Multidimensional Analysis of Attainment of Higher Education Goals in South Africa's Public Universities: Access, Quality, Diversity, Success and Efficiency

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Abstract

The National Development Plan in South Africa aims to combat inequality. The Department of Higher Education and Training has identified goals for public universities not only to improve knowledge creation, transmission, and exchange but also equity. This paper analyzes the degree to which universities are successful in meeting the goals. We use a novel approach that allows disentangling persistent and transient underachievement to investigate achievement and their determinants of the traditional, comprehensive, and technology universities in South Africa from 2009 to 2016. We find contrary to previous studies that technology universities are the top performers, followed by comprehensive universities, while traditional universities have the lowest achievement levels. Additionally, the study demonstrates that although all types of universities exhibit comparable transient underachievement, the overall underachievement of comprehensive and traditional universities is primarily driven by persistent or long-term factors. Finally, we show that the attainment of goals is not correlated with popular international university rankings. The findings carry important implications for effectively executing the objectives determined by policymakers.

JEL: I23, I24, I28, H52

Keywords: Higher Education; South Africa; Inequality; Underachivement; Government Policy

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1 Introduction

South Africa is regarded as one of the most unequal societies in the world (see e.g., Ballard et al. 2005, Beresford 2015, Verwey and Quayle 2012). The inequality runs very deep in the country and the educational sector is not an exception (Lemon 2005). South Africa has historically advantaged and disadvantaged universities (Temoso and Myeki 2022), the establishment of which can be traced back to previous political regimes that permitted the provision, evolution, and reproduction of higher education along racial and ethnic lines matched by imbalance in gender participation and lack of approved social legitimacy from the native public (Bunting 1994, Boughey 2003, Badat 2012). Along the lines of the National Development Plan of South Africa (NDP, thereafter), the Department of Higher Education and Training (DHET, thereafter) carries a statutory mandate to address the challenges arising from the legacy left by the previous generation of politicians in the public higher educational sector.

DHET seeks to ensure the attainment of notable aspirations of both the NDP and its white paper for Post-School Education and Training (PSET, thereafter). To put the plan in numbers, the DNP intends to achieve 75% of PhD qualified academic staff, 70% student participation rates at universities, 1.62 million student enrollment, and train at least 100 PhD graduates per million people per year by 2030 (Temoso and Myeki 2022). Further, the post-school system is to be established to build a fair, equitable, non-racial, non-sexist, and democratic South Africa. The white paper additionally calls to ensure a single and coordinated post-school education and training system, coupled with expanded access, improved quality, and increased diversity of educational provision. Universities should be a place to provide a stronger and more cooperative relationship between education and training institutions and the workplace. Finally, to design and implementation of the post-school education and training system should be responsive to the needs of citizens, and employers in both public and private sectors, so as to shape, achieve, and maintain broader societal and developmental objectives (Department of Higher Education and Training 2013). It seems that the landscape and progress in public higher education institutions can be properly understood only by employing an approach that takes a multifaceted view on higher education institutions that engage not only in (1) creation (i.e., research), (2) transmission (i.e., teaching), and (3) exchange of knowledge (i.e., work with local communities and businesses) (Uyarra 2010), but also promote equality and upward mobility.

The main aim of this paper, therefore, is to perform a multidimensional analysis of achieving all DHET goals by benchmarking the performance of public universities. Performance can be measured in several ways. The traditional approach for performance

assessment of public higher education institutions in South Africa involves investigating the attainment of each goal separately and the publication of research results in subsidy-earning journals (Rehman et al. 2019). This approach is common in South Africa with researchers either focusing on performance in terms of equity (Cloete and Moja 2005, Boughey 2003) or efficiency (Myeki and Temoso 2019, Marire 2017). However, it neglects a number of aspects that are crucial to the performance of public higher education institutions given their multidimensional nature. Hence there is a growing realization of the need for an alternative approach that takes into consideration multiple domains of universities' activities. For example, university identity, influence, reputation, research and teaching outputs (Steiner et al. 2013), student learning, funding, infrastructure, faculties and quality (Rehman et al. 2019), and incorporation of community engagement, equity, efficiency, decolonization and diversity (Mabokela and Mlambo 2017, Van der Berg 2007, Lange 2017).

Taking another approach, this paper employs multidimensional techniques to analyze the attainment of the five DHET goals for 22 public higher education institutions in South Africa from 2009 to 2016. These goals include (1) increased access, measured by university enrollments, (2) quality, referring to the number of staff with doctoral degrees and professorship, (3) equity and diversity, measured by increased participation of black students and staff, particularly the African females, (4) academic success, and (5) efficiency of provision. The study period was chosen to trace the evolution of achievement during the implementation of DHET goals. The employed benchmarking approach allows us to break down the overall attainment into persistent (long-term) and transient (short-term) attainments. The paper thus provides the most comprehensive assessment of performance by public higher education institutions and an indirect evaluation of progress toward the pursuit of the NDP.

Contrary to existing literature, we found that technology universities are the top performers, followed by comprehensive universities, while traditional universities have the lowest achievement levels. Additionally, the study demonstrates that although all types of universities exhibit comparable transient underachievement, the overall underachievement of comprehensive and traditional universities is primarily due to persistent or long-term factors. Finally, the large portion of overall efficiencies is attributed to persistent inefficiency, hence we advocate using the method that accounts for persistent inefficiency, otherwise, policy evaluation and implications may be incorrect and can lead to false policy implications for the public higher educational sector.

The rest of the paper is structured as follows. Section 2 reviews the related literature with special emphasis on inputs, outputs, goals, research gaps, and merit of the study.

Data information and sample construction are presented in Section 3. The model and estimation approach are discussed in Section 4. The findings of the study are presented in Section 5 followed by a conclusion in Section 6.

2 Review of literature and our approach

2.1 Performance studies in higher education

The extensive research on performance in higher education worldwide can be broken down into two strands. The first strand analyzes the level of performance and the second strand explores the determinants that influence it. However, the research on the performance of higher education is shaped by several factors that include the need for continuous improvement to align with prevailing conditions, ensure proper allocation of resources, and maintain resilience in the face of policy reforms and shocks. One of the most common measures of performance within higher education is efficiency.

