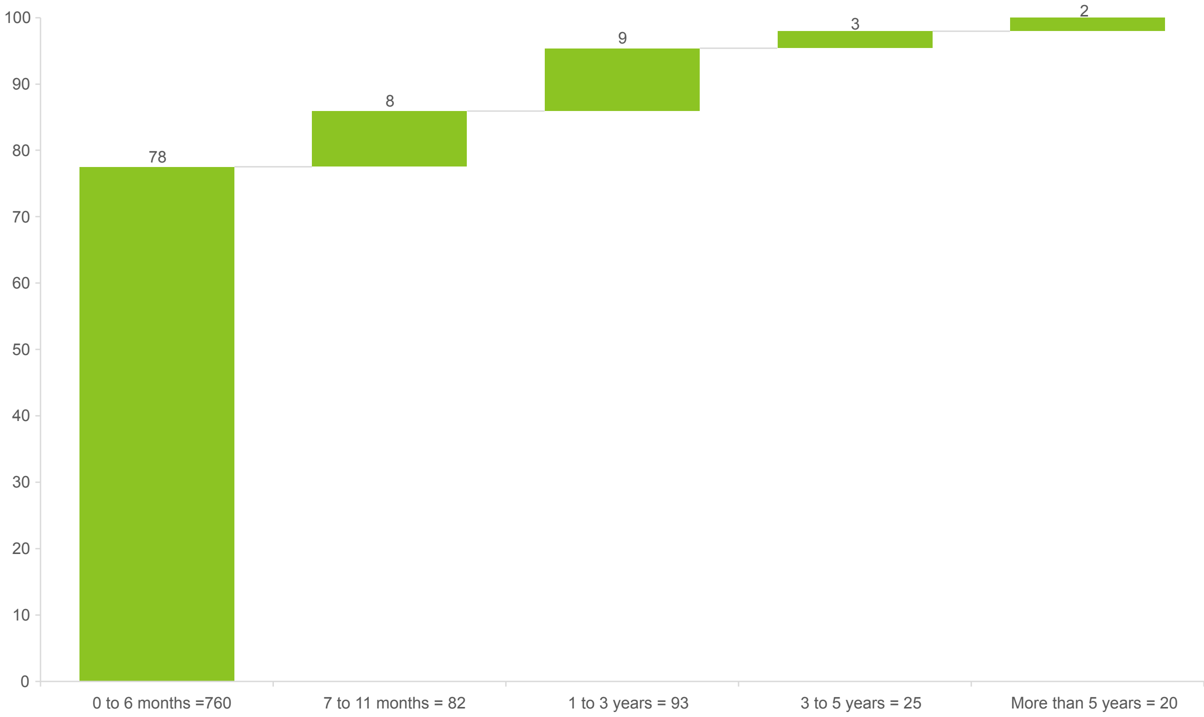
In terms of gender and race distribution:

- African scientists were more likely to be in Agricultural Sciences whilst White scientists dominated the Animal Sciences. African women were specifically overrepresented in Environmental Science, Microbiological Science, and Water Resources Science.
- Very few Africans were found in Aquatic Sciences.
- More African males were in Chemical Sciences than any other group.
- More White males were in Geospatial Sciences (43%), and Earth Sciences (26%).

6.3.2 Time taken to find first job after graduation

The duration as well as speed at which graduates enter the labour market is an important indicator of ease or difficulty of transitions in a specific labour market. To determine the length of time taken to find first employment, scientists were asked to indicate how long it took from leaving formal education to entering their first job.

Figure 40: How long did it take to find first job after graduating? (n = 980)



Source: HSRC-SACNASP Track and Trace Survey 2021

About 78% of the scientists indicated that it took them less than 6 months after graduation to find their first job. About 8% of the natural scientists found work within a year of graduation and 9% within 1 to 3 years, while 5% took 3 years and above. This indicates that most natural science graduates in the sample did not experience chronic unemployment, which is unemployment lasting more than 12 months after graduation. This compares positively to another South African study by Graham et al. (2019), which shows that on average graduates take 12.8 months prior to finding their first graduate job.

However, the time it takes to make the transition to work differed substantially by race and gender. Whites were more likely to find work within 6 months of graduation. They were followed by Coloured respondents at 80% (small sample size of 22 respondents). A slightly lower proportions of Africans (67%) indicated that they secured jobs within 6 months. These population groups also had a greater representation amongst those taking longer, that is between 7 and 11 months and a year and above to transition into the labour market. Males were also significantly more likely to start work quickly compared to their female counterparts (80% vs. 75%). Notably, African females were actually overrepresented amongst those finding work after waiting for from a year to 3 years.

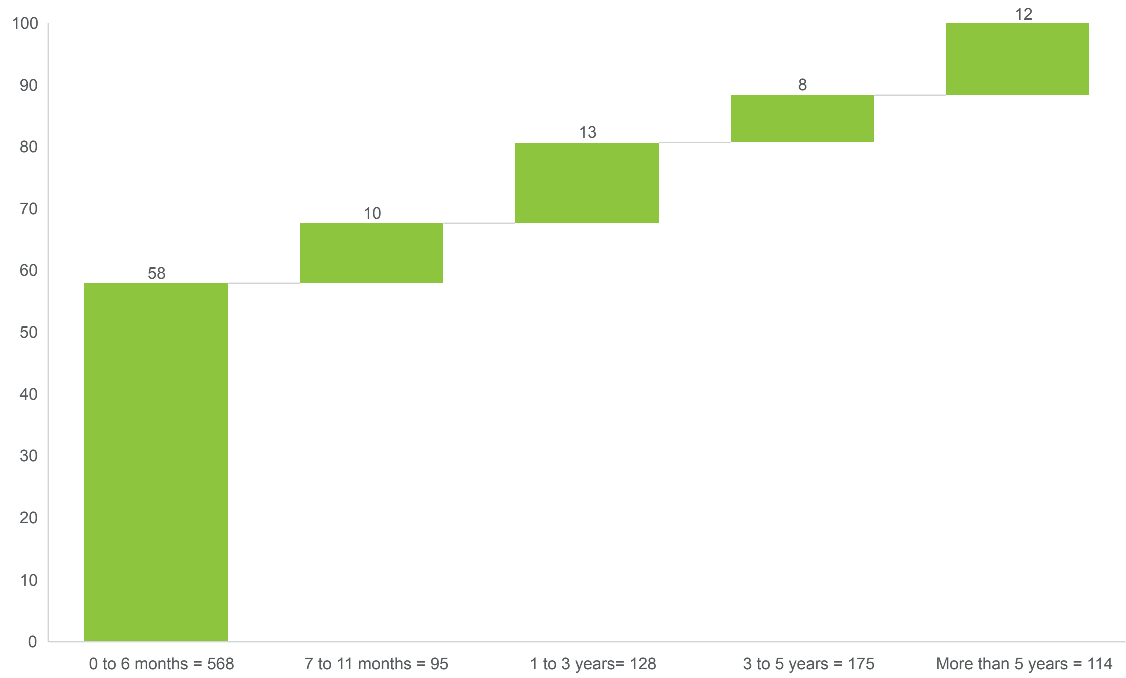
6.3.4 Time taken to find current job

Shifting the discussion from the early labour market entry trends of natural scientists, in terms of the time it took to secure their first job after graduation, the scientists were also asked to indicate how long it took to find their current jobs.

While it took 58% of the scientists less than 6 months to find their current jobs, for 10% it took between 7 and 11 months, 13% took between 1 and 3 years, whilst it took a further 20% 3 years and above. The trend is similar to the previous, confirming that natural scientists take a shorter time to find employment, compared to graduates from other fields. Reddy et al. (2016) also indicate that SET- related skills are in critical demand. The list of OIHD by the DHET reiterates the high need for SET-related skills (DNA Economics, 2020).

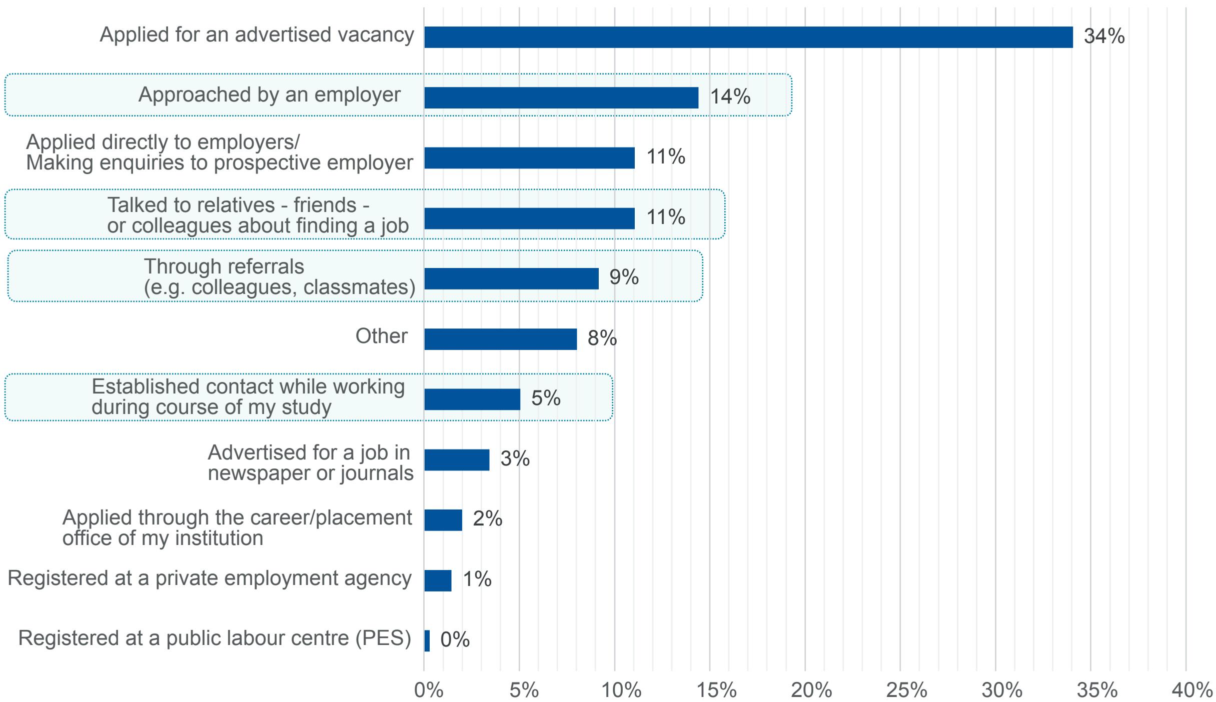
The same trends reflective of race and gender variations in the time taken to enter the labour market continue to emerge, where Africans have a smaller proportion of scientists getting jobs within 6 months. In fact, a larger proportion of Africans take 1 to 3 years or 3 to 5 years and above to secure employment. Again, women generally take longer to transition into the labour market.

Figure 41: How long it took to find current job (n = 980)



Source: HSRC-SACNASP Track and Trace Survey 2021

Figure 42: How did you find the current job?



Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.4 Job search strategy used to find current job

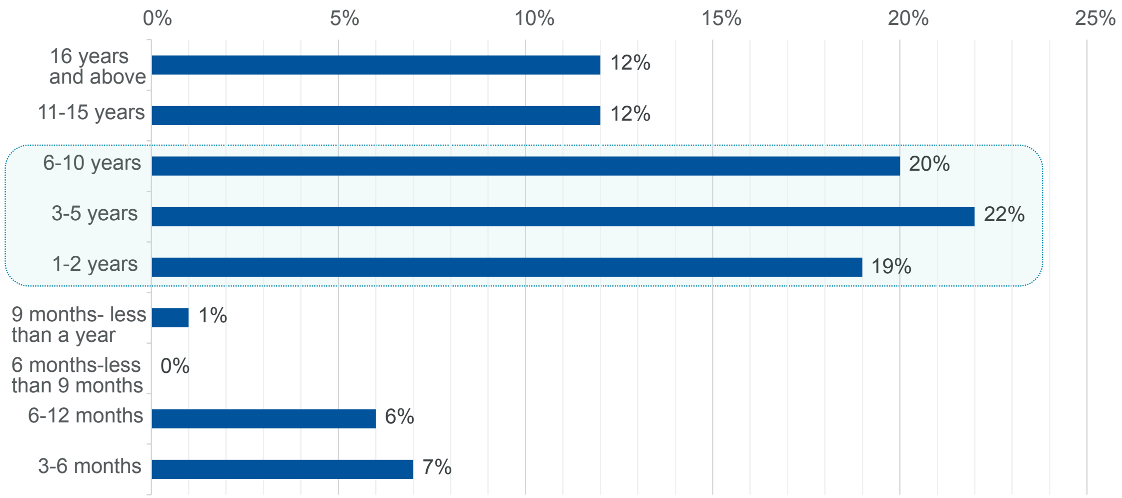
Figure 42 presents evidence of the job search method adopted by scientists to find their current jobs. The choice of a job search method is influenced by a variety of factors, including costs and access to information, but ultimately the method used to look for work affects the probability of finding it.

The analysis reveals that a large majority of scientists who found employment did so through responding to advertised job vacancies (34%). The second most important channel is being approached by employers or 'headhunted' (14%). Direct applications made to employers and family and friends came third, both being utilised by similar proportions of 11%. In fact, if family and friends could be grouped together with approached by employer, referrals, and contacts from education institutions under social networks, on the basis that they all operate on the principle of social connections, the analysis shows that almost 40% of the scientists used social networks to find work. Therefore, having good connections matters to finding employment in the natural science labour market. Very few found employment through placing adverts in newspapers, through career offices at the institutions of higher learning or by registration with private placement agencies.

6.3.5 Tenure in current job

Scientists were also asked to indicate how long they had been in the current jobs during the time of the survey. Evidence from the data suggest that most natural scientists spend an average of 3 to 10 years in jobs. About half of all respondents (44%) have spent at least 6 years in the current job, with about a quarter spending more than 10 years. This could indicate more stable working conditions and continuity within the field of practice. It could also mean there is room for more specialisation within the field and professions.

Figure 43: How long have you been in this job? (n = 980)

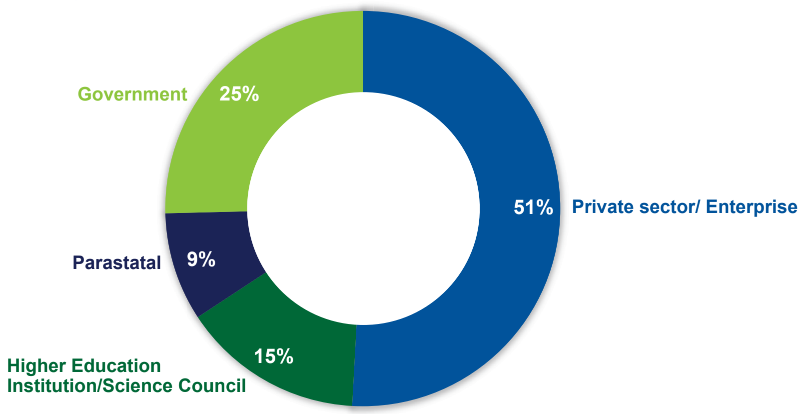


Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.6 Sector of employment

The major employer of natural scientists is the private sector, with half (51%) of the natural scientists working there. A quarter are employed by government, 15% are in the higher education institutions and science councils, whilst 9% are in the parastatals.