Performance studies assessing efficiency in higher education abound. The literature can be categorized by geography and studies scrutinize both developed and developing countries. For example, in Asia (Johnes and Li 2008, Jiang et al. 2020, Arjomandi et al. 2015), Africa (Amina and Turyahebwa 2015, Kiwanuka 2015, Bornmann et al. 2023), Europe (Wolszczak-Derlacz 2017, Johnes and Schwarzenberger 2011, Laureti et al. 2014), Australia (Worthington and Lee 2008, Siemens et al. 2013, Yang et al. 2020) and America (Sav 2012b, Zoghbi et al. 2013, Ferreyra et al. 2017). Further categorization can be made by the estimation method: non-parametric (Andersson et al. 2017, Wolszczak-Derlacz 2017) or parametric (Agasisti and Gralka 2019, Guccio et al. 2016) approach; with cost or productive perspectives (Sav 2012a,b). The number of studies triggered comprehensive reviews (Witte and López-Torres 2017, Rhaiem 2017, Gralka 2018b, Ferro and D'Elia 2020) studies. All the reviewed studies however suffer from being limited to either teaching or research outputs, thus leaving out other societal aspects. The results from existing studies can be a poor guide for policymakers and can even be misleading as we show below. Hence, in our study, we analyze the performance of public universities as a society role model rather than pure educational establishments.

2.2 Performance indicators for South African higher education

PSET is one of the key sectors of South African society. It consists of 342 institutions that are decomposed into private higher education institutions (124); technical, voca-

tional education and training colleges (50); private colleges (133); community education and training colleges (9); and public higher education institutions (26) (Department of Higher Education and Training 2021). The latter institutions are of specific interest to our study, and they are further classified into traditional universities, comprehensive universities, and universities of technology (Temoso et al. 2023). These classifications imply heterogeneity, for instance, traditional universities specialize in teaching and research while universities of technology tend to have very few research activities. Another implication is inefficiency due to underutilization of capacity, geographic location, past policies of discrimination, and differences in resource endowments (Temoso and Myeki 2022). The DHET has been granted a mandate to redress challenges arising from the aforesaid national developments. The mandate of the DHET oversees how public universities serve both educational as well as societal objectives.

In 2019, DHET launched the PSET Monitor Report intended to provide an analysis of the trajectory of the PSET system and track the progress made against the goals as stated in the White Paper by identifying a number of performance indicators (Department of Higher Education and Training 2021). The indicator include *access*, measured by the number of student enrollment, *success* which is assessed by graduation rates in percentage terms, *equity*, focusing on participation by race and gender distinctions, *quality*, signified by student-to-staff ratio, academic staff with doctoral qualifications and professorships, *efficiency*, defined as improving throughput rate and reducing dropout rate and funding (Department of Higher Education and Training 2019, 2021).

A recent report shows that *access* exceeded 1.2 million per year. In terms of equity, the number of black African students enrolled at public universities grew by an average rate of 3.8 percent from 2010 to 2019, resulting in black African students making up over 80 percent of the enrollment rate at public universities, the number of whites and Indian/Asian students declined by 3.7 percent and 2.4 percent, respectively (Department of Higher Education and Training 2021). Quality indicator shows that the student-to-staff ratio remained relatively stable during the period 2010–2019 while the proportion of university academic staff with a PhD qualification during the same period increased by 12.0 percentage points, from 35.7 percent in 2010 to 47.7 percent in 2019. The average university graduation rate in 2019 was 20.6 percent, reflecting an improvement from the 2010 graduation rate of 17.2 percent. Throughput rate improved while dropout rates remained relatively high (Department of Higher Education and Training 2021). These numbers alone are useful but are not informative as they are not analyzed in conjunction with one another. Furthermore, the aggregates also belie heterogeneity among different types of universities. Our study addressed the two latter points.

2.3 Additional indicators of performance

Funding is one of the most fundamental indicators of performance in public higher education institutions. The sources of funding include government grants, student tuition fees, and private income (Ferro and D'Elia 2020). Among these three indicators, government funding is the major source of funds for public higher educational establishments. The second-level indicators include cost per student and utilization of budget expenditure (Lu and Chen 2013). These indicators have come under serious scrutiny in light of tough economic conditions caused by Covid-19 leading to the declining share of government funding. Enrollment in crucial skills is increasingly observed as an important indicator of performance in higher education. This is commonly described as the proportion of students enrolled for science, technology, engineering, and mathematics (STEM), and pro-efficiency rates for each subject (Department of Higher Education and Training 2019, 2021, Witte and López-Torres 2017), the proportion of classes using technology, percentage of administrators using technology, social media engagement and calls to technology department per month (Gralka 2018b).

Other studies (Johnes and Li 2008, Ferro and D'Elia 2020, Witte and López-Torres 2017), devote special attention to operational indicators such as the proportion of faculty with advanced certificates or degrees, the number of training sessions per year, faculty and staff attendance rates, and faculty and staff retention rate, the proportion of students using public transport, the proportion of students that commute and cost of transportation, percentage of students living on and off campus (Gralka 2018b), student to faculty ratio, faculty to administration ration and the number of students enrolled per number of applications (Lu and Chen 2013). Lastly, some studies (Witte and López-Torres 2017, Rhaiem 2017) highlight the contribution to economic productivity, entrepreneurial energy, quality of life, social mobility, political participation, civil society, democratic governance, and cultural and environmental development. Our study fits well into the latter strand as we treat universities as part of society rather than institutions producing academic minds that generate, transmit, and exchange knowledge.