Figure 44: Sector of employment

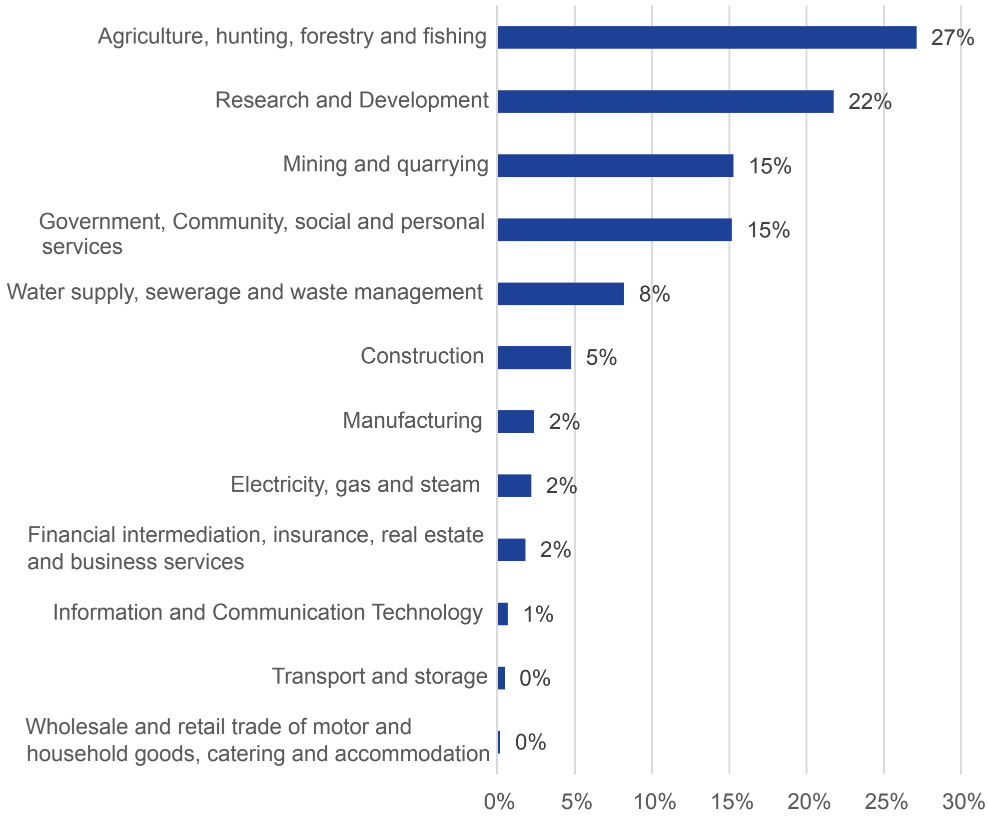


Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.7 Industry of employment

As part of understanding the sectors that absorb natural scientists, Figure 45 examines the distribution of employment of natural scientists across the broad industry categories.

Figure 45: Distribution of employment by industry (n = 980)



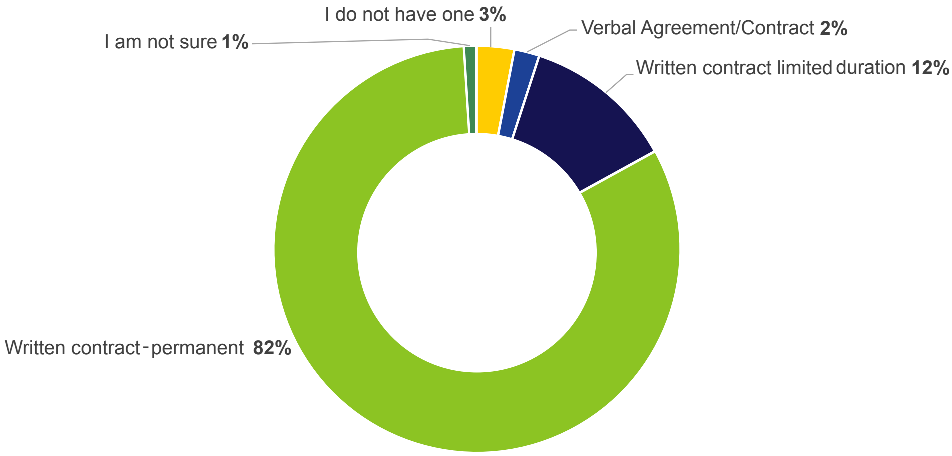
Source: HSRC-SACNASP Track and Trace Survey 2021

Despite national declines in agriculture and farming, about 27% of natural scientists are in these sectors. This is followed by research and development, which account for about 22% of employment. Mining and quarrying, and government services contribute equal proportions of 15% to the employment of scientists. Less than a tenth were employed in other sectors, such as water and waste, construction, manufacturing and gas, finance and ICT, with a further few accounting for less than a percentage found in the transport and storage fields as well as wholesale.

6.3.8 Types of work contract held by natural scientists

The majority of natural scientists (82%) have written contracts and are in permanent positions. A small proportion of 12% also have written contracts, although their positions are non-permanent. Only 2% indicated having a verbal contract, whilst a further 4% were either not sure of the type of contract or did not have a contract. A written contract is a key indicator of the conditions of employment, and from this analysis it shows that natural scientists generally have good jobs with employment security.

Figure 46: What type of contract do you have? (n = 980) (%)

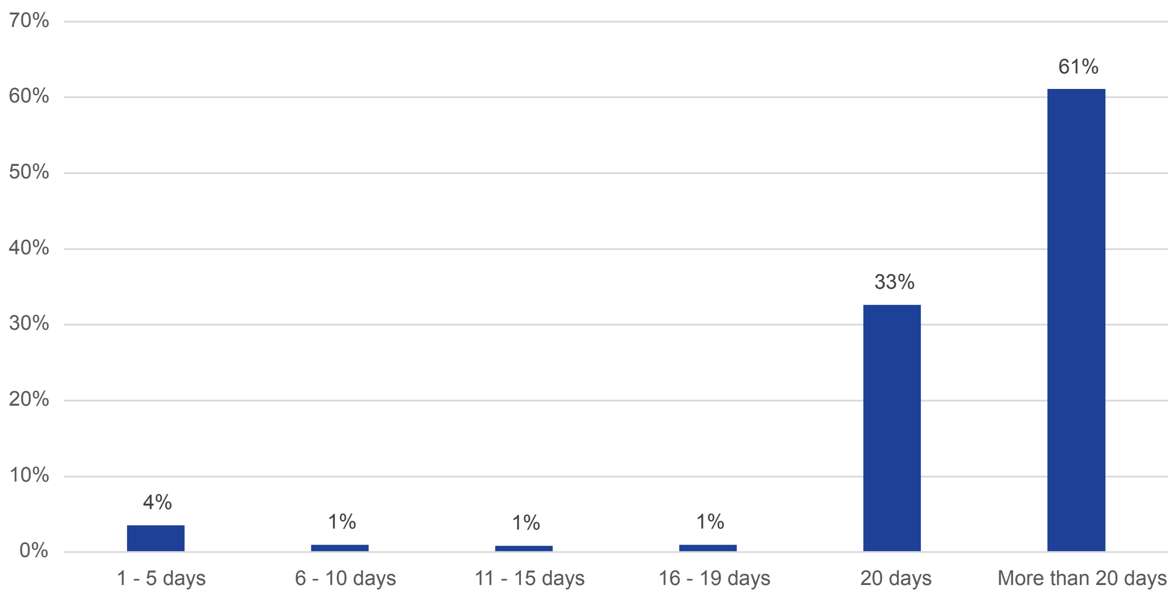


Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.9 Number of days worked in a month

On average, almost all employees work over 20 days or more a month; 61% work more than 20 days, whilst a third indicated working 20 days a month.

Figure 47: How many days do you work in a month?



Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.10 Gross monthly income

Table 18 shows the intersection of gender, race, and income, it highlights the largest, and the second largest proportion of each demographic subgroup earning a given monthly income. It can be seen that not only do Africans earn relatively lower incomes; African females are disproportionately worse off relative to all other groups, as they have the largest number of scientists in the lower income bands. This finding resonates with evidence that shows that "While policies and legislation that support gender equality and women's empowerment are in place, they have not been sufficient to reduce disparities in the labour market" (Ndinda and Ngandu, 2016, p. 5). African males fare somewhat better as they are well represented in the higher income bands.

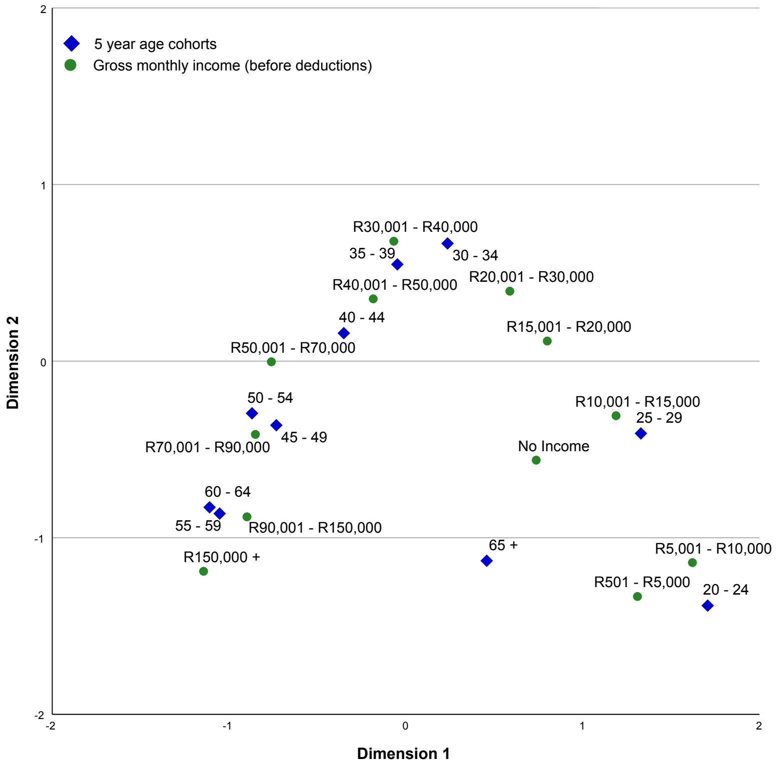
Table 18: Gross monthly income (before deductions) by race and gender

Monthly income band	B-Male	B-Female	W-Male	W-Female	I-Male	I-Female	C-Male	C-Female	Total
n	**422**	**320**	**530**	**466**	**58**	**64**	**23**	**20**	**1903**
No Income	1%	1%	1%	0%	0%	0%	0%	0%	1%
R501 - R5,000	3%	3%	1%	0%	3%	6%	0%	0%	2%
R5,001 - R10,000	6%	11%	1%	3%	0%	0%	0%	0%	5%
R10,001 - R15,000	7%	7%	2%	3%	0%	11%	0%	0%	5%
R15,001 - R20,000	6%	10%	4%	5%	3%	6%	8%	0%	6%
R20,001 - R30,000	14%	24%	12%	16%	7%	22%	0%	20%	16%
R30,001 - R40,000	13%	16%	14%	16%	10%	3%	17%	20%	14%
R40,001 - R50,000	12%	10%	10%	15%	13%	14%	0%	10%	12%
R50,001 - R70,000	13%	6%	16%	19%	20%	14%	33%	30%	14%
R70,001 - R90,000	12%	3%	14%	9%	13%	3%	17%	10%	10%
R90,001 - R150,000	3%	1%	9%	2%	0%	3%	0%	0%	4%
R150,000 +	4%	1%	6%	0%	7%	3%	8%	0%	3%
Prefer not to say	5%	7%	9%	8%	13%	17%	17%	10%	8%
Not sure	1%	1%	2%	2%	10%	0%	0%	0%	2%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: HSRC-SACNASP Track and Trace Survey 2021. Largest percentage in category and second largest

Figure 48 shows a bi-plot of gross monthly income and age. The basic intuition behind the correspondence analysis pertains to the pattern of association between age and income; the closer together the two are, the stronger the association. The results clearly show the expected pattern between age and income, which to some extent is moderated by level of experience. Lower age groups are strongly associated with lower incomes; for example, the 20–24 age cohort is associated with incomes ranging between R501 and R10,000 per month.

Figure 48: Correspondence analysis: relationship between income and age

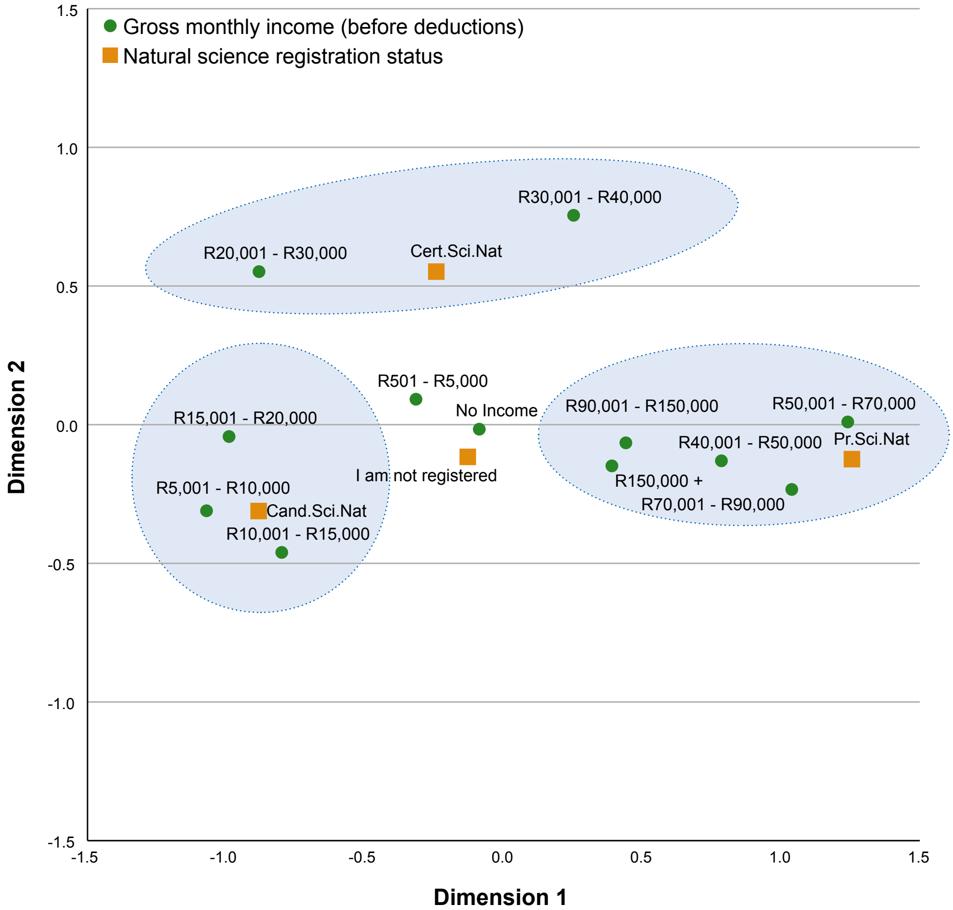


Source: Authors HSRC-SACNASP Track and Trace Survey 2021

The positively corelated income and age association continues all the way to older age cohorts, with strong associations between the 55–59 and 60–64 age cohorts and incomes ranging between R90,000 – R150,000 and beyond. The figure also shows the 65+ age cohort, where the association weakens with this cohort waged between the higher and lower income bands, indicating that whilst some scientists continue to earn relatively high incomes, others, especially those who are not currently working, are probably relying on lower pension incomes.

The registration status of a natural scientist can also be used as a proxy for level of experience. Figure 49 shows the association between income and natural scientist registration status. It shows a strong association between higher income bands and the Pr.Sci.Nat status. This is followed by an association between the middle-tier status, Cert.Sci. Nat, and middle incomes that range from R20,001 to R40,000 a month. Both Cand.Sci.Nat and those who are not registered are associated with lower incomes.

Figure 49: Correspondence analysis: relationship between income & registration status



Source: Authors HSRC-SACNASP Track and Trace Survey 2021

6.3.11 Qualifications and skills mismatches in the natural science professions labour market

The next discussion focuses on the theme of qualifications and skills mis/matches of graduates. Qualification mismatches refers to discrepancies between one's qualification and what is required in the job. In some instances, workers' qualifications could be higher (over-qualification) or lower (under-qualification) than the minimum required for the job, resulting in a qualification mismatch. Either way, qualification mismatches point to failure to allocate workers to where they would adequately apply their skills and competencies (Grapsa, Mncwango and Rogan, 2018; Mncwango, 2016). Previous results have found that about 30% of South Africans perceive themselves as overqualified (Mncwango, 2016). Reddy et al. (2016) found a signification proportion of employed South Africans to be underqualified and mismatched in terms of the skills and qualifications they possessed. Grapsa et al. (2018) found more than half of the South African workforce to either be over- or under-educated, with only 40% of workers with a tertiary education being well matched to their occupations.

Four indicators of qualifications/skills mismatches were included in the survey:

- Usefulness of knowledge and skills in the current job.
- Alignment between level of education and current work.
- The extent to which field of study was useful in getting the current job.
- Relationship between qualification and current work.