2.4 Research Gaps and Merit of the Study

The existing account of the literature on the performance of higher education pays attention to a limited part of the university's role in society. As a result, a number of performance indicators such as quality, diversity, transformation, and responsiveness remain partially explored or unexplored singularly or jointly. Previous research has also been criticized for using empirical methods that fail to account for various sources of het-

erogeneity and distinguishing the short-term from the long-term trends. In this study, we employ the four error component stochastic frontier model that allows us to do exactly that. A few studies have used this model in higher education. Badunenko et al. (2021) investigated adult education, while Agasisti and Gralka (2019) analyzed the panel data of 125 universities (55 in Italy and 70 in Germany) from 2001 to 2011. They found that the universities demonstrated short-run (transient) efficiency, with the overall discrepancy driven by long-term (persistent) structural inefficiency. Gralka (2018a) used the same method on 72 public institutions in Germany from 2004 to 2013 and found that increasing efficiency is only possible if future initiatives are directed at long-term issues. Even though these studies applied up-to-date methods, they failed to model the determinants of underachievement, which we do in this study.

In sum, this research will explore the attainment of the five performance indicators in South African higher education using a multidimensional approach. In addition, we will distinguish between short-term and long-term attainments. Further, we will model the determinants of attainment. Finally, we discuss the implications for the effective implementation of policies required to achieve the DHET goals.

3 Data

3.1 Data Source and Compilation

The DHET is the only official and reliable source of data for higher education in South Africa. It draws this data from Higher Education Management Information System (HEMIS), which contains data provided by public higher education institutions (HEIs), the annual reports submitted by registered private HEIs, the Technical and Vocational Education and Training Management Information System (TVETMIS), which contains data provided to by Technical and Vocational Education and Training (TVET) colleges, Community Education and Training (CET) Unit Level Record data for student enrolment and annual survey data which contains staff data for CET colleges. Other data sources for the DHET include the annual survey data submitted to the Department which contains data for registered private colleges, the National Examinations Database, which contains administrative data about student examinations and certification for the General Education and Training Certificate-Adult Basic Education and Training (GETC-ABET), the National Certificate (Vocational) [NC(V)] and the N part-qualifications, Skills Education and Training Authorities Management Information System (SETMIS), which contains data provided to the Department by Sector Education and Training Authority

(SETAs), data provided to the Department by the National Artisan Development Support Centre (NADSC), data extracted from the DHET levy system, and finally data obtained from the National Student Financial Aid Scheme (NSFAS) annual reports and NSFAS database.

The data contains 176 observations on 22 public universities. Public universities in South Africa are classified into 3 categories. The first category is traditional universities. They offer basic formative degrees such as BA & BSc, and professional undergraduate degrees such as BSc Eng. and MBChB. At the postgraduate level, they offer honors degrees and a range of post-graduate and doctoral degrees. The second category is the universities of technology which provide mainly vocational or career-focused undergraduate diplomas and BTech but also offer a limited number of post-graduate and doctoral programs. The third category is the comprehensive universities that offer programs typical of the traditional university as well as programs typical of the university of technology. Our sample, therefore, includes traditional universities (University of Cape Town, Rhodes University, University of Pretoria, University of Fort Hare, University of Limpopo, University of the Western Cape, University of Stellenbosch, University of Witwatersrand, North-West University, and the University of Kwa-Zulu Natal), comprehensive universities (Nelson Mandela University, University of South Africa, University of Johannesburg, University of Venda, University of Zululand and Walter Sisulu University), and technology universities (the Cape Peninsula University of Technology, Central University of Technology, Durban University of Technology, Tshwane University of Technology and Vaal University of Technology). All universities are spread over South Africa's seven provinces. Four universities (Sol Plaatje University, University of Mpumalanga, Mangosuthu University of Technology, and Sefako Makgatho Health Science University) were removed from the study because of insufficient data for the observed period.

3.2 Variables Construction

We construct indices to quantify the goals determined by the DHET to perform a multidimensional performance analysis of public universities. We discuss their construction one by one. Table 1 shows the descriptive statistics, while Appendix A provides densities describing whole distribution by university type.

3.2.1 Access

The first goal 'access' represents equal opportunities to access university by (i) gender and (ii) race. Panel A in Figure A1 (Appendix A) shows the distribution of gender share of students ($ShSt_g$) by type of university. We assume that the share value of 50% is desirable. Therefore, we construct a variable $ShSt'_g = 1 - |0.5 - ShSt_g|/0.5$, which shows how far away is the university from the desired share of 0.5. The larger the $ShSt'_g$ the better the access in terms of gender. Panel B in Figure A1 presents densities of the transformed share and presents the distribution of the transformed share by the university type. The technology universities turn out to provide the best access in terms of gender, followed by comprehensive and then traditional universities. Panel C in Figure A1 shows the distribution of the share of non-white students $ShSt_{nw}$. We now multiply the transformed share $ShSt'_g$ by the share of non-white students to obtain variable Y_1, which proxies the access goal set by DHET. A larger value of Y_1 implies better access. The distributions of Y_1 by university type are shown in Panel D in Figure A1.

The findings on traditional universities presented in Figure A1 are worrisome and may reflect a resistant culture towards transformation for the country to realize a non-racial and non-sexist public university sector in so far as student access is concerned. They can be ascribed to the fact that most non-white students regardless of gender come from poor basic education schools and their acceptance in large numbers may affect the quality of teaching outputs in traditional universities. A possible explanation regarding the universities of technology is that most of these universities have relatively flexible admission policies with maximizing the teaching outputs as their main focus. On the other hand, the improvement of student access in comprehensive universities can be attributed to the merger policy of higher education institutions which made it easy for greater enrollment of non-white students and females (Mzangwa 2019).