6.3.11.1 Usefulness of knowledge and skills in the current job

From Table 19, it can be observed that more than half (56%) of natural scientists feel that their qualifications, knowledge and skills acquired are highly relevant for their current professions or jobs. If combined with over a quarter (28%) of respondents who confirm that their skills are moderately relevant, it suggests a close alignment between curriculum, pedagogy and employers' needs. However, about 13% said this is the case only to a certain extent, 6% said to a small extent and 1% said not at all.

Table 19: To what extent are the knowledge and skills you acquired useful in this current job?

	African	Coloured	Indian/ Asian	White	Other	Total
%	43%	2%	4%	50%	1%	100%
Male	**239**	**12**	**22**	**277**	**8**	**558**
Not at all	2%	0%	0%	1%	0%	1%
To a small extent	3%	8%	9%	3%	0%	3%
To some extent	10%	8%	5%	13%	13%	11%
To a moderate extent	23%	17%	36%	22%	13%	23%
To a great extent	63%	67%	50%	61%	75%	62%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
%	39%	2%	7%	51%	1%	100%
Female	**191**	**10**	**36**	**248**	**4**	**489**
Not at all	1%	0%	6%	0%	0%	1%
To a small extent	9%	0%	3%	6%	0%	7%
To some extent	14%	20%	14%	15%	25%	15%
To a moderate extent	23%	40%	25%	31%	25%	28%
To a great extent	53%	40%	53%	48%	50%	50%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
%	41%	2%	6%	50%	1%	100%
Grand Total	**430**	**22**	**58**	**525**	**12**	**1,047**
Not at all	1%	0%	3%	1%	0%	1%
To a small extent	6%	5%	5%	4%	0%	5%
To some extent	12%	14%	10%	14%	17%	13%
To a moderate extent	23%	27%	29%	26%	17%	25%
To a great extent	59%	55%	52%	55%	67%	56%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

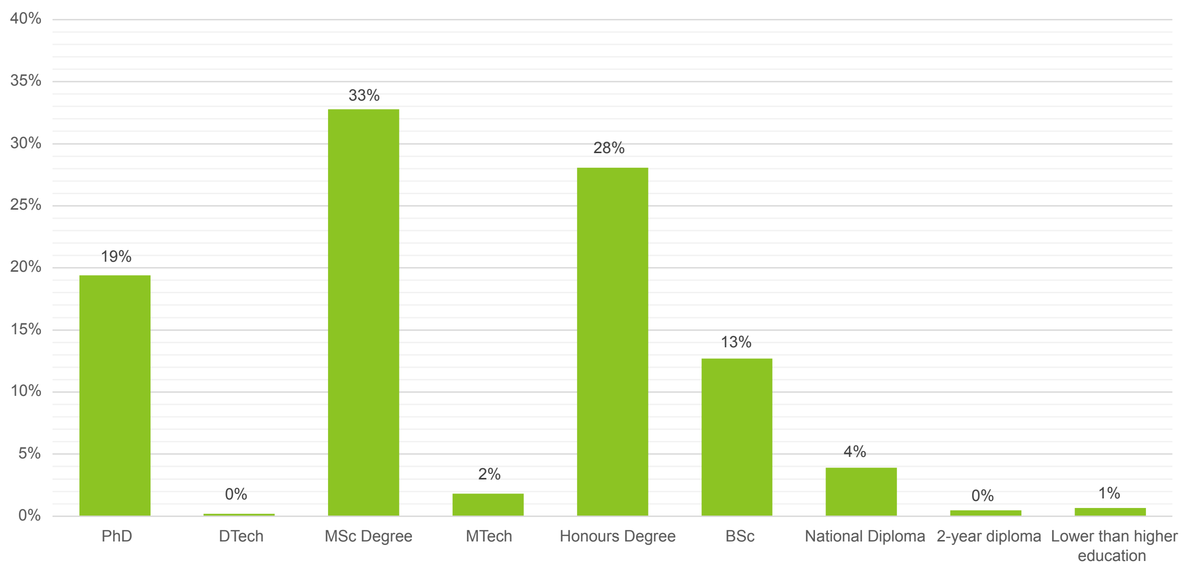
Source: HSRC-SACNASP Track and Trace Survey 2021, Largest percentage in category and second largest.

Interesting race and gender differences emerge. Within the male category, African and Coloured scientists (63%; 67%) were disproportionally more likely to indicate that their education and skills acquired were very relevant in their current jobs. Similarly, within the female category, African and Indian (53% each) female scientists were more likely to indicate that their knowledge and skills were more useful in their jobs.

6.3.11.2 Alignment between level of education and current work

To assess the scientists' perceptions regarding the match or mismatch between their highest level of education versus actual activities involved in carrying out their jobs, they had to indicate the extent to which they feel that their level of education is appropriate for the work they are doing. Figure 50 clearly shows a bias towards high qualifications with about 55% of them saying PhD/DTech and MSc. About 28% said Honours degrees, followed by BSc (13%).

Figure 50: What level of education do you feel is most appropriate for your current work? (n = 1,047)



Source: HSRC-SACNASP Track and Trace Survey 2021

6.3.11.3 The extent to which field of study was useful in getting current job

Linked to the preceding section, most natural scientists (80%) agree that their qualifications and fields of study have been important in them getting their current employment. This includes about 75% and 15% who felt that their field of study was 'very useful' and 'useful' in obtaining their jobs. Only 8% said 'to some extent', with a very small proportion of 4% saying the field of study did not assist much. This shows that with most natural science professions, increasingly demanding membership with a professional body which regulates the design of curriculum, pedagogy and professional development of its professionals securing jobs within the profession, has been increasingly aligned to field of study, training and skills developed.

Table 20: To what extent did your field of study assist you in getting current job (n = 1,041)

	African	Coloured	Indian/ Asian	White	Other	Total
Male	**238**	**12**	**22**	**276**	**8**	**556**
Not at all	1%	0%	0%	1%	0%	1%
To a small extent	3%	8%	5%	2%	0%	3%
To some extent	8%	0%	9%	7%	0%	7%
To a moderate extent	13%	0%	23%	13%	25%	14%
To a great extent	76%	92%	64%	76%	75%	76%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 20 (*continued overleaf*)

Table 20 (*continued*)

	African	Coloured	Indian/ Asian	White	Other	Total
Female	**188**	**10**	**36**	**246**	**4**	**484**
Not at all	2%	0%	3%	0%	0%	1%
To a small extent	4%	0%	3%	4%	25%	4%
To some extent	9%	30%	3%	10%	0%	9%
To a moderate extent	13%	10%	17%	21%	0%	17%
To a great extent	72%	60%	75%	65%	75%	68%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Total	**426**	**22**	**58**	**522**	**13**	**1041**
Not at all	1%	0%	2%	1%	0%	1%
To a small extent	3%	5%	3%	3%	8%	3%
To some extent	8%	14%	5%	8%	0%	8%
To a moderate extent	13%	5%	19%	17%	15%	15%
To a great extent	74%	77%	71%	71%	77%	72%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

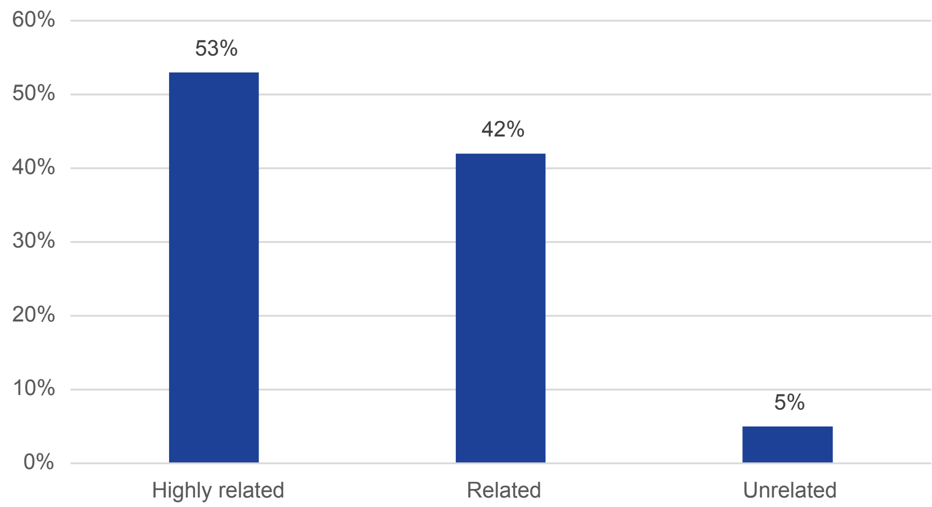
Source: HSRC-SACNASP Track and Trace Survey 2021

Table 20 further shows males were generally more likely (90%) to perceive their field of study as having assisted them greatly in getting jobs. This percentage was 85% for their female counterparts.

6.3.11.4 Relationship between qualifications and current work

Linked to the specialised nature of training, degrees and jobs within the natural science professions, most of the respondents indicated a close alignment between their fields of study and current employment. According to a survey of 3.5 million homes, the United States Census Bureau reported that 75% of all BSc degree holders in STEM fields do not have jobs in STEM occupations (Robinson, 2014). Similar trends have been observed in the United Kingdom, where *"STEM graduates were more likely to work in teaching and management than in key 'shortage areas' such as science, engineering and ICT"* (Smith and White, 2018).

Figure 51: How would you describe the relationship between current job and qualifications? (%)



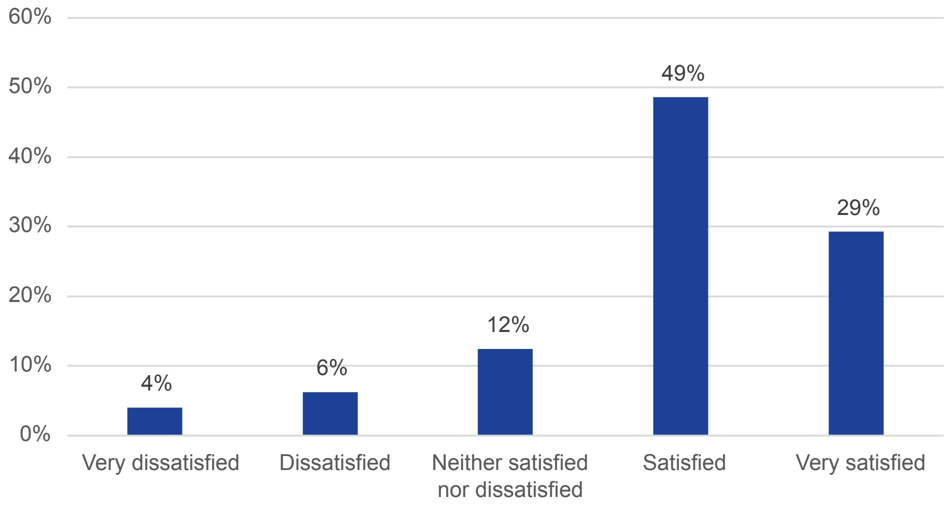
Source: HSRC-SACNASP Track and Trace Survey 2021

Within the South African context, the LMIP study revealed that *"a high proportion of the Science and Engineering graduates prefer to work in the financial services sector" (Reddy et al., 2016, p. 10).* While most of those who study STEM subjects veer into other fields, the data from SACNASP shows that most natural scientists in the sample have jobs related to their field of study. This evidence is, however, based on the natural science database, and further analysis of a wider dataset will be needed to understand the extent of natural scientists veering into other professions, and how to promote and support more young people coming into the natural science fields of study and related professions.

6.3.12 Satisfaction levels with current job

In terms of job satisfaction, close to 80% of natural scientists are satisfied with their current employment conditions, with 30% expressing high levels of satisfaction. Less than 10% expressed some form of dissatisfaction.

Figure 52: Overall satisfaction with current job



Source: HSRC-SACNASP Track and Trace Survey 2021

6.4 Natural scientists in self-employment

As observed in Table 15, 17% of natural science professionals are self- employed. This section provides a broad overview of the experiences of natural science professionals who consider themselves as self-employed. The discussion starts by examining the distribution of the self- employed across the various fields of studies, investigate the nature of enterprises, look at their size, the industrial sector in which they operate, and will also offer some insight regarding challenges facing businesses enterprises which can serve as barriers to the development and expansion of the enterprises.

6.4.1 Self-employment by field of practice

Table 21 provides a detailed overview of the distribution of scientists who are self-employed by field of practice. The analysis provides evidence for an association between self-employment and field of study, where scientists with backgrounds in Geological (15%) and Environmental sciences (13%) were more likely to be in self-employment. These are followed by the Botanical sciences (8%) and Animal sciences (6%) although with much lower proportions. Results also point to striking differences in business ownership by race, demonstrating that White scientists are more likely than scientists of other race groups to be in self-employment.

Table 21: Self-employed Scientists by Field of Study (n = 236)

#	Field of Study	B-Male	B-Female	W-Male	W-Female	I-Male	I-Female	C-Male	C-Female	Total	%
1.	Agricultural Science (Includes Forestry and Wood Science)		1	7	1					9	4%
2.	Animal Science	3		5	7					15	6%
3.	Aquatic Science (Includes Marine -	1		2	3	1				7	3%
4.	Botanical Science	3	1	7	9					20	8%
5.	Chemical Science (Includes Industrial Science)	1		4						5	2%
6.	Conservation Science			2	2					4	2%
7.	Earth Science	2	1	4	1					8	3%
8.	Ecological Science	1		5	4					10	4%
9.	Environmental Science	1	5	6	16		2		1	31	13%
10.	Food Science	1	1	1	2					5	2%
11.	Geological Science	4		23	6	2				35	15%
12.	Mathematical Science			1	1					2	1%
13.	Microbiological Science	1	1	1	1					4	2%
14.	Soil Science			2	2					4	2%
15.	Water Resources Science (Include			2	2					4	2%
16.	Zoological Science	2		4	1		1			8	3%
17.	Other	1	4	34	15	4				58	25%
	Grand Total	**21**	**14**	**113**	**76**	**7**	**3**	**1**	**1**	**236**	**100%**

Source: HSRC-SACNASP Track and Trace Survey 2021

6.4.2 Reasons for being self-employed

The literature indicates that individual may choose to be self-employed for different reasons. It has been suggested that for analytical purposes, self-employment could be classified into two broad types, namely, (a) "*those who have entered voluntarily for reasons such as independence, job satisfaction, or anticipated higher incomes and (b) those that have 'been pushed' into self-employment because of the absence of any other attractive alternative*"(Dawson, Henley, & Latrielle, 2009, p. 2). Reasons associated with the former which have to do with improving one's quality of life and exploring creative entrepreneurial opportunities are often perceived positively and, in this instance, public policy seeking to encourage entrepreneurship would successfully yield sustainable economic and social benefits.

Table 22 below shows more than half (51%) of all self-employed natural science professionals made a conscious decision or choice to become self-employed to gain greater independence, which is not always the case with those employed in an organisation. About 14% opted for self-employment since they could not find a job. Just under a tenth (9%) wanted to work more flexibly. This is a positive finding demonstrating that natural science business ventures could benefit from improved business support and development initiatives. Hence, SACNASP and other relevant stakeholders can thus support the scientists to not only seek for employment but also become entrepreneurs and create jobs for other non-natural scientists within their enterprises. This has implications in the development of curriculum and pedagogy to integrate courses and practices to support entrepreneurship. This will go a long way to alleviate the high unemployment levels affecting the South African economy.