3.2.2 Quality

Quality at the university is determined by two factors, (1) the share of staff holding doctoral degrees and professorship (Cloete et al. 2018), and (2) the number of students taught by one member of staff. Panels A, C, and E in Figure A2 (Appendix A) show the distribution of the share of professors of all staff ShA^U_{pr}, share of staff with doctoral qualification ShA^U_{dr}, and students-to-lecturer ratio SL^U, respectively by university type. To create a composite index of quality, we first transform these shares in such a way that they are comparable between university types, namely to range between 0.01 and 1. This allows us to account for the idiosyncrasies of different types of universities and

universities are benchmarked against similar types. Therefore, the transformed share of professors is $ShA^{U'}_{pr} = (ShA^{U}_{pr} - min^{U}_{pr})/(max^{U}_{pr} - min^{U}_{pr})$, where max^{U}_{pr} and min^{U}_{pr} are university specific maximum and minimum shares of professors. the transformed share of staff with doctoral qualification is $ShA^{U'}_{dr} = (ShA^{U}_{dr} - min^{U}_{dr})/(max^{U}_{dr} - min^{U}_{dr})$, where max^{U}_{dr} and min^{U}_{dr} are university specific maximum and minimum shares of academics with doctoral qualification. The distributions of these transformed shares are presented in Panels B and D in Figure A2. The larger the share the better the quality. The student-to-lecturer ratio is transformed in a similar way to obtain a range between 0.01 and 1, however, the larger the transformed share the worse the quality. To address this, we subtract the transformed ratio from 1. The final transformation is $SL^{U'} = 1 - (SL^{U} - min^{U}_{SL})/(max^{U}_{SL} - min^{U}_{SL})$, where max^{U}_{SL} and min^{U}_{SL} are university specific maximum and minimum student to lecturer ratios. The distribution of this transformed ratio is shown in Panels F in Figure A2. This transformation ensures that the larger the transformed ratio the greater the quality. The composite index is obtained as the product of the three transformed variables ($Y_1 = ShA^{U'}_{pr} \times ShA^{U'}_{dr} \times SL^{U'}$) by the type of university. The distribution of this index is shown in Panels G in Figure A2. The larger Y_2 implies better quality.

Figure A2 suggests that Universities of technology had a low quality over the study period. This can be attributed to their main focus on teaching output with very little research output, which requires more qualified staff such as doctorates and professors. In fact, these universities strive towards the promotion of knowledge and skills and the application of such knowledge and development along with releasing the means for applying that knowledge in the training of manpower, emphasizing the practical and the vocational (Cunningham et al. 2019). Hence they also fall short of achieving the desired student-to-lecturer ratios due to their high teaching inputs. A change in the mission focus of Universities of technology to incorporate a greater level of research outputs might improve the current status of their quality. As expected, the traditional and comprehensive universities had better quality because they are more research-intensive, therefore hiring more doctoral and professorial staff compared to universities of technology.

3.2.3 Diversity of Academics

Diversity is a concept that can encompass ideals, intentions, programs, outcomes, proportions, curricula, and many other elements (Swain 2013). It represents a spectrum of variation in people regarding all of the innate and sociocultural differences that shape their perspectives and lived experiences. Our study measures diversity by proportions of non-white academics ShA_{nw} and share of female academics ShA_{f}. The distributions

of the share of non-white academics and female academics by university type are presented in Panels A and C in Figure A3 (Appendix A). The transformation that is applied to these shares assumes that the desired level is 50%. Under this assumption, the transformations $ShA'_{nw} = 1 - |0.5 - ShA_{nw}|/0.5$ and $ShA'_{f} = 1 - |0.5 - ShA_{f}|/0.5$ are applied. Panels B and D in Figure A3 show the distributions of these transformed shares. The composite 'Diversity of Academics' index is obtained as a product of the transformed shares, ($Y_3 = ShA'_{nw} \times ShA'_{f}$) by the type of university. Its distribution by university type is presented in Panels E in Figure A3.

The traditional universities witnessed a significant improvement in the share of female academics, universities of technology achieved the desired outcome in terms of the share of non-white academics while Comprehensive Universities were slightly behind in the share of non-white academics. Overall both technology and comprehensive universities showed a larger diversity of academics while traditional universities fell short of the desired level. These findings are deeply rooted in the institutional culture (Muswede 2017). For instance, most traditional universities have a culture and legacy that is greatly influenced by white colonial and apartheid regimes in South Africa and this cannot be easily changed within a short space of time.

3.2.4 Success Rates

In the context of South Africa, success rate indicates the proportion of the courses for which students were enrolled were passed (completed) in a specific year (Council on Higher Education 2016). It is calculated by dividing the completed credits by the enrolled credits expressed as a percentage. We operationalize this concept by considering the share of PG graduates (ShG^{U}_{pg}) and the share of graduation success rate (ShG_{sr}). The distribution by the university type is presented in Panels A and C in Figure A4 (Appendix A). Because of differences between universities regarding PG studies, we transform the share of PG graduates, $ShG^{U'}_{pg} = (ShG^{U}_{pg} - min^{U}_{pg})/(max^{U}_{pg} - min^{U}_{pg})$, where max^{U}_{pg} and min^{U}_{pg} are university specific maximum and minimum shares of PG graduates. Panels B in Figure A3 show the distributions of the transformed share. This transformation ensures fair treatment of all universities in our analysis. The composite 'Success Rates' index is obtained by multiplying the transformed share of PG graduates by the share of graduation success rate, $Y_4 = ShG^{U'}_{pg} \times ShG_{sr}$. The distribution of the index by university type is presented in Panels D in Figure A4.

The study measures success rates by share of postgraduates and success rates. In line with the previous discussion, the first observation is variations in success rates by class of universities and this arises from many factors. As expected the traditional universi-

ties had the highest share of postgraduate due to the fact that they are more research-intensive compared to the other two classes of universities (Temoso and Myeki 2022). Additionally, traditional universities produce the largest research output published in subsidy-earning income journals which in turn is invested back into postgraduate enrollments. The number of students graduating has significantly climbed over the last two decades, with 58 560 students graduating in 1994 and 210 931 students graduating in 2017. While university throughput has improved, only 22 percent of students in the 2010 cohort completed their three-year degree within three years, according to the assessment. By the fourth year, only 39 percent had completed their degrees. By the sixth year, only 56 percent of students who enrolled in 2010 had completed their three-year degree (Department of Higher Education and Training 2019). This suggests that access can be improved further if more students complete their degrees on time. Another key impediment to success is the high dropout rate in these public universities (Moodley and Singh 2015), which is caused by a variety of causes including lack of finance (Murray 2014).

3.2.5 Efficiency

The final goal of DHET is the efficiency of public funding use. This goal is reflected in the income-to-debt ratio of a university. The higher the ratio the greater the ability of public universities to use income to generate assets. Figure A5 (Appendix A) presents the income-to-debt ratio by university type. No single type of public university meets the desired outcome of income-to-debt ratio. This finding can be traced back to annual government budget cuts and few third-stream incomes for the public higher education sector in South Africa (Temoso and Myeki 2022).

3.3 Universities' Resources

For the purpose of our study, we consider the three input resources that were used to achieve the goals of the public higher education sector in South Africa. Table 1 shows the descriptive statistics. The entire public university sector in South Africa, used on average 1 076 academics, 1 428 other staff, and 28 740 students to achieve the five goals over the reported period. The graphical description of the inputs by type of university is shown in Figure 1.

The traditional universities had more academic staff at an average of 1 209 compared to both comprehensive (1 101) and technology universities (752). The same finding was observed for other staff by type of university. The findings were expected given

Table 1: Descriptive statistic of the variables included in the empirical analysis

Variable	Type	Mean	SD	Min	Max
Inputs/Resources					
Academic FTE (X1)	Comprehensive	1,101	988	294	4,694
Academic FTE (X1)	Technology	752	328	333	1,325
Academic FTE (X1)	Traditional	1,209	560	314	2,235
Other Staff (X2)	Comprehensive	1,377	987	461	3,537
Other Staff (X2)	Technology	969	463	402	2,128
Other Staff (X2)	Traditional	1,665	761	420	3,707
Student enrollment (X3)	Comprehensive	45,803	57,842	8,122	197,102
Student enrollment (X3)	Technology	21,361	10,337	9,697	42,846
Student enrollment (X3)	Traditional	22,787	10,769	5,881	43,920
Determinants					
Government funds (Z1)	Comprehensive	0.450	0.084	0.300	0.660
Government funds (Z1)	Technology	0.520	0.032	0.438	0.589
Government funds (Z1)	Traditional	0.394	0.078	0.225	0.550
Student fees (Z2)	Comprehensive	0.377	0.059	0.250	0.511
Student fees (Z2)	Technology	0.346	0.035	0.299	0.436
Student fees (Z2)	Traditional	0.303	0.063	0.183	0.458
Z1 / Z2	Comprehensive	1.23	0.354	0.688	2.52
Z1 / Z2	Technology	1.52	0.191	1.08	1.84
Z1 / Z2	Traditional	1.34	0.321	0.768	2.00

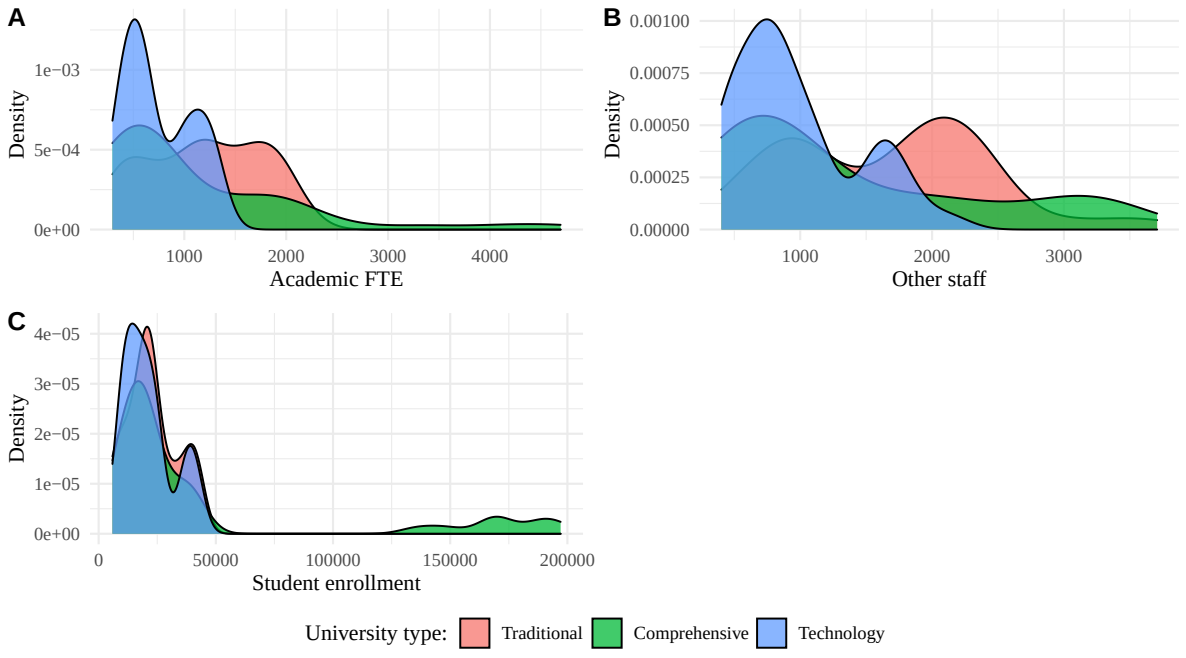

Figure 1: Resources available to achieve goals of the Department of Higher Education and Training. Panel A: Academic FTE; Panel B: Other staff; Panel C: Student enrollment

the research-intensive nature of traditional universities in South Africa. Comprehensive universities had more student enrollment at an average of 45 803 compared to technology

(21 361) and traditional universities (22 787) from 2009 to 2016. This is not surprising because comprehensive universities are unique in the sense that they offer a combination of qualifications from traditional and universities of technology. Taken together, the findings suggest that the differences in resources are more likely to result in differences in the attainment of the five goals. They also hold implications for formulating university-specific policies.

4 Methodology

4.1 Modeling underachivement

The approach undertaken in this article is based on the premise that outputs are multidimensional and that a decision-making unit (the university) is set to maximize them, also known as a utility gap concept. The implementation is broken down into two parts. First, it is assumed that a university possesses some resources that it transforms into multidimensional achievements. The resources (also known as inputs) as well as the achievements (also known as outputs) will be discussed separately. Assume that the vector of inputs $\boldsymbol{X}$ can be transformed into the vector of outputs $\boldsymbol{Y}$ via some implicitly written transformation function $AF(\boldsymbol{Y},\boldsymbol{X}) = 1$. The transformation function F can be made stochastic by assuming that $A = \exp(v)$ instead of the general premise that $A = 1$. The term v is the usual symmetric error with an expectation 0 making $\exp(v)$ positive.