Table 22: Why did you choose to be self-employed? (n = 235)

Reason	B-Male	B-Female	W-Male	W-Female	I-Male	I-Female	C-Male	C-Female	Total
n	**20**	**14**	**113**	**76**	**7**	**3**	**1**	**1**	**235**
Could not find a wage/salary job	35%	36%	9%	11%	14%	33%			14%
Greater independence as self employed	35%	29%	55%	53%	57%	67%	100%	100%	51%
More flexible hours of work	5%	36%	4%	14%					9%
Higher income level	10%		8%						5%
Other	15%		24%	22%	29%				21%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: HSRC-SACNASP Track and Trace Survey 2021

Further observations from Table 22 above are that:

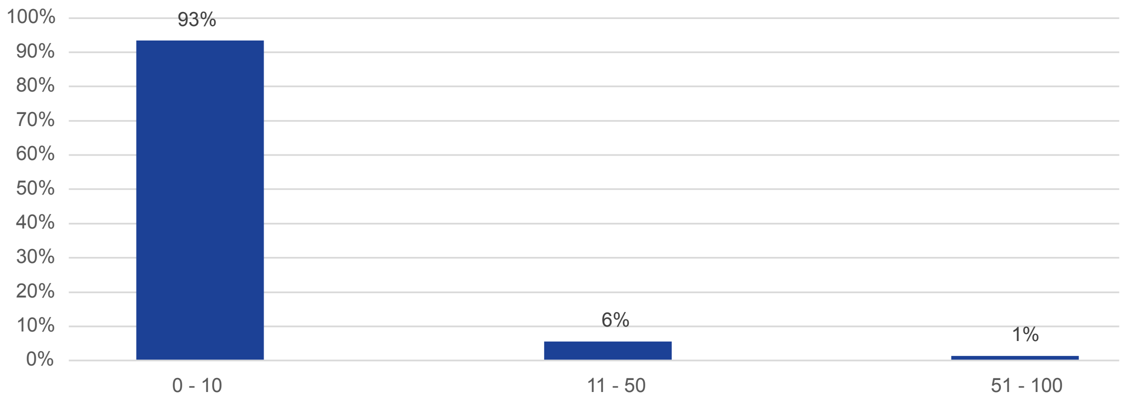
- Africans (both males and females) constitute a larger proportion (35%; 36%) of those who started businesses because they could not find work.
- Whites (both males and females) (55%; 53%) as well as Indian males constitute a larger proportion of those who started business because they sought greater independence. This entrepreneurial capacity can be linked to social capital and networks of friends and family which can provide support and guidance compared to Africans and Coloured graduates as has been shown in previous studies (CHEC, 2013; Rogan and Reynolds, 2016, Walker and Fongwa 2017)
- The observation of African females to opt for self-employment can be linked more to other care-giving responsibilities and lack of decent employment than the flexibility it affords.
- White and African males were also likely to cite enhancing income levels as motivations for self-employment.

A combination of need for independence and more flexible working hours indicates a need for more flexible working structures within the formal workforce. Experience from COVID-19 has accentuated the need for employers to consider more flexible, working-from-anywhere scenarios. Within the 'Other' criteria, most of the respondents indicated that they opted to become self-employed at the end of their formal employment term when they became retired from the formal structures. Being still passionate about their vocation, they became self-employed, creating work for themselves and others.

6.4.3 Business size

Analysis of the data show that 93% of natural scientists having a business wherein they are self-employed, the further create jobs for up to 10 other people.

Figure 53: How many people does your business employ?



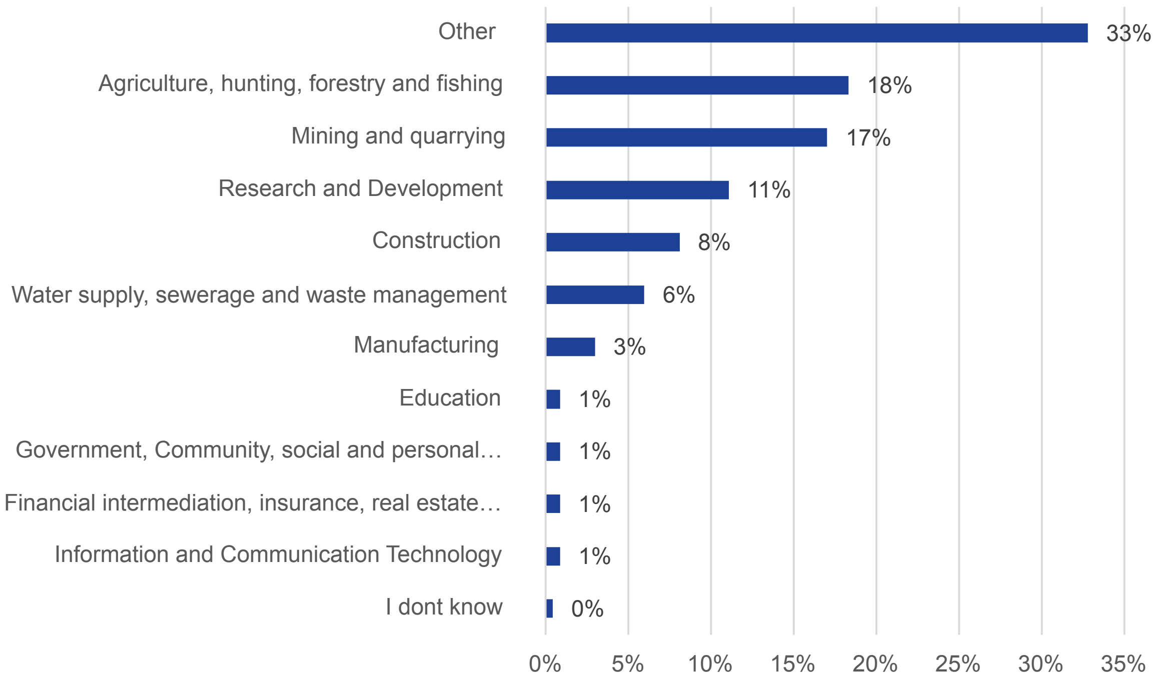
Source: HSRC-SACNASP Track and Trace Survey 2021

SACNASP can identify this type of business model and support its members not only in seeking employment but also in becoming entrepreneurs and creating jobs for other non-natural scientists within their enterprises. This will go a long way to alleviate the high unemployment levels affecting the economy.

6.4.4 Industrial sector into which the business falls

Linked to the broader employment sectors, most of the small, medium and micro-sized enterprises of natural science professionals fall within the traditional employment sectors, such as agriculture, mining, research and development, and construction. It is expected that the number of self-employed professionals within the government, community and social services will be less as there will be few consultants for government departments.

Figure 54: In which sector does your business fall under?

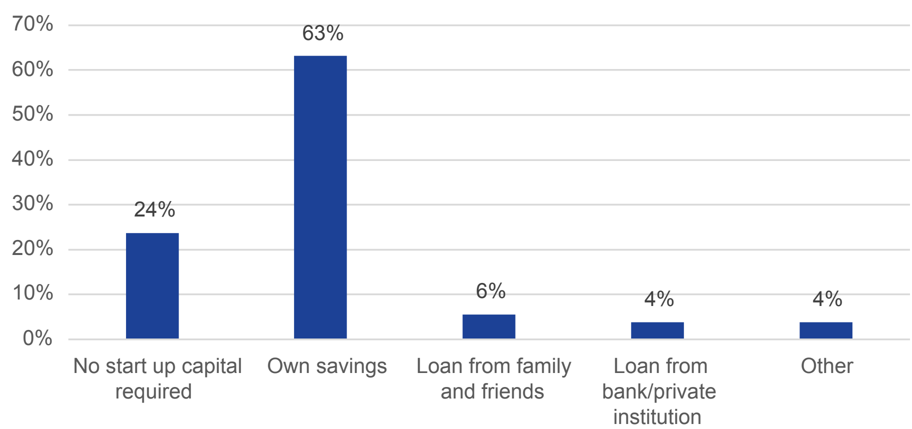


Source: HSRC-SACNASP Track and Trace Survey 2021

6.4.5 Source of start-up capital

Similar to the experiences of other small and medium-sized enterprises within the economy, most self-employed natural scientists used own savings as the main source of business capital. However, more importantly is the fact that about a quarter of self-employed natural scientists indicate that they never needed start-up capital. This is an interesting finding as start-up capital is always a significant limiting factor for emerging entrepreneurs.

Figure 55: What was the source of your start-up capital?

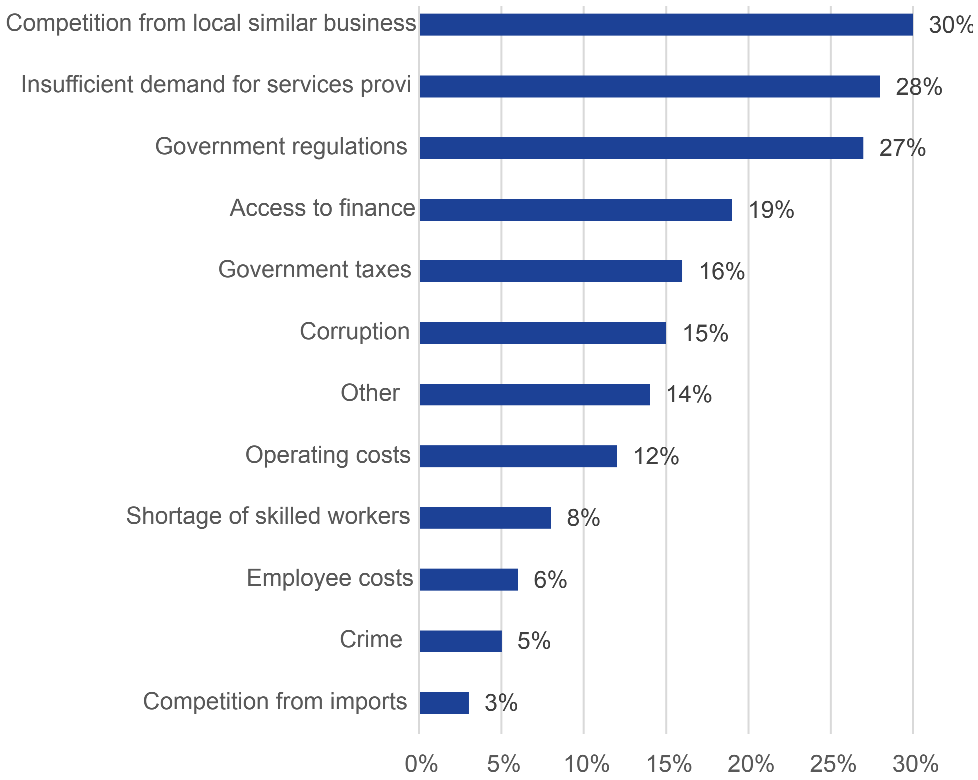


Source: HSRC-SACNASP Track and Trace Survey 2021

6.4.6 Key challenges facing self-employed scientists

Although access to finance has been identified as a major challenge facing SMEs in Africa and South Africa, natural scientists show a slightly different pattern regarding their most significant challenges. Competition from bigger businesses, especially corporates, along with weak demand for local services have been identified as the two main challenges.

Figure 56: What challenges does your business face?



Source: HSRC-SACNASP Track and Trace Survey 2021

Government regulations such as employment and hiring regulations, the tax system as well as business patterns in business ownership and management regulations could be perceived as constraining. This could be particular to family businesses, where government requires quotas of African ownership and control. Balancing transformation imperatives and supporting SME start-up and growth becomes critical not only for government but for potential entrepreneurs in general, and within natural science professions.

6.5 Natural scientists who are studying

One of the graduate outcome pathways of natural scientists, as observed from the analysis, is further studies. As expected, further studies are linked to the large metropolitan provinces which employ most of the graduates. These include KwaZulu-Natal (University of KwaZulu-Natal), Western Cape (University of Western Cape, Stellenbosch University, and Cape Peninsula University of Technology) and Gauteng (University of Pretoria, UNISA). The high enrolment at North West University can be attributed to its close proximity to Gauteng. As observed in the preceding section, there is a high number of natural scientists with Diploma qualifications, and this can be linked to the high enrolments in colleges across the country.

Table 23: Which university are you registered with?

University	Frequency	Percent of cases
University of the Free State	1	2
University of KwaZulu-Natal	8	17
University of Limpopo	2	4
Nelson Mandela University	2	4
North West University	4	9
University of Pretoria	6	13
Rhodes University	1	2
University of South Africa	2	4
University of Stellenbosch	1	2
Walter Sisulu University	1	2
University of Venda	1	2
University of the Western Cape	3	6
Cape Peninsula University of Technology	1	2
Central University of Technology Free State	1	2
Tshwane University of Technology	1	2
Vaal University of Technology	1	2
Other college, please specify	3	6
Other university, please specify	8	17
Total	**47**	**100**

Source: HSRC-SACNASP Track and Trace Survey 2021

6.5.1 Scientists in further studies by population group

Table 24: Distribution of natural scientists in further studies by race

	African	Coloured	Indian / Asian	White	Total
Frequency	**37**	**1**	**1**	**8**	**47**
PhD	2	0	0	0	2
DTech	1	0	0	0	1
MSc	**13**	**0**	**0**	**6**	**19**
MTech	1	0	0	0	1
BSc Honours	**15**	**1**	**1**	**1**	**18**
B Tech	1	0	0	0	1
BSc 3 year	3	0	0	0	3
Diplomas	1	0	0	1	2

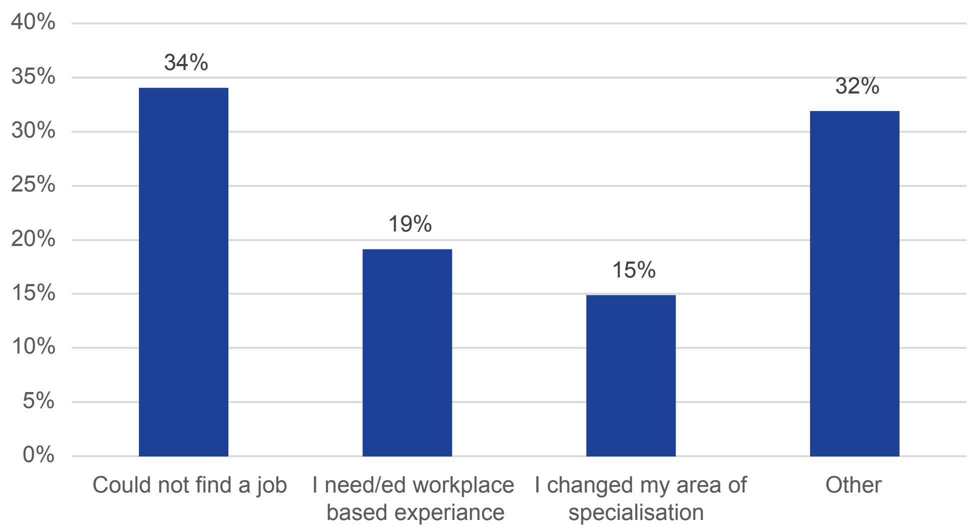
Source: HSRC-SACNASP Track and Trace Survey 2021

Such a distribution reflects some of the challenges facing African graduates in securing meaningful employment within the broader society. Previous studies have suggested that some employers are reluctant to employ graduates from the historically disadvantaged Black universities, which most African graduates come from, and hence the need for these graduates to further their studies, sometimes at the historically advantaged universities for Honours or Master's qualifications which would be better recognised by these employers (Walker and Fongwa, 2017).

6.5.2 Main reason for continuing with studies

With growing unemployment in South Africa and the need for more specialised skills and attributes, more professionals are advancing their qualifications in order to enhance their possibility of securing their preferred employment or any relevant employment. More than 50% of those in further studies said that it was job related and not necessarily due to their academic interest. However, it is important to note that once employed, natural scientists still continue with various aspects of further studies and specialisation in their current disciplines or towards changing specialisation.

Figure 57: Primary reason for continuing with your studies



Source: HSRC-SACNASP Track and Trace Survey 2021

Other reasons
Academic interests
Broadening my skill base
Career progression and reskilling to better respond to the job market
I do not have experience and I'm not a registered scientist
I needed more
I needed something to do
I needed to gain expertise in my desired field of research, and increase my chances of getting employed
I want to be in academia and continue with research
I wanted to further my studies and to change career
I wanted to learn more about nature
I wanted to specialise in agricultural project management
Interest in the development of photonic materials which I was using as devices during my Master's and undergraduate projects
Professional advancement
To attain the peak of my career
To enable socio-enviro stewardship

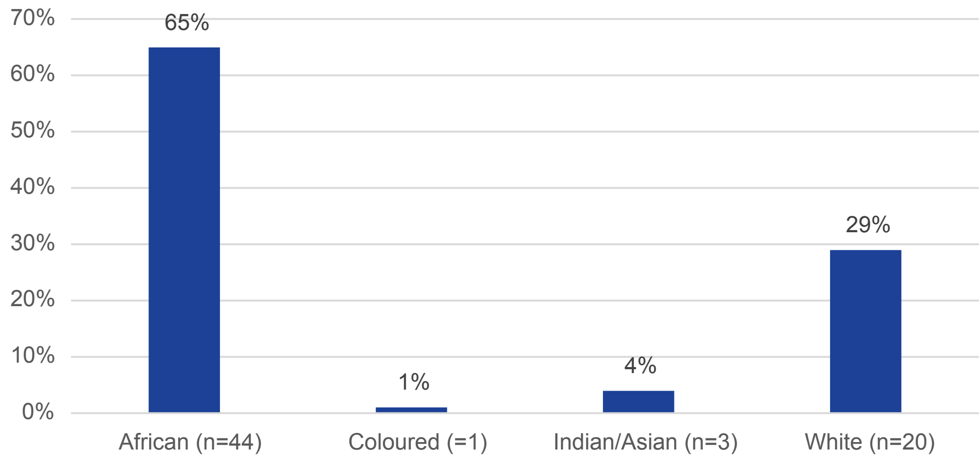
Source: HSRC-SACNASP Track and Trace Survey 2021

When analysed by population group, it seems that most of those studying full time are Africans, who account for about 80% of the full-time studying scientists, with Whites making up 17%. Analysed by levels of studies, it becomes interesting to note that two qualification levels contribute about 80% of all those furthering their studies. Of the total 47 respondents currently studying full time, 19 are enrolled in a Master of Science degree programme (representing 40%), while 18 respondents (representing 38% of respondents) are enrolled for an Honours degree. Of these figures, 15 MSc students are African while 6 are White, while 15 of the Honours graduates are African while the other population groups are represented by one student.