The second part of the implementation is that there is a gap between what a university achieves and what it can potentially achieve. Denote the achievement level by a scalar $0 < \theta \leq 1$, whereby a university achieves its potential if $\theta = 1$ and it is below its potential if $0 < \theta < 1$. The shortfall or gap between the observed and potential achievement or attainment will provide a measure of underachievement.

Then the transformation function can be expressed as

$$F\left(\frac{\boldsymbol{Y}}{\theta},\boldsymbol{X}\right)\exp(v) = 1.$$

The well-behaved transformation function is homogeneous of degree 1 in outputs, implying that

$$F\left(\lambda\frac{\boldsymbol{Y}}{\theta},\boldsymbol{X}\right)\exp(v) = \lambda, \tag{1}$$

with λ being some positive scalar. Setting $\lambda = y_1^{-1}\theta$, equation (1) becomes

$$F\left(\frac{\boldsymbol{Y}}{y_1}, \boldsymbol{X}\right)\exp(v) = y_1^{-1}\theta, \tag{2}$$

where $\boldsymbol{Y}/y_1 = (1, y_2/y_1, \ldots, y_M/y_1)$ and M is the number of outputs. Denoting $\boldsymbol{Y}_{-1} = (y_2/y_1, \ldots, y_M/y_1)$, and applying logarithm transformation, (2) can be written as

$$\log f(\boldsymbol{Y}_{-1}, \boldsymbol{X}) + v = -\log y_1 + \log\theta, \tag{3}$$

where $f\left(\boldsymbol{Y}_{-1}, \boldsymbol{X}, \boldsymbol{\beta}\right) = F(1, \boldsymbol{Y}_{-1}, \boldsymbol{X})$ is the parametric function with technology parameters $\boldsymbol{\beta}$. Using the $\theta = \exp(-u)$ notation, where $u \geq 0$ is underachievement, yields the composite error transformation function, which is also known as the stochastic output distance function. Operationalization of the concept can be traced to a familiar stochastic frontier framework (introduced by Aigner et al. 1977, Meeusen and van den Broeck 1977) by writing (3) as

$$-\log y_1 = \log f\left(\boldsymbol{Y}_{-1}, \boldsymbol{X}, \boldsymbol{\beta}\right) + u + v, \tag{4}$$

where the error term v is assumed to be a normally distributed random variable, whereas underachievement u is usually assumed to have an exponential or half-normal distribution.

4.2 Determinants of (under)achievement

The interest of the empirical application lies not only in the quantification of underachievement but also in explaining it. The determinants of underachievement u are introduced via the variance following Reifschneider and Stevenson (1991), Caudill et al. (1995),

$$u_{is} \sim N^{+}(0, \sigma^2_{u_{is}}) \text{ where } \sigma^2_{u_{is}} = \exp\left(\boldsymbol{z}_{is}\boldsymbol{\gamma}\right), \quad i = 1, \cdots, n, \quad t = 1, \cdots, T_i, \tag{5}$$

and $\boldsymbol{z}_{it}$ is the vector of covariates that explain underachievement. Since $E(u_{it}) = \sqrt{(2/\pi)}\sigma_{u_{it}} = \sqrt{(2/\pi)}\exp\left(0.5\boldsymbol{z}_{u_{it}}\boldsymbol{\gamma}\right)$, the $\boldsymbol{z}_{it}$ variables are not only determining the heteroskedasticity of underachievement but underachievement itself (Badunenko and Kumbhakar 2017). Consider a marginal effect (ME thereafter) of a variable z_1 on underachievement, which is the underachievement change due to a change in z_1 holding everything else fixed. Since the underachievement is $\exp(-u_{it})$, the rate of change in it due to a change in z_1

is given by

$$\text{ME} :\equiv -\frac{\partial u_{it}}{\partial z_{1i,t}} \approx -\frac{\partial E(u_{it})}{\partial z_{1i,t}} = -\sqrt{\frac{2}{\pi}}\frac{\partial \sigma_{u_{it}}}{\partial z_{1i,t}}. \tag{6}$$

Under the assumption (5), equation (6) can be written as

$$-\sqrt{\frac{1}{2\pi}}\frac{\partial\left(\boldsymbol{z}_{it}\boldsymbol{\gamma}\right)}{\partial z_{1i,t}}\exp\left(0.5\boldsymbol{z}_{it}\boldsymbol{\gamma}\right). \tag{7}$$

5 Empirical results

5.1 Universities' achievement of goals

5.1.1 Overall

We first discuss the underachievement of the DHET goals by the public university sector by type of university in South Africa. Note that the employed model allows us to split the overall attainment into transient (short-term, easier to address) and persistent (long-term, structural, more difficult to address/correct) attainments. The overall aggregate achievement of goals is shown in Figure 2. The average for overall attainment was 0.812. These findings corroborate those by Nkohla et al. (2021) who found similar levels of underachievement in teaching and research at 23 public universities in South Africa from 2009 to 2016. In addition, similar findings were also observed by Marire (2017) while investigating cost efficiency for public universities over the period 2009 to 2013.

However, the previous studies provided limiting results for two reasons. First, they considered only two goals that concern only knowledge, the research and teaching, while failing to disentangle attainment by termism and university classification. Using a similar set of goals, Temoso and Myeki (2022) examine productivity growth for university classifications in South Africa and found that comprehensive universities show higher attainment measured by technical efficiency at 1.15% compared to traditional (0.92%) and technology (0.07%) universities from 2009 to 2016. However, the findings in this paper over the same period and sample show that universities of technology had the largest average for overall attainment at 0.949 compared to that of traditional (0.732) and technology (0.845) universities. The variations in attainment levels from previous research and our study can be attributed to differences in conceptualization employed in the two studies. Thus the difference emphasizes the importance of considering multiple goals and not just teaching and research. The attainment of technology universities is