6.6 Natural scientists in unemployment

Unemployment continues to be a stark reality in South Africa, affecting almost all economic and professional sectors. The recent unemployment statistics from Stats SA (2021) with unemployment rates of 30.1% within the last quarter of 2020 confirm the growing trend across the economy, which is compounded by COVID-19 effects (Stats SA, 2021). However, as seen in Figure 53 below, data from the survey of natural scientists suggest a significantly low unemployment rate of about 5%, with only 68 respondents indicating being unemployed.

Figure 58: Population group of the unemployed (n = 66)



Source: HSRC-SACNASP Track and Trace Survey 2021

Further analysis of these unemployed respondents provides a clear understanding of the nature of unemployed natural scientists within SACNASP. Firstly, the analysis shows that more than two-thirds (68%) of all unemployed natural scientists are youths below 35 years of age. This group has also been identified by Stats SA as the most vulnerable group after the 15–24-year-olds. In the first quarter of 2020 more than 43% of young people within the age range of 15–34 years were unemployed. The age group with the second highest unemployment were those above 60 years (18%). These are most likely officially retired scientists who might be busy with other private or personal activities, but not considered as formally employed or not active consultants within the self-employed category.

Stats SA as well as other graduate tracer studies in South African have strongly shown that Whites and White graduates have a much more significant probability of getting employed compared to their African/Black counterparts.

6.6.1 Unemployed scientist by field of practice

A question of interest is which fields of study have highest proportions of scientists without work? To address this question, Table 25 provides the distribution of the unemployed scientists by field of practice and shows that levels of unemployment vary significantly across the different fields of practice with race and gender effects also at play.

Table 25: Unemployed Scientists by Field of Study (n = 69)

#	Field of Study	B-Male	B-Female	W-Male	W-Female	I-Male	I-Female	C-Male	C-Female	Total	%
1.	Agricultural Science (Includes Forestry and Wood Science)	5	2						1	**8**	*12%*
2.	Animal Science	4	5				1			**10**	*14%*
3.	Biological Science	1	4		1					**6**	*9%*
4.	Botanical Science			1						**1**	*1%*
5.	Chemical Science (Includes Industrial Science)			1						**1**	*1%*
6.	Earth Science			1						**1**	*1%*
7.	Environmental Science	1	4	1	1		1			**8**	*12%*
8.	Extension Science	2	1							**3**	*4%*
9.	Food Science			1						**1**	*1%*
10.	Geological Science	2	3	1	1					**7**	*10%*
11.	Physical Science (Includes Radiation Science)	2	1			1				**4**	*6%*
12.	Soil Science	2	1							**3**	*4%*
13.	Water Resources Science (Includes Hydrological and Water Sciences)	1	2							**3**	*4%*
14.	Other	2	1	7	3					**13**	*19%*
	Total	**22**	**24**	**13**	**6**	**1**	**2**		**1**	**69**	**100%**
	%	**32%**	**35%**	**19%**	**9%**	**1%**	**3%**	**0%**	**1%**	**100%**	

Source: HSRC-SACNASP Track and Trace Survey 2021

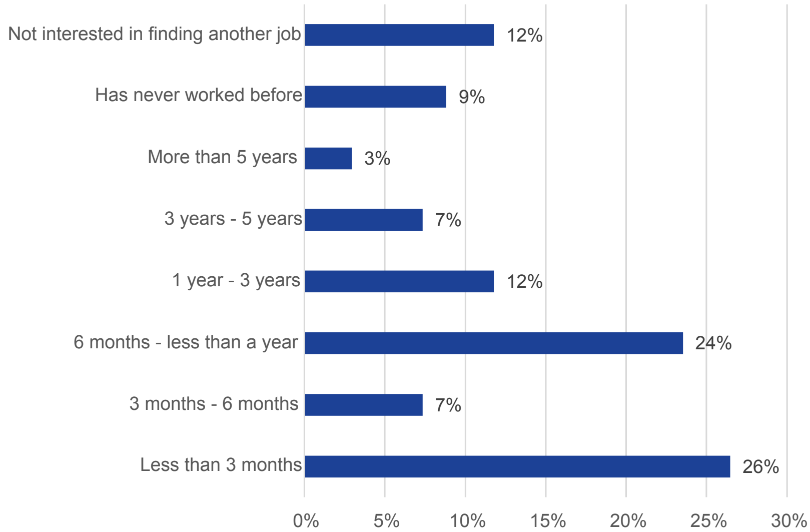
The largest proportion of unemployed scientists came from the Animal sciences (14%), followed by Agricultural sciences and environmental sciences (12%), then the Geological sciences (10%) and Botanical sciences (9%). Further analysis also reveals that African male and female scientists were overrepresented amongst the unemployed within the various study fields. For instance, African males were predominantly found amongst the unemployed in agriculture and animal foods, whilst African females dominated the Animal, Biological, and Environmental sciences.

6.6.2 Duration in unemployment

Unemployment duration is an important indicator of future labour market participation prospects. When an individual is out of work, their skills may erode due to lack of use. The erosion of skills or depression of human capital increases as time passes. Prolonged periods of unemployment are also associated with reduced social capital, which are networks which make it easier to find work. Overall, periods of unemployment tend to diminish further chances of finding work in the future. Figure 59 shows that almost two-thirds of the scientists have been without work for only 6 months or less.

About 33% of natural scientists who participated in the survey have only been without work for six months or less. Almost 20% have been without work and engaging in job search between 6 months to a year. About 22% have been unemployed for a about a year and above. This is a group which is of concern as it has been indicated that those in long term unemployment are likely to remain unemployed. Notably, about 12% said they were not interested in finding work.

Figure 59: How long have you been without work and trying to find a job? (n = 68)

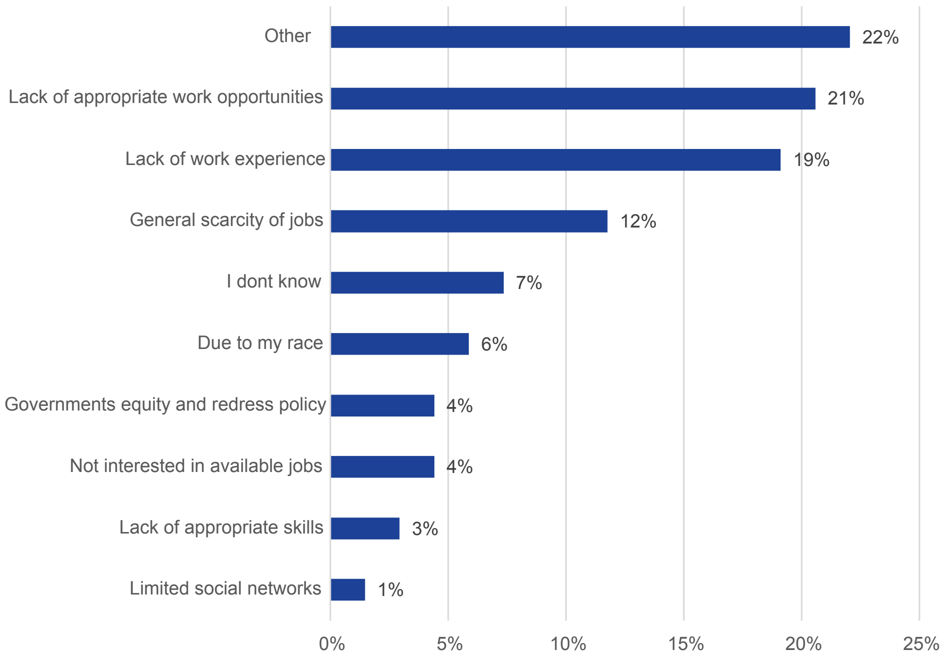


Source: HSRC-SACNASP Track and Trace Survey 2021

6.6.3 Perceived reasons for unemployment

The scientists were also asked to indicate what they think to be the main reason for being unemployed. Results show that a larger proportion of 21% cited lack of appropriate work opportunities. This was followed by 19% that cited a lack of work experience. About 12% attributed their status to the general scarcity of jobs. About 6% said it is because of their race that they have not found a job. This is also linked to 4% who said it is because of the government equity and redress policies that they have not found employment. Another 4% said they are not interested in available jobs, whilst a further 3% cited lack of appropriate skills. Just 1% said they lack social networks to assist them in finding employment.

Figure 60: Reason for persistent unemployment (n = 68)



Source: HSRC-SACNASP Track and Trace Survey 2021

Figure 59 echoes some of the skills perceived by natural scientists as critical in securing a job in the current context, as well as within the forthcoming 4IR context. From the analysis of the open-ended questions, computer-related skills, including coding and data analysis, and ability to work with Geographical Information Systems software are perceived as key skills for the 4IR. Current skills needed include good knowledge of subject matter, research and report writing skills, networking skills and soft skills such as communication and presentation skills. Another important set of attributes identified includes personal attributes or right attitude displayed through hard work, integrity, passion, resilience, and a good work ethic. Practical work experience was identified as a key skill within the current economy; it was not perceived as critically important for the 4IR.

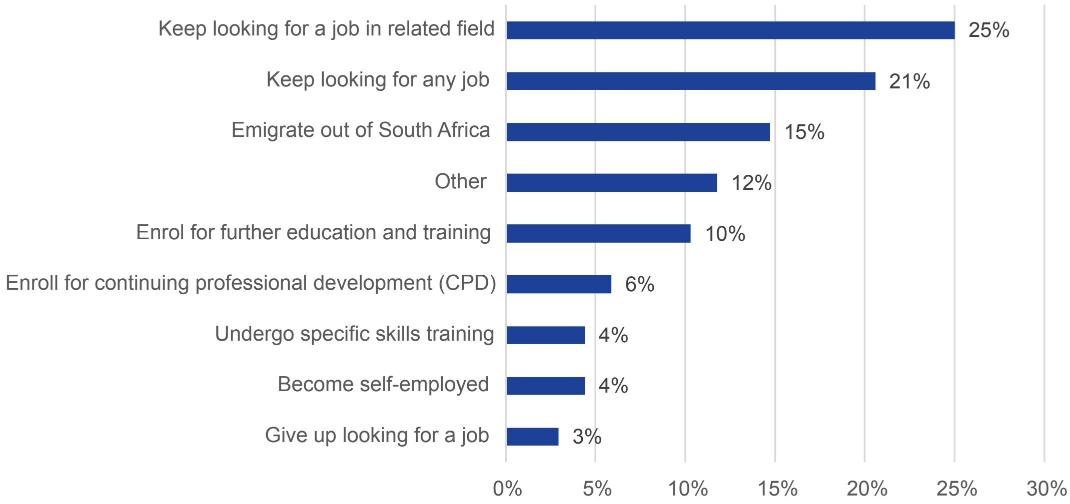
Table 26: Emerging and current skills needs

Factors	Emerging skills and training (558)	Current skills needed (673)
Computer skills / New technologies	116	36
Big data analysis / statistical skills	65	18
Coding / Programming skills	56	5
Good subject knowledge	51	62
GIS Skills	43	8
Research / Report Writing skills	42	66
Good Communication / Presentation skills	31	84
Problem solving / Entrepreneurial mindset	30	30
People Skills / interpersonal / Networking skills	28	38
Project management	24	24
Practical skills / work experience	13	56
Right attitude (Hard work, integral, commitment, resilient, passion, work ethics, etc)	13	61
Lifelong learner	12	41
Adaptability	8	57
Emotional intelligence	8	1
Fieldwork	6	1
Social science skills	5	5
Critical thinking / Analytical skills	4	35
Ability to work independently	3	10
Confidence	0	1
Financial management	0	3
Leadership	0	16
Teamwork	0	15

6.6.4 Plans to change unemployment status

Those in unemployment were asked to indicate what they were doing in the first few months to change their employment status. On a positive note, about 46% indicated that they will continue looking for employment, with only 3% indicating that they are giving up looking for employment. A quarter (25%) said they will continue looking for work in related fields.

Figure 61: What are you planning to do to change your status? (n = 68)



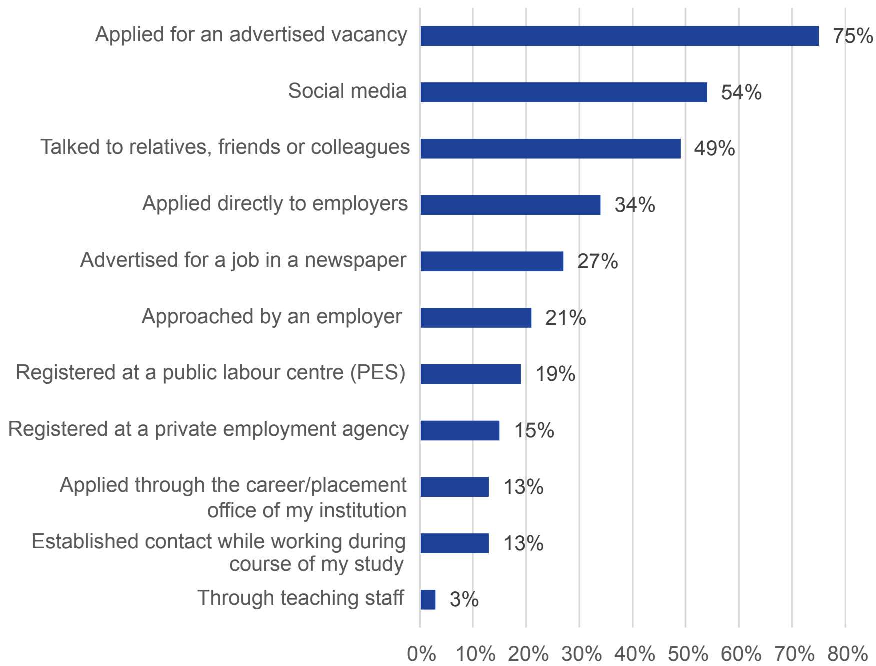
Source: HSRC-SACNASP Track and Trace Survey 2021

Notably, about 21% said they will continue looking for any job, demonstrating some level of desperation. Of concern is the 15% who have resorted to emigrating out of the country. About 10% are planning to enrol for further education and training. Equal proportions of 4% are planning to start their own businesses and to undergo specific skills training.

6.6.5 Job search behaviour of those in unemployment

The analysis of how the unemployed scientists were searching for work shows that most rely on responding to advertised job opportunities (75%). This is followed by the use of social media to look for employment vacancies (54%). The third commonly employed job search technique is the use of social networks, specifically enquiring from family and friends (49%). A few scientists have advertised in newspapers and journals, registered with public and private agencies, made use of university career offices or enquired from teaching staff. Overall, the analysis shows that the unemployed scientists employ a wide variety of job search strategies concurrently, with responding to job adverts, social media and social networks playing a bigger role.

Figure 62: How are you looking for employment? (n = 68)

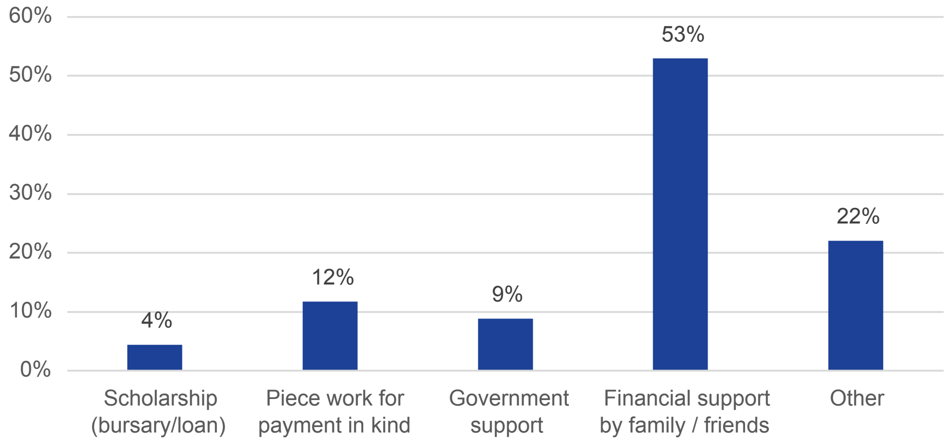


Source: HSRC-SACNASP Track and Trace Survey 2021

6.6.6 Socio-economic support of the unemployed

About half (53%) of the unemployed natural scientists depend on family and friends for financial support. Less than 10% of the unemployed benefit from Government support structures. Some of the students have bursaries and scholarships which provide financial support.

Figure 63: Sources of financial support for unemployed natural scientists (n = 68)



Source: HSRC-SACNASP Track and Trace Survey 2021

6.6.7 Factors sought when looking for employment

To further understand career aspirations of the unemployed scientists, these individuals were asked to indicate specific factors that they consider when looking for work. Scientists are largely concerned about finding work which is aligned to their qualification, skills or training. The second most important criterion considered is the salary. Other factors mentioned included the extent to which work is seen to be interesting, whether there are career development opportunities, the extent to which it will enable the scientist to achieve work-life balance, job security, ability to work from home and hours of work. Three individuals had no set criteria and were prepared to take any job available.

Table 27: Most important factors you consider when looking for a job (n = 66)

Factors	Frequency	Percentage of cases
Suitability with qualifications/skills/training	23	35%
Wages or income	13	20%
Interesting work	7	11%
Career prospects or chances for promotion	6	9%
A job that fits in with my family responsibilities	5	8%
Job security	4	6%
No criteria, I will take any job	3	5%
Work environment safe during COVID-19 pandemic	2	3%
For the benefits, such as medical aid, pension, etc.	1	2%
Job that is close to where I live	1	2%
Able to work from home	1	2%
Working hours	0	0%

Source: HSRC-SACNASP Track and Trace Survey 2021

7

Stakeholder perceptions of Natural Science graduates' employment outcomes

Samuel Fongwa and Bongiwe Mncwango

This section uses qualitative data collected through stakeholder interviews, including students and graduates, private and public sector employers, academics and university career offices, to deepen and contextualise some of the statistical analysis as well as provide more nuances to the perceived trends of natural science graduates' outcomes. The analysis of the data supports existing knowledge on the general outcomes of graduates, while providing nuanced emerging findings specific to natural science graduates. Findings show that natural science graduate employment outcomes are affected by demand factors, supply factors and personal factors.

7.1 Demand factors

Demand factors are characterised by two main issues: the nature of the economy, and the attitude of employers towards natural science graduates.

7.1.1 State of the economy and role of employers

One of the most significant factors affecting employment outcomes of graduates in general and natural science graduates is the capacity of the economy to create enough jobs to absorb the growing number of graduates released into the labour market every year. As demonstrated using the quantitative data, there is a close correlation between the macro economic performance of the country and the capacity of the economy to attract, absorb and keep graduates in employment. This is even more so for natural science graduates, considering the structured nature of the natural science employment sector. With the shrinking economy, most employers have downsized their business operations, limiting their capacity to employ. One of the employers in the mining sector captures this sentiment as follows:

> *Well, in South Africa, the problem is the mining industry is in decline … the gold, to a certain extent, the platinum. And, you know, we're training. Wits University training and I know [unintelligible] is because I've seen in the biggest other universities. We are training a hell of a lot of people to go into the natural sciences and engineering science and there aren't jobs, you know, in the country as a whole 29% of the population does not have a job.*
>
> **— Mining and Geological Employer**

Recently a high number of employees have been retrenched by the mining sector, and Anglo-Gold Ashanti has recently decided to leave South Africa and expand its mining operations outside the country. While there is positive sentiment that the assets are taken over by local firm Harmony, there are growing concerns about the implications for the economy, jobs and investment outlook.

Employers play a number of roles in the employment outcomes of natural science graduates. One of these roles is the provision of internship opportunities for students as part of their training or after graduation. These internships or work-integrated learning opportunities provide the students or graduates with the necessary practical and technical skills needed for future employment. A public sector employer in the agricultural sector attests to this:

> *Yes, we have an internship programme every year. There's a call from our sector education and training. We have sector education and training that offers bursaries and for experimental training. Even this year, it's been extended; it was normally for 12 months, but now it's been extended for two years.*
>
> **— Government employer Agriculture**

Furthermore, there is a sense that employers are raising the levels of entry qualifications to a minimum of Honours and Master's degrees. This can be linked to the increasing number of Bachelor's degree graduates and the need for more specialisation. While professional bodies register graduates from as low as diplomas and certificates, an Honours degree is usually required to register at professional levels. Employers can also be enhancing employment outcomes of graduates affiliated and registered with SACNASP and other Vas, as they increasingly request membership of professional bodies. This can be perceived as a form of regulation and quality control for those who might not be operating within the approved standards of the profession.

> *I think it [does], sometimes. I come from Nelson Mandela University, and yeah, maybe here in office, very few of us, but I think your UCTs, your Wits, your Tuks, they do give you that extra edge, but at the same time, I was fortunate ... you have to have those attributes to push on to be able to keep that work, get as best as you can just, until things happen. Sometimes you need a little bit of luck here and there.*
>
> **— Employed Graduate**

However, while these perceptions exist, there are also institutional factors across universities' curriculum, pedagogy and cultures which prepare some graduates better than others.

7.2 Supply factors

From the analysis of the interview data from the stakeholders, three supply factors are presented. First is the nature of the qualifications, followed by the variance across institutional types, and the role of career guidance offices

7.2.1 Nature of the qualification

In the current changing nature of work, with social skills being more important in the working environment, these effective teaching practices are even more relevant for natural science graduates. These graduates generally work in non-social environments like laboratories and in the field, away from the natural social and human settings. The need for soft skills such as communication, emotional intelligence, communication and presentation skills is becoming more critical for all graduates, and more so for natural science graduates. The analysis of the data suggests that natural science graduates are not effectively developing these skills. Reasons for the lack of development are both linked to the narrow nature of the curriculum and also the attitude of graduates in general – maybe more so with natural science graduates.

Two of the major private employers interviewed identify the disconnect between academic curriculum of natural science graduates and the expectations of the employers and regulatory councils. In some universities the nature of the academic programmes, such as in Geological Sciences, does not permit the graduates to register as professional members within the professional regulatory bodies. While this could be perceived as an individual experience, it suggests that some of the universities and degree programmes do not provide the students with adequate information regarding potential employment outcomes and professional membership.

> *They'll offer them geology up to third year and if they want to move into the geotechnical field, they will make them do an MSc in engineering ... But because they don't have 4 years of geological training, like you would if you did an Honours, you cannot register as a professional certificated natural scientist; and they lead them down the wrong path and then they make them do this MSc Engineering course. And then they enter the workforce, and they are there and in the second year working and find out that [they] can't get registered.*
>
> **— Geological and Engineering Consulting Firm Senior Management**

Also linked to the nature of the qualification, one of the universities acknowledges that some of the graduates have suffered less favourable employment outcomes because their qualifications did not meet the minimum expected requirements by employers and regulatory bodies. The university previously offered a Bachelor of Agriculture degree which did not meet the minimum requirements of natural science subject content. Hence, graduates from the department struggled to register with relevant professional bodies, including SACNASP. Based on consultation with external stakeholders, including employers and SACNASP, they have identified this limitation in the curriculum and have revised the curriculum to enhance the employment outcomes of their graduates, as explained below:

> *The member of SACNASP highlighted that [besides] having high points on physical science, mathematics or whatsoever a degree should consist of, I don't know whether it was 70 to 30% of science. And when we looked at our module content or programme, it doesn't meet that. So, it might be one of the reasons that when some of the students are applying to be candidate scientists, so when they apply to be professional scientists some were rejected. Hence, we want to beef up the programme that we have so that it can be in line with what is needed by the professional bodies, and the employers – be it the private or the public sector.*
>
> **— HoD Agricultural Economics at HDU**

Furthermore, they have observed that using the terminology of Bachelor of Agriculture (BA) instead of BSc Agriculture undermines the natural science value of the qualification and sometimes presents challenges in registering with a science body, because their qualification is perceived as a Bachelor of Arts and not Bachelor of Science.

> *Yes, we're still in the process of recurriculation of our curricula because we have realised that we have been offering this BA of Agriculture Economics for quite some time. The response in the market is quite slow ... our graduates are not getting employment as it used to be in the past. Now we decided that it is better to change to BSc Agricultural Economics so that at least the market can recognise these qualifications, because if it is a BSc it has got some weight, a lot of weight more than the qualification of B Agric...*
>
> **— Lecturer HDU**

The above experience highlights the importance of aligning the names of qualifications with relevant SACNASP designations. This enhances the students' outcomes and places the universities in the relevant position in terms of the employability of its graduates and ensures closer collaboration with SACNASP and potential employers.

7.2.2 Institutional variances

The difference in qualification ultimately affects how graduates from one university are perceived by employers when compared to others. While graduates from some universities are perceived as more ready for the world of work, others struggle due to inherent institutional challenges linked to the university, their degree quality or the experiences acquired at university outside of their degree programme.

From the evidence obtained from recent graduates, employers and even academics, graduates from historically advantaged universities (HAUs) seem to get better employment prospects compared to those from historically disadvantaged universities (HDUs). Analysis of the data suggests several reasons attributed to this perception and observation. Primarily, it is the difference in curriculum and pedagogy which shapes the effective teaching and learning practices, which ultimately affect the employability of natural science graduates. Even academics from HDUs assert that the universities are less resourced compared to the HAUs. This is particularly observed in the quality of the laboratories, libraries and student to staff ratios as a proxy for quality. One of the respondents from an HDU concurs as follows:

> *Now as someone who sits in summits, the argument about the standard of our labs comes up quite often. So, I'm tempted to agree with them. I mean, I can't argue on that one ... But I know I mean from general discussions within those different forums, it's always the case [of poorly resourced labs], it comes up that they are under-resourced in terms of their laboratories. Yeah. It is a fact.*
>
> **— Rural-based HDU Institutional respondent**

One of the natural science graduates from another HDU explains his experience of participating in chemistry practical as follows:

> *Sometimes we didn't even have enough equipment, you find that in a practical [session], we're divided into 5 or maybe 7 students at a station. And then at the next station there's DNA extraction for example. And then there will only be 1 student who would have the opportunity to use the pipette.*
>
> **— HDU Graduate**

Despite the strong theoretical base of the curriculum and training of students and graduates from HDUs, the reported lack of adequate exposure to the practical components of the training process is partly accountable for the perceived lower employment outcome of these graduates. Furthermore, the student staff ratios, which ultimately affect the class sizes and hence the opportunities for engaging with students at personal level, limit adequate preparation. One of the respondents from the HDUs confirms that large class size limits their preparedness and hence their possible employability.

> *I think it [does], sometimes. I come from Nelson Mandela University, and yeah, maybe here in office, Yes, yes, ... talking about our classrooms, the state of our classrooms, some are not in a usable state, forcing us to have bigger classrooms and in terms of preparedness, yes, it becomes an issue.*
>
> **— Rural-based HDU Institutional respondent**

Besides practical employment skills, universities do not adequately inform students and graduates about the various professional bodies they are supposed to consider affiliating with, towards enhancing their employment outcomes. This ultimately also limits their knowledge of the various career or employment options available to them. Most of the students/graduates interviewed did not know what SACNASP was prior to graduation.

> *We have a serious problem. I can tell you and assure you that 50% of us here, when we're at university, we never knew that there is a body called South African Council for Natural Sciences Professionals. Even the lecturer can't tell you about that. So, if you saying we talk about the future, we need to really, really start from scratch. The information is not relayed to relevant people. I didn't know about this body. I knew it through this other White woman. She was a researcher in agriculture. She told me; you should register with this body. And I was like, what is this?*
>
> **— Unemployed Male, HDU Graduate**

Earlier studies have also suggested that while students are not taking career counselling services as seriously as they should, most of the offices are also plagued by challenges such as short and under-qualified staffing, and are usually not represented within the entire university (Chireshe, 2012). This is particularly so for natural science students, who are usually more focused on their academic work in the labs or in the field and hence need more innovative strategies to attract and engage them in extracurricular-related activities.

However, some students and graduates, especially those from the HAUs, feel that they received adequate support from both their careers office and their academic programmes. One student recounts how doing group assignments and presenting regularly to class and to external stakeholders as part of their course enhanced her presentation skills, her confidence and her self-belief. Asked if she thinks her degree prepared her for the world of work, she responded as follows:

> *Yes. I think it did prepare me for my employment so I know that I also have to present because there was a lot of presentations because almost every course that I did, there were presentations, and some of the projects that they gave us like in final year and third year, they give you a project from Exxaro, you have to present to the CEO of Exxaro.*
>
> **— Black female unemployed HAU graduate**

Meanwhile some of the unemployed graduates from HDUs felt that their degree did not adequately prepare them for employment:

> *We didn't have many discussions, presentations as much ... it was theoretical plus when we had practicals it was tutorial ... I remember for my first interview I was a nervous wreck. I couldn't even get the basic concepts ... It was because I was asking myself if I was capable. Stressing and shaking and just messing everything up.*

Jackson (2014, p. 137-138) suggest that inasmuch as "what constitutes good teaching and learning is hotly debated", facilitating students' access to appropriate vehicles for enhancing employability is vital, and effective teaching practices are equally critically important for positive graduate outcomes (Pegg et al., 2012). Rogan and Reynolds (2015) also indicate that the quality of schooling affects access to university and ultimately employment outcomes. They observe poor employment prospects of graduates from HBUs, which to some extent aligns with earlier studies (Development Policy Research Unit, 2006); those employers continue to perceive graduates from HBUs as of lower quality.

As already shown in earlier studies on graduate outcomes, the lack of adequate skills developed at university relates to the limited or lack of curriculum-embedded activities or practices supported by relevant pedagogy to expose students to the practical dimensions of the workplace expectations. From the analysis of the data, it was also observed that most natural science graduates, like other graduates, do not have the core skills required to secure and excel in their preferred sector of work. From the analysis of the data, four main skill sets emerged. These include emotional intelligence, confidence, communication, and project management skills. These were also presented in the previous chapter as some of the core skills identified through the online survey of SACNASP members.

7.2.3 Careers guidance offices

Career guidance offices have a mandate to, inter alia, support students' preparedness for the world of work. This is supposed to be achieved through a variety of interventions, activities and programmes, including work-integrated learning, student work placements, CV writing and interview preparation coaching. From the evidence it is evident that while some universities are well resourced and supported to carry out this mandate, other universities struggle to meet the basic demands. HDUs seem to struggle much more than the HWUs. With employers increasingly demanding practical skills and work-relevant attributes from graduates, universities have a heightened obligation towards their students and graduates. One of the respondents from a comprehensive university agrees that while the emphasis has earlier been on work-integrated learning, they are now taking onto themselves the added task of preparing students for job search and job readiness.

> *So, at our unit, what we've now embarked on is we're starting to prepare them now, in terms of their CV preparation, interviewing skills, job search skills, and even career fair workshops. When employers come onto the campus, they mustn't just rock up there and go for the freebies, they must go there with a plan, they must go there armed with a CV or if it's an online application or whatever, but knowing what exactly to say within the first minute or two so that you can grab the attention of your prospective employer.*
>
> **— Comprehensive University Career Office Representative**

However, at another university the lack of human capacity and resources limits their ability to respond to the employability needs of the students.