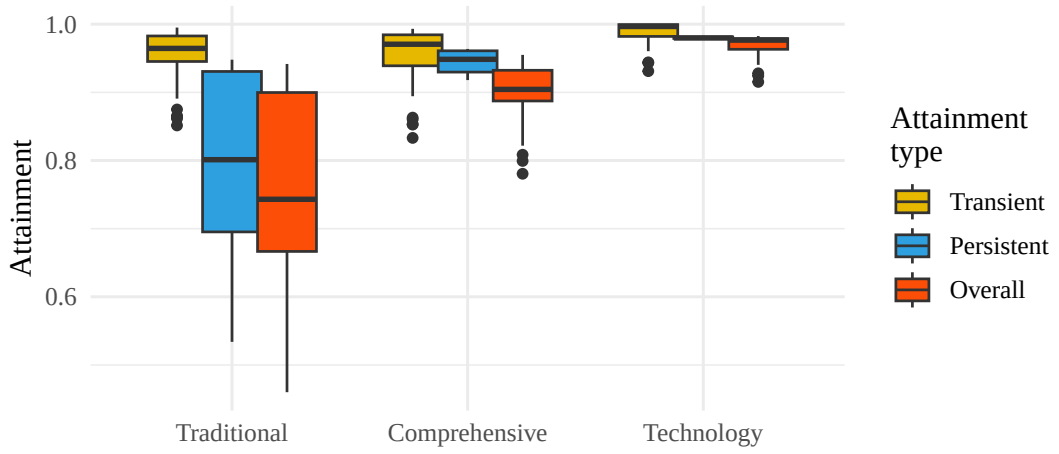

Figure 2: Attainment of goals by university type

quite understated in such a limited view, i.e., if the focus is only given to research and teaching while other important societal goals are ignored. Therefore we advocate a new perspective on assessment of attainment in higher education in South Africa, which can be replicated in other countries. The importance of this perspective is that it can provide targeted policy interventions specific to each class of university.

5.1.2 Over time

For a better understanding of the impact of policy and shock of performance, Figure 3 presents the mean annual scores for various types of efficiency, pre (2009-2011) and during (2013-2016) the establishment of the NDP. Over the study period, persistent efficiency remains unchanged (by design) whereas transient and overall efficiencies follow the same trend. In the pre-NDP period, both transient and overall efficiency show an upward trend. This was the time DHET was gaining more attention in terms of organization, planning, and establishment after it was separated from basic education. Both transient and overall efficiency reached their peak in 2013, and this can be credited to the implementation of NDP and the White Paper on PSET. However, the subsequent years show fluctuations due to disruptions of the academic calendar by fees-must-fall protest match with high dropout rates and many public education institutions being put under administration due to poor governance (Godsell et al. 2016, Swartz et al. 2019).

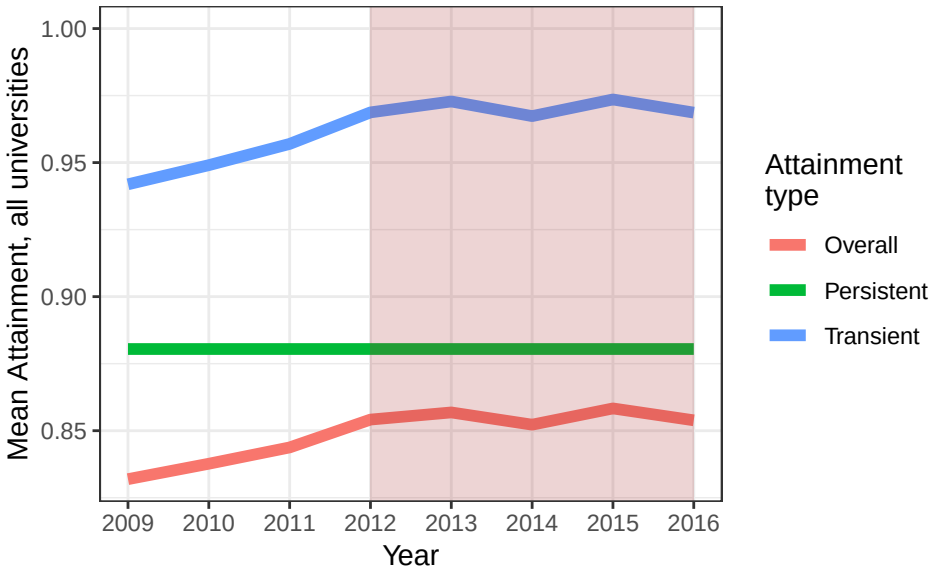

Figure 3: Mean Attainment over Time

5.1.3 By geographical location

Figure 4 shows the type of attainments by geographic location of South African universities. The Mpumalanga and Northern Cape provinces were excluded from our analysis due to the missing data over the reported period. The results for North West had the lowest level of attainment with mean transient at 0.94%. This province has one public university with two campuses that are structurally not fully integrated with each other perhaps due to their diverse history. It is characterized by difficulties of interaction with racial minority and majority groups, lack of adaptation to high workload and academic climate along with language and cultural barriers (Matsheka et al. 2022). The dissolution of the merger between former Medunsa and the University of the North may be ascribed to improvements in transient attainment levels in Limpopo province. The Kwa-Zulu Natal, Western Cape, and Gauteng provinces had transient attainment ranging from 0.935 to 1.00 due to the fact that universities in these provinces are located in metropolitan municipalities characterized by advanced economic development and improved governance. These tend to attract more students and are highly associated with better access to quality health care, housing, and labor markets (Walker and Mathebula 2020). The low levels of persistent attainment can find roots in colonial and apartheid influence on South Africa's education system (Legodi and Shai 2018). This legacy continues to undermine the overall attainment of higher education in different provinces. Investment in curriculum reform, early childhood development, and quality of academic staff could assist in redressing low persistent attainment (NPC 2012). The