> *Because we only 3, 4, 5 in the department, we 5 permanent staff members, it's a function that we have to split amongst the 5 of us to assist our students, because it doesn't formally reside within any department in the university. We've decided to take it upon ourselves so that we can also assist ...*
>
> **— Career Office Representative at Rural-based HDU**

The respondent above acknowledges that more could be done, although with only 5 permanent staff to cater for more than 20 000 students, they must do more to ensure graduates are better prepared. Furthermore, the representative from the rural-based HDU feels that the location of the university does not offer students opportunities for practical skills development. While employers are not very motivated to go to these rural locations, as shown in other studies (see Walker and Fongwa, 2017), even proactive students who want to use their agency do not also have opportunities like those at urban-based universities.

> *Maybe the best way to illustrate this would be by way of an example. Because I worked in Cape Town before coming here. The fact that students in cities have got proximity to industries makes it better. Because even though some might not necessarily be amenable to volunteering, but the need for cash forces them to go and seek jobs. So those weekend jobs count for something. And we are in an isolated area where we don't have an abundance of industries. So, the readiness of our students comparatively is not up to that level.*
>
> **— Rural-based University respondent**

7.3 Personal factors of the graduates

7.3.1 Attitude of natural science students

While the universities are making efforts to provide opportunities for students to develop relevant employability skills, the majority of students are not making the most of these opportunities. This seems even more the case for natural science graduates, who also confirm that they are more focused on the science than on other social activities. Asked if students make the most of the career guidance office interventions, the respondent from a rural university responded that students are less interested, and staff have to identify new ways of going to the students.

> *Unfortunately, not. They are not in spite of our orientation, where we tell first years about these problems, but what we have also realised is that the calibre of students that we are attracting now has drastically changed. In the past, you'd see queues at the Health Care Centre, at the counselling unit, at the Graduate placement offices. But now you will find students who want practitioners to go to them. So, the focus has changed. We now try and go to where they are, where we'd have those awareness campaigns, workshops and talks in the residences and in other public spaces. They do not come to offices in numbers.*
>
> **— HDU Career Office representative**

A natural science graduate from the University of the Free State agrees with the above observation as he describes his experience while at university:

> *I was one very socially awkward person, especially in varsity and maybe it's because I was person who was just too focused on the need to get this chemistry, I need to pass this … I was just absent-minded towards those things because I was focused on one thing and to a certain extent, it actually got bad because you can't always be stuck doing one thing and not breaking out and exploring other avenues and just relaxing your mind a little bit, so that you can maybe even improve your performance to a certain extent.*
>
> **— Unemployed BSc Graduate**

This observation was also affirmed by a representative from a comprehensive university who also feels that natural science graduates, especially those from the traditional universities, are not very keen on gaining practical exposure. However, she has not been able to engage with natural science students at her university.

From the other universities, you get a sense that natural science students are very focused on the academic work and not so much on extracurricular activities and things like being placed [in industry or workplace learning]. It would be interesting to know if that is also a factor here.

Even an employed graduate acknowledges that although coming from a more reputable university with field work integrated into her degree programme, she did not consider opportunities which should have enhanced her employment outcomes and has only been able to be employed currently because of the relationship between her current employers and the university where she did her Master's.

> *I had a lot of field work; I was very lucky. Yeah, basically at UCT we went out all the time, but I should have done work shadowing and internships, definitely, in order to get an idea of industry and I think it applies not even just to the natural sciences, I've spoken to a lot of people.*
>
> **— White female HAU Master's Graduate**

She concurs that having exposure, even to work shadowing outside one's field of study, enhances graduate employment skills such as communication and confidence.

7.3.2 Socio-economic background and social capital effects.

As in previous graduate employment outcomes studies, students' or graduates' socio-economic background tends to significantly influence access to other forms of capital needed to ensure better graduate outcomes. While more students from challenging personal backgrounds are making the most of opportunities such as government financial aid, private sector bursaries and other interventions, other students continue to face these socio-personal challenges. Relating to the need for preparing graduates for the 4IR, one of the academics in the Agriculture department had concerns that there is a lack of adequate resources for ICT preparation due to the lack of resources, but also due to the students not being able to have these facilities at home.

> *But here, it might have challenges given the fact that there is poor infrastructure in the environment. There are few labs for students to work on, whereby they don't have access to the internet and stuff. And bear in mind that the large percentage of students that are here, they're from mostly poor families. So, one wouldn't have his or her own [facilities] and they must use the company's and here they are limited.*
>
> **— Rural-based HDU respondent**

The above challenges in some respects have been compounded by the COVID-19 lockdown, for which effects will only be noticed when the current students graduate. While some universities have tried to provide limited internet data to some students, access to other academic resources for large groups of students has remained a challenge.

The role of social capital of the graduates has significantly contributed to graduates' employment, underemployment or unemployment. Middle-income families have friends and relatives who are or who know owners or managers of firms and businesses, and hence are more likely to gain access to internships and other academic and employment-related benefits (Ball, 2010). The CHEC study (2013) confirms that a key aspect of low unemployment of graduates with more affluent social backgrounds from Stellenbosch University and the University of Cape Town was due to the social capital they have, with about 28% of White graduates benefitting from social capital as a job search strategy compared to only 11% of African graduates.

8 Synthesis And Conclusion

Samuel Fongwa and Bongiwe Mncwango

This report has used a combination of primary and secondary data collected through qualitative and quantitative methodologies to identify, determine, and present the employment experiences and outcomes of natural science graduates. The report was conceived with the aim to enhance understanding of natural science graduates' experiences, while also providing scientific information for relevant stakeholders such as universities, graduates themselves, and SACNASP. From the preceding analysis of the data, several general and specific findings have been identified.

8.1 Synthesis and general findings

At the general level, it can be observed that graduate employment outcomes of natural science graduates closely follow the pattern of graduate employment of the general labour force. While earlier studies agree that the employment outcome of natural science graduates is better than for those from other fields, this study shows that such outcomes are significantly dependent on other factors, such as race, gender, institutional type and social capital.

8.1.1 The role of personal or background factors in labour market outcomes

The race of the graduate, the gender, and institutional type as well as level of work experience all emerged as significant factors in determining the employment outcomes of graduates. The survey results show that there are more male than female scientists in full-time employment. Whites have significantly larger proportions of scientists in full-time employment, compared to all other race groups. The picture shifts when looking at the distribution of part-time employed scientists; although this proportion is small, African scientists predominate that group. Further, scientists identifying as in self-employment were also more likely to be White. in fact, White scientist were more than five times likely to be in self-employment compared to African scientists. In contrast, African scientists were more likely to be found amongst those identifying as studying full time (although a small sample) or unemployed. Notably, natural scientists are predominantly aged between 35 and 65 years, with just over half the scientists aged 20–34 years in part-time employment and a large proportion of this group also studying further or unemployed. Interestingly, when looking amongst those aged 66 and above, they featured more amongst those in self-employment.

Natural science graduates from the more recognised or prestigious universities seem to have easy access to internships and ultimately employment. White graduates have a shorter time from graduation to labour force participation compared to their African or Coloured counterparts. Similar findings have been largely observed in earlier studies in South Africa. Case, Marshall and Fongwa (2019) provide a comprehensive account of the graduate outcome patterns, showing that aspects of race, gender, university type and field of study play significant roles in graduate outcomes. Case et al. (2019) also echo findings by Rogan and Reynolds (2016), who highlight the role of social capital in graduate outcomes.

8.1.2 Employable versus unemployable natural scientists.

Cognizant of other contextual factors, some of which have been presented in this study, evidence from the qualitative data suggest that graduates from some natural science fields are more employable than others. While graduates within the agriculture-related fields were more employable in 2013, the analysis shows that in 2018 graduates within the ICT field have a higher probability of being employed. Graduates from other fields such as Statistics and Information Technology are experiencing better employment outcomes.

This observation above highlights several factors affecting graduates. Firstly, there is a shift in natural science graduate employment within the changing labour market dynamics. The more technical and applied science fields, such as biotechnology and microbiology, have become more employable. Secondly, with the advent of the 4IR, along with applications for data science, artificial intelligence and deep learning fields with more numeracy applications, such as maths, physics and statistics and information and communication, are becoming more employable. In contrast, graduates from more general fields such as biology, chemistry and others are finding other employment opportunities outside the natural science fields.

8.1.3 Geographical factors and the location of universities

Another general finding concerns the location of both the university and the graduates. As observed in previous studies, the location of the university and the graduate seem to significantly influence their employment outcomes due to a couple of reasons. Firstly, most of the rural-based universities are less resourced compared to those in the major metros. These rural-based universities, which were historically the HBUs, lack adequate staffing, constant access to quality internet (on campus and in residences), laboratory equipment and adequately resourced libraries. They also lack access to internships and workplace learning due to a limited number of employers who can provide opportunities to work while studying.

Earlier studies have revealed a negative perception about graduates from the HDUs from employers, especially those in the private sector. Most employers prefer to employ graduates from the more prestigious universities, which are largely HAUs. While graduates from HDUs are already faced with inequalities of access and experience at university, this attitude from some employers continues to entrench what has been described as inequalities of outcomes (Duta and Iannelli, 2018).

A third general finding from the study, applicable to other graduate tracer studies, especially in South Africa, is the role of graduate career development and support units. The research findings suggest that most graduate support units are not fully equipped to support students and provide them with the necessary support to enrol for the right courses, and access internship and graduate training opportunities, as well as preparing them for job searching and employment after graduation.

8.1.4 Low unemployment of SACNASP members

Analysis of the survey data shows a high employment rate amongst natural scientists within the SACNASP database. While this does not necessarily suggest a low unemployment rate of natural scientists, a combination of the employed and self-employed natural scientists support the DHET finding that natural science occupations are in high demand, as observed in the DHET's OIHD list. This confirms the need for more natural science, and SET-related skills as captured on the OIHD list are natural science-related. Natural scientists also demonstrate high levels of satisfaction with their current employment conditions. However, within the low unemployed numbers, Africans continue to dominate. This aligns to broader unemployment trends within South Africa. Conscious efforts should be made to ensure more skills development, internships initiatives and continuous capacity development within the sector in general and for young African graduates.

8.1.5 Curriculum and knowledge of SACNASP

The main finding from the qualitative data concerns the role of curriculum and natural science training in preparing graduates for careers in the natural science fields. It was observed from several stakeholders (graduates and employers) that most graduates do not have the relevant soft skills needed to obtain or secure employment, as well as to facilitate collaborations with other scientists within the sector. The lack of these soft skills can be linked to the very technical and content-heavy nature of the curriculum, which most often does not provide time and occasions for graduates to find opportunities for practical training. This is even more so for graduates or students from HDUs. Another possible reason could be due to the ideological gap between universities' departments or course directors and the changing needs of employers.

8.1.6 Summary of the key findings

Table 28: Summary of findings

Research questions	Summary of findings
1. What are the final destinations of natural science graduates? ▪ What is the proportion of employed, unemployed and underemployed natural science graduates (2013–2018) cohort ▪ How has this changed over time?	▪ The survey revealed that natural scientists are largely employed, with some self-employed and some undertaking further studies. ▪ Less than 5% unemployment. ▪ From the LFQS data, employment has been high but is declining slowly, from 79% in 2013 to 76% in 2013. This aligns with the natural rise in unemployment figures.
2. What are individual, and institutional determinants that influence successful/unsuccessful transitions into the labour market? Specifically: ▪ How do these differ in terms of individual, demographic and sociodemographic profiles, including race, gender, and age? ▪ How does this differ in terms of institutional (type of university) characteristics? ▪ How does this differ across provinces with different economic and labour market structures? ▪ Overall, what factors significantly influence graduate destinations in terms of the three main possible labour market states: employment (and underemployment), unemployment or economic inactivity?	▪ Factors affecting natural scientists' employment outcome are similar to those affecting graduate outcomes in South Africa. Race, gender, field of study, university graduated from, social networks. ▪ White graduates seem more employable than other racial groups, with Africans reportedly less employable. ▪ Graduates from HWUs easily find employment compared to those from HDUs. ▪ As with most other sectors, natural science jobs are more concentrated in the three big economic provinces – Gauteng, Western Cape and KwaZulu-Natal. ▪ The nature of the economy: The weakening economy has significantly affected firms' capacity to absorb graduates.
3. What are key stakeholders' perceptions of employability attributes of natural sciences graduates in South Africa? ▪ What are their current understandings, propositions and assumptions regarding graduate employment in general, and for natural science graduates in particular? ▪ What factors do they perceive to be affecting the employment outcomes of natural science graduates? ▪ This includes skills, attributes and values, and other structural factors affecting graduate outcomes of natural science graduates.	▪ There is a important role for individual universities in quality training (resourcing labs and libraries, etc.) and aligning curricula to SACNASP registration requirements. ▪ Some qualifications were not aligned, such as BA Agriculture, now changed to BSc Agriculture ▪ Private employers continue to be negatively biased against graduates from HDUs. ▪ Graduates need to find opportunities to get some form of practical experiences prior to graduation. ▪ Career guidance offices need to link better with employers. ▪ Social capital continues to significantly affect graduate outcomes.

9

Recommendations

Several recommendations have been distilled from the analysis, findings and discussions.

9.1 Government to support employers in creating and retaining jobs

The employment of graduates in general and natural science graduates in this context is a function of the health of the economy. The South African economy has over the last decade experienced very little growth within a context of economic and policy uncertainty. The country's economic situation has also been made worse by the impact of the COVID-19 pandemic. The study has shown evidence of how the health of the economy can support graduate employment or can push potential employers out of the economy and beyond the country's shores, forcing even more loss of employment for the previously employed. This study hereby recommends more robust government efforts and interventions to create a conducive environment not only to attract foreign direct investment through foreign-owned business start-ups and growth, but also to motivate and support young graduates and entrepreneurs to start businesses. The partnership between labour unions, government and employers needs to support business growth across all sectors. The closing of major employers, including those in the mining and finance sectors, suggests the need for a greater role for government in facilitating a conducive business environment.

9.2 Universities to revise curriculum and training of natural science graduates

The study has shown that while natural science graduate training has rightly focused on developing the theoretical needs of the curriculum, graduates need more soft skills to navigate the job demands as stated by employers. Employers also demand soft skills such as communication, presentation, emotional intelligence, teamwork and report writing. Higher education institutions need to do more in creating opportunities for students to experience some form of internship, work-integrated learning or workplace learning as part of the curriculum, to expose students and graduates to various practical employment skills. While students and graduates from urban universities seem to be making personal efforts to seek part-time employment opportunities, universities in more rural areas need more conscious efforts to support skills development amongst students and graduates. Various forms of partnerships with external stakeholders, such as government departments and civil society, could assist with such interventions. However, graduates also have to identify opportunities during their study and after graduation to enhance their employment outcomes.

9.3 Addressing institutional variances

The negative perception of some universities and their graduates is a negative legacy of the apartheid era, where some universities were poorly resourced and hence perceived as serving a secondary function within the labour market. Historically disadvantaged universities (HDUs) have been found to largely suffer from negative perceptions from students and graduates and more so from employers, who prefer graduates from the more recognised historically White universities. While government has introduced numerous interventions to support HDUs and enhance their profile within the higher education system as well as in the labour market, current challenges affecting some of these universities, including maladministration, corruption and resource lack, continue to limit the teaching and learning experiences of the students and ultimately their employment outcomes.

9.4 More skills planning with gender focus is required in the sector

A closer collaboration between universities, SACNASP and other stakeholders is necessary to inform the process of skills planning. In the wake of changing labour market dynamics, and the growing role of ICT in the 4IR, there is an increased demand for some critical skills while others are becoming redundant. More natural science graduates are getting into non-science careers, such as finance and administration, which could suggest that natural science graduates are flexible and adaptable to a changing skills labour force. However, there is a high and growing demand for some key skills needed to support the transition to the 4IR within the knowledge economy discourse. Previous national level studies, such as the LMIP by the former DHET (Reddy et al., 2016), have sought to inform skills training and development at a national cross-sectoral level. However, a sector-specific study focusing on the natural science skills demands and supply will benefit from such an initiative to inform skills training at university and other post-school training institutions.

Relating to gender, the study shows that while the distribution of males and females seems balanced at the start of the academic journey, women are not adequately represented within the employed sector, with females dominating the unemployed sector. There is a need for stronger incentive structures and policies to support women in science professions. Furthermore, considering the demands of natural processes such as childbearing and care giving, employers should consider better employment and working conditions which allow women to access these jobs, but also to maintain and return to their employment after childbearing and care-giving responsibilities. Furthermore, while some natural science professions have been historically more male gender inclined, more sensitisation is needed to expose and support females for studying in these fields and getting employment therein.

9.5 Develop more entrepreneurial versus job-seeker approach

The evidence from the research supports findings from previous studies of the need to develop more entrepreneurial graduates through the higher education system. While most graduates go to university to seek education towards getting a job, and do actually get employment, it is increasingly clear that neither the public nor the private sector can employ all of the graduates. Therefore, the training of natural scientists should seek to integrate and stimulate an entrepreneurial mindset. Practical courses linked to becoming and succeeding as an entrepreneur need to be considered at different stages of the undergraduate and postgraduate training. Courses such as financial training, developing business proposals or tenders, and management skills should be developed and strengthened through practical assignments, internship placements and work-based training.

Furthermore, there is a need to assume the responsibility of supporting and stimulating all students, and more so natural science students, in engaging in extracurricular activities which enhance their employment outlook upon graduation. While most natural science students are more academic driven, with less involvement in extramural activities, universities could expand opportunities for students to be involved in activities which enhance entrepreneurial skills.

9.6 The role of private sector employers in supporting natural science graduates

Employers, especially those within the private sector, have been observed to provide employment for many natural science graduates. While the private employers can only employ a finite number of graduates, they could develop opportunities for various graduate training programmes which provide opportunities for graduates or final-year students. Such programmes could be better coordinated through universities' career and graduate development programmes. This is particularly important for natural science students and graduates from rural areas, where opportunities for work internships or volunteering are limited. Employers can also partner with Voluntary Associations (VAs) to identify graduates who are unemployed or have lost employment towards various vacancy openings. This will also limit the number of non-accredited or regulated natural science graduates in natural science positions.

9.7 Raising the profile and enhancing the visibility of SACNASP

The study highlights once more the need for SACNASP to engage more with stakeholders, to sensitise the public of its role and mandate. This is not only regarding the universities, but also students and employers. Some of the stakeholders did not know about SACNASP. Some employers (private and even public) were aware of the existence of the organisation but were not sure of its mission. It is therefore recommended that SACNASP should continue its efforts to bolster its image through continuous and sustained engagement with external stakeholders. A strong communication plan might be required to begin to communicate SACNASP's vision and mission, positioning it as a critical player in the natural sciences. Such a strategy will also help to attract women and those from previously disadvantaged backgrounds to natural science careers.

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11

Appendices

Table 29: Characteristics associated with employment status: 2013

Employed	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	1.999	0.547	3.65	0.000	0.926	3.072	***
40-49	2.106	0.654	3.22	0.001	0.824	3.388	***
50-59	0.404	0.584	0.69	0.489	-0.740	1.548	
60+	-1.165	0.773	-1.51	0.132	-2.681	0.350	
Education							
Honours	-0.180	0.417	-0.43	0.667	-0.998	0.639	
Master or PhD	1.812	0.601	3.01	0.003	0.633	2.990	***
Science fields							
Life Sciences	-0.279	0.389	-0.72	0.473	-1.042	0.483	
Mathematics/stats	-0.037	0.553	-0.07	0.946	-1.121	1.047	
Gender							
Female	-0.718	0.338	-2.12	0.034	-1.382	-0.055	**
Marital status							
Ever-married	-0.170	0.577	-0.29	0.769	-1.300	0.961	
Race							
Coloured	-0.245	0.703	-0.35	0.727	-1.623	1.133	
Indian/Asian	0.445	0.872	0.51	0.609	-1.263	2.153	
White	0.659	0.419	1.57	0.116	-0.162	1.481	
Location							
Non-urban	0.204	0.615	0.33	0.740	-1.001	1.409	
Province							
Western Cape	-1.924	1.114	-1.73	0.084	-4.107	0.259	*
Eastern Cape	-1.591	1.243	-1.28	0.201	-4.028	0.846	
Northern Cape	-0.087	1.545	-0.06	0.955	-3.116	2.942	
Free State	0.166	1.463	0.11	0.910	-2.703	3.034	
KwaZulu-Natal	-1.204	1.140	-1.06	0.291	-3.439	1.030	
North West	-2.791	1.200	-2.33	0.020	-5.143	-0.438	**
Gauteng	-1.929	1.064	-1.81	0.070	-4.015	0.157	*
Mpumalanga	-1.616	1.158	-1.40	0.163	-3.886	0.654	
Constant	2.424	0.954	2.54	0.011	0.555	4.294	**

Mean dependent var	0.805	SD dependent var	0.397
Pseudo r-squared	0.258	Number of obs	333.000
Chi-square	76.146	Prob > chi2	0.000
Akaike crit. (AIC)	289.952	Bayesian crit. (BIC)	377.539

**** p<0.01, ** p<0.05, * p<0.1*

Table 30: Characteristics associated with unemployment status: 2013

Unemployed	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	-2.197	0.815	-2.70	0.007	-3.794	-0.600	***
40-49	-1.797	1.005	-1.79	0.074	-3.767	0.173	*
50-59	1.005	0.853	1.18	0.238	-0.666	2.677	
60+	0.000	0.000	0.000	0.000	0.000	0.000	
Education							
Honours	-0.174	0.663	-0.26	0.793	-1.473	1.125	
Master or PhD	0.000	.	.	.	.	.	
Science fields							
Life Sciences	-0.842	0.594	-1.42	0.156	-2.007	0.323	
Mathematics/stats	-1.836	1.135	-1.62	0.106	-4.061	0.389	
Gender							
Female	0.973	0.725	1.34	0.179	-0.447	2.393	
Marital status							
Ever-married	0.505	0.773	0.65	0.513	-1.010	2.020	
Race							
Coloured	-2.482	1.758	-1.41	0.158	-5.928	0.965	
Indian/Asian	0.378	0.774	0.49	0.626	-1.139	1.895	
White	-3.873	0.950	-4.08	0.000	-5.734	-2.012	***
Location							
Non-urban	-0.255	0.846	-0.30	0.763	-1.914	1.404	
Province							
Western Cape	1.957	1.222	1.60	0.109	-0.438	4.352	
Eastern Cape	0.453	1.680	0.27	0.787	-2.840	3.747	
Northern Cape	1.209	1.516	0.80	0.425	-1.763	4.181	
Free State	0.000	0.000	0.000	0.000	0.000	0.000	
KwaZulu-Natal	-0.103	1.476	-0.07	0.944	-2.995	2.789	
North West	2.201	1.337	1.65	0.100	-0.420	4.822	
Gauteng	0.857	1.151	0.75	0.456	-1.399	3.114	
Mpumalanga	0.941	1.369	0.69	0.492	-1.742	3.624	
Constant	-1.753	1.015	-1.73	0.084	-3.743	0.237	*

Mean dependent var	0.108	SD dependent var	0.311
Pseudo r-squared	0.262	Number of obs	223.000
Chi-square	32.860	Prob > chi2	0.025
Akaike crit. (AIC)	152.453	Bayesian crit. (BIC)	220.597

**** p<0.01, ** p<0.05, * p<0.1*

Table 31: Characteristics associated with not economically active status: 2013

Not economically active	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	-2.040	0.770	-2.65	0.008	-3.550	-0.531	***
40-49	-2.007	0.817	-2.46	0.014	-3.608	-0.405	**
50-59	-0.680	0.784	-0.87	0.385	-2.217	0.856	
60+	1.509	0.954	1.58	0.114	-0.361	3.379	
Education							
Honours	0.537	0.500	1.08	0.282	-0.442	1.516	
Master or PhD	-1.469	0.813	-1.81	0.071	-3.062	0.125	*
Science fields							
Life Sciences	1.074	0.573	1.87	0.061	-0.049	2.197	*
Mathematics/stats	1.016	0.587	1.73	0.083	-0.133	2.166	*
Gender							
Female	0.549	0.395	1.39	0.165	-0.225	1.323	
Marital status							
Ever-married	-0.102	0.707	-0.14	0.885	-1.487	1.283	
Race							
Coloured	1.696	0.849	2.00	0.046	0.032	3.360	**
Indian/Asian	0.000	0.000	0.000	0.000	0.000	0.000	
White	0.798	0.437	1.83	0.068	-0.058	1.653	*
Location							
Non-urban	-0.397	1.102	-0.36	0.719	-2.556	1.763	
Province							
Western Cape	0.116	0.826	0.14	0.889	-1.504	1.735	
Eastern Cape	-0.341	0.907	-0.38	0.707	-2.119	1.437	
Northern Cape	0.000	0.000	0.000	0.000	0.000	0.000	
Free State	-1.208	1.139	-1.06	0.289	-3.441	1.025	
KwaZulu-Natal	0.164	0.993	0.17	0.869	-1.783	2.110	
North West	0.542	1.093	0.50	0.620	-1.600	2.685	
Gauteng	0.564	0.782	0.72	0.471	-0.969	2.097	
Mpumalanga	0.000	0.000	0.000	0.000	0.000	0.000	
Constant	-2.830	0.951	-2.98	0.003	-4.695	-0.966	***
Mean dependent var		0.140	SD dependent var			0.348	
Pseudo r-squared		0.300	Number of obs			293.000	
Chi-square		72.632	Prob > chi2			0.000	
Akaike crit. (AIC)		206.089	Bayesian crit. (BIC)			279.692	

**** p<0.01, ** p<0.05, * p<0.1*

Table 32: Characteristics associated with employment status: 2018

Employed	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	1.320	0.473	2.79	0.005	0.393	2.247	***
40-49	2.841	0.737	3.86	0.000	1.397	4.285	***
50-59	1.961	0.670	2.93	0.003	0.649	3.274	***
60+	1.073	1.061	1.01	0.312	-1.007	3.153	
Education							
Honours	0.474	0.543	0.87	0.383	-0.590	1.538	
Master or PhD	0.327	0.563	0.58	0.562	-0.778	1.431	
Science fields							
Life Sciences	0.563	0.404	1.39	0.163	-0.228	1.355	
Mathematics/stats	0.751	0.497	1.51	0.131	-0.224	1.725	
Gender							
Female	-0.739	0.363	-2.03	0.042	-1.450	-0.027	**
Marital status							
Ever-married	0.294	0.418	0.70	0.481	-0.525	1.114	
Race							
Coloured	2.869	1.128	2.54	0.011	0.658	5.079	**
Indian/Asian	-1.156	0.817	-1.42	0.157	-2.756	0.444	
White	0.630	0.542	1.16	0.245	-0.433	1.692	
Location							
Non-urban	0.460	0.567	0.81	0.417	-0.650	1.571	
Province							
Western Cape	1.186	0.836	1.42	0.156	-0.452	2.824	
Eastern Cape	1.629	0.750	2.17	0.030	0.159	3.099	**
Northern Cape	0.000	0.000	0.000	0.000	0.000	0.000	
Free State	1.453	1.007	1.44	0.149	-0.521	3.427	
KwaZulu-Natal	1.243	0.776	1.60	0.109	-0.278	2.763	
North West	1.803	1.213	1.49	0.137	-0.575	4.181	
Gauteng	0.883	0.624	1.42	0.157	-0.340	2.105	
Mpumalanga	0.000	0.000	0.000	0.000	0.000	0.000	
Constant	-1.443	0.752	-1.92	0.055	-2.917	0.031	*
Mean dependent var		0.757	SD dependent var			0.429	
Pseudo r-squared		0.283	Number of obs			305.000	
Chi-square		71.343	Prob > chi2			0.000	
Akaike crit. (AIC)		284.284	Bayesian crit. (BIC)			362.410	

**** p<0.01, ** p<0.05, * p<0.1*

Table 33: Characteristics associated with unemployment status: 2018

Unemployed	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	-0.831	0.614	-1.35	0.176	-2.035	0.374	
40-49	-2.630	1.114	-2.36	0.018	-4.813	-0.448	**
50-59	-1.499	0.877	-1.71	0.088	-3.218	0.221	*
60+	0.000	0.000	0.000	0.000	0.000	0.000	
Education							
Honours	-0.326	0.665	-0.49	0.625	-1.630	0.979	
Master or PhD	-0.795	0.845	-0.94	0.347	-2.452	0.861	
Science fields							
Life Sciences	-0.621	0.519	-1.20	0.232	-1.639	0.397	
Mathematics/stats	-0.453	0.594	-0.76	0.445	-1.617	0.710	
Gender							
Female	0.366	0.416	0.88	0.379	-0.449	1.181	
Marital status							
Ever-married	0.164	0.592	0.28	0.781	-0.995	1.324	
Race							
Coloured	-1.213	1.126	-1.08	0.281	-3.420	0.994	
Indian/Asian	0.772	0.826	0.94	0.350	-0.846	2.391	
White	-0.687	0.608	-1.13	0.259	-1.880	0.505	
Location							
Non-urban	0.417	0.592	0.70	0.481	-0.744	1.578	
Province							
Western Cape	-0.828	0.936	-0.89	0.376	-2.662	1.006	
Eastern Cape	-0.367	0.753	-0.49	0.626	-1.842	1.108	
Northern Cape	0.000	0.000	0.000	0.000	0.000	0.000	
Free State	-0.847	1.229	-0.69	0.491	-3.256	1.562	
KwaZulu-Natal	-1.245	0.993	-1.25	0.210	-3.191	0.700	
North West	0.000	0.000	0.000	0.000	0.000	0.000	
Gauteng	-0.784	0.655	-1.20	0.231	-2.067	0.500	
Mpumalanga	0.000	0.000	0.000	0.000	0.000	0.000	
Constant	-0.307	0.783	-0.39	0.696	-1.842	1.229	
Mean dependent var		0.118	SD dependent var			0.324	
Pseudo r-squared		0.179	Number of obs			287.000	
Chi-square		34.762	Prob > chi2			0.010	
Akaike crit. (AIC)		209.560	Bayesian crit. (BIC)			279.090	

**** p<0.01, ** p<0.05, * p<0.1*

Table 34: Characteristics associated with 'Not economically active' status: 2018

Not economically active	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age							
30-39	-1.113	0.583	-1.91	0.056	-2.255	0.029	*
40-49	-2.278	1.000	-2.28	0.023	-4.238	-0.318	**
50-59	-1.560	0.809	-1.93	0.054	-3.146	0.026	*
60+	0.150	1.203	0.13	0.901	-2.207	2.507	
Education							
Honours	-0.375	0.542	-0.69	0.489	-1.438	0.688	
Master or PhD	0.161	0.648	0.25	0.803	-1.108	1.431	
Science fields							
Life Sciences	-0.221	0.528	-0.42	0.676	-1.255	0.814	
Mathematics/stats	-0.578	0.725	-0.80	0.426	-1.999	0.843	
Gender							
Female	0.730	0.453	1.61	0.107	-0.159	1.618	
Marital status							
Ever-married	-0.616	0.508	-1.21	0.226	-1.612	0.381	
Race							
Coloured	0.000	0.000	0.000	0.000	0.000	0.000	
Indian/Asian	0.645	0.953	0.68	0.498	-1.222	2.513	
White	-0.493	0.594	-0.83	0.407	-1.656	0.671	
Location							
Non-urban	-1.606	1.002	-1.60	0.109	-3.569	0.357	
Province							
Western Cape	-0.915	0.911	-1.00	0.315	-2.701	0.870	
Eastern Cape	-2.609	1.301	-2.01	0.045	-5.159	-0.060	**
Northern Cape	0.000	0.000	0.000	0.000	0.000	0.000	
Free State	-1.407	1.520	-0.93	0.355	-4.386	1.572	
KwaZulu-Natal	-0.551	0.890	-0.62	0.535	-2.295	1.192	
North West	-0.762	1.247	-0.61	0.541	-3.205	1.681	
Gauteng	-0.572	0.749	-0.76	0.445	-2.041	0.897	
Mpumalanga	0.000	0.000	0.000	0.000	0.000	0.000	
Constant	0.063	0.952	0.07	0.948	-1.804	1.929	
Mean dependent var							
Pseudo r-squared							
Chi-square							
Akaike crit. (AIC)							

**** p<0.01, ** p<0.05, * p<0.1*

Source: Author's estimates based on Labour Market Dynamics South Africa data 2013–2018

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