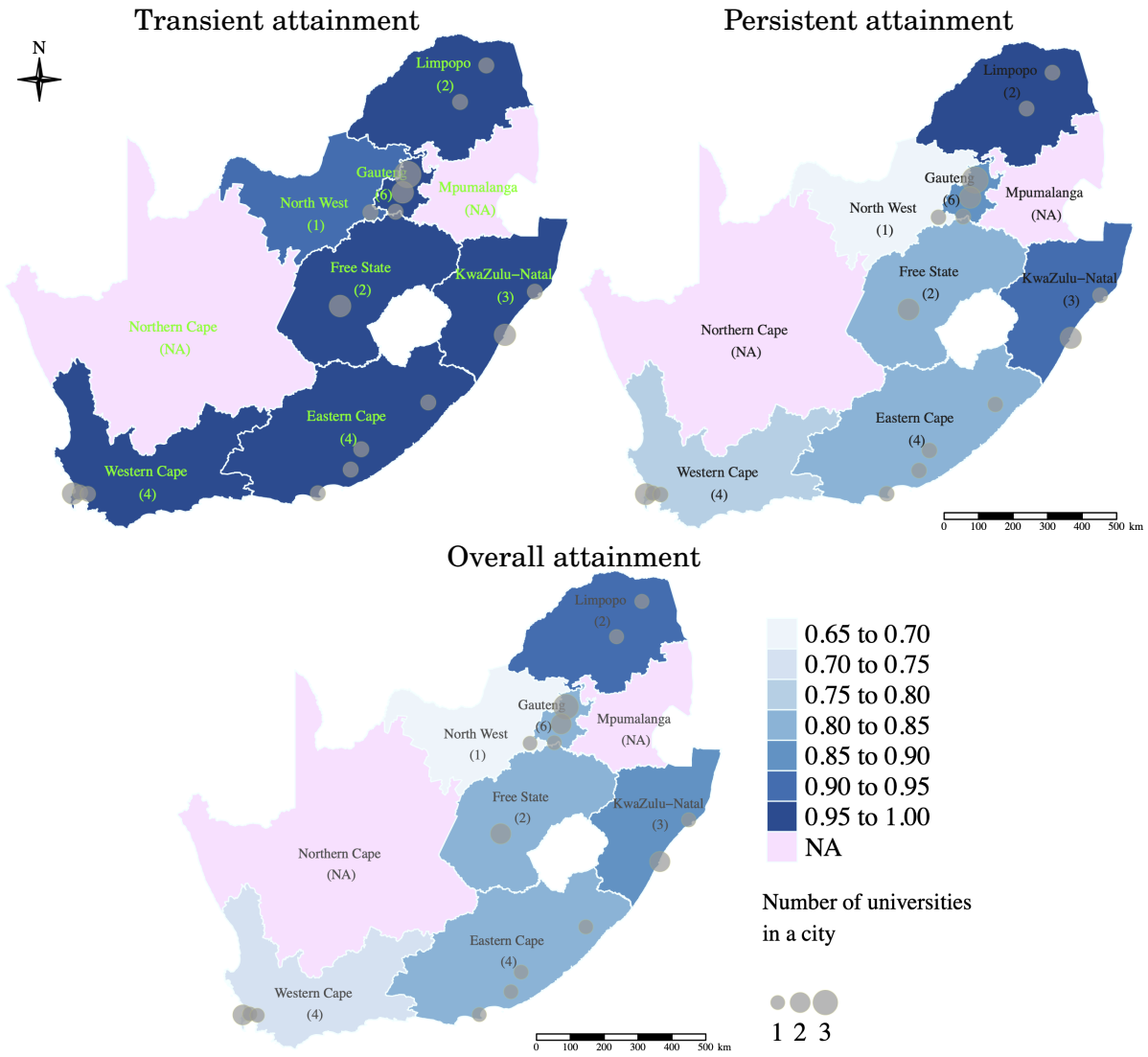

Figure 4: Attainment of goals by provinces

Notes: The data on two provinces are not available.

recent adoption of the District Development Model has the potential to redress uneven economic development in these areas and therefore contribute to the attainment of goals for universities in these respective locations.

Fugire 5 shows the time trend by provinces. The overall attainment has improved in KwaZulu-Natal and Gauteng, but a downward trend can be observed for Limpopo and Western Cape. North-West had the lowest level of attainment below 70% but slight improvements were observed during years of NDP implementation. The remaining provinces showed a fairly stable trend of overall attainment ranging between 80% and 86%. The persistent attainment of the province does not change over time which is the feature of the model. However, the means for each province vary due to heterogeneity

in terms of uneven economic development in these geographic areas. In terms of transient attainment, most provinces are performing quite well. Slight fluctuations can be observed post-2012.

Overall attainment is undermined by the under-achievement in persistent attainment hence it deserves special attention. On average the long-term attainment was 0.853 with universities of technology leading at 0.961 followed by comprehensive (0.886) and traditional (0.766) universities. The overall attainment thus can be improved on average by 16% while that of traditional, comprehensive, and technology universities by 23, 13, and 4%, respectively. Additionally, this indicates that long-term attainments are more likely caused by structural problems such as institutional legacy and regulatory measures. The short-term attainments suggest that institutional operational problems such as managerial capacity affect traditional universities more compared to comprehensive and technology universities. These findings echo the results about long-term attainments in Germany (Gralka 2018a).

5.1.4 Catch-up of attainment over time

This section analyzes the growth and catch-up of attainment over time. In each year we calculate the average by province and university type. Then we divide these averages by respective averages in the first year 2009. Figure 6 visualizes the calculations.

In the context of South Africa, the technology universities were designed to teach applied technology. But as far as 2017, Kruss and Visser (2017) reported that these universities were rapidly developing national and local reputations. The lower panel of Figure 6 suggests that technology universities exhibit a high level of growth over the study period. In the case of comprehensive universities, a huge regress was observed from 2009 to 2011, and this can be explained by complex institutional mergers, the conceptualization of identity and reputation as well as operating across multiple campuses (Pattman 2007, Mohuba and Govender 2016). In subsequent periods, they witnessed significant improvement toward the attainment of goals because of the merger program characterized by excellent communication, stakeholder convergence, buy-in from influential constituencies, coherent strategies to deal with change, and trust among the key drivers of the merger (Mohuba and Govender 2016). The results for traditional universities suggest that they should adapt to the fourth industrial revolution (4IR) and diversify their mode of delivering education to improve on the attainment of goals.

The upper panel of Figure 6 identifies fast and slow-growing universities in terms of attainment. The North Western universities improved their attainment the most – by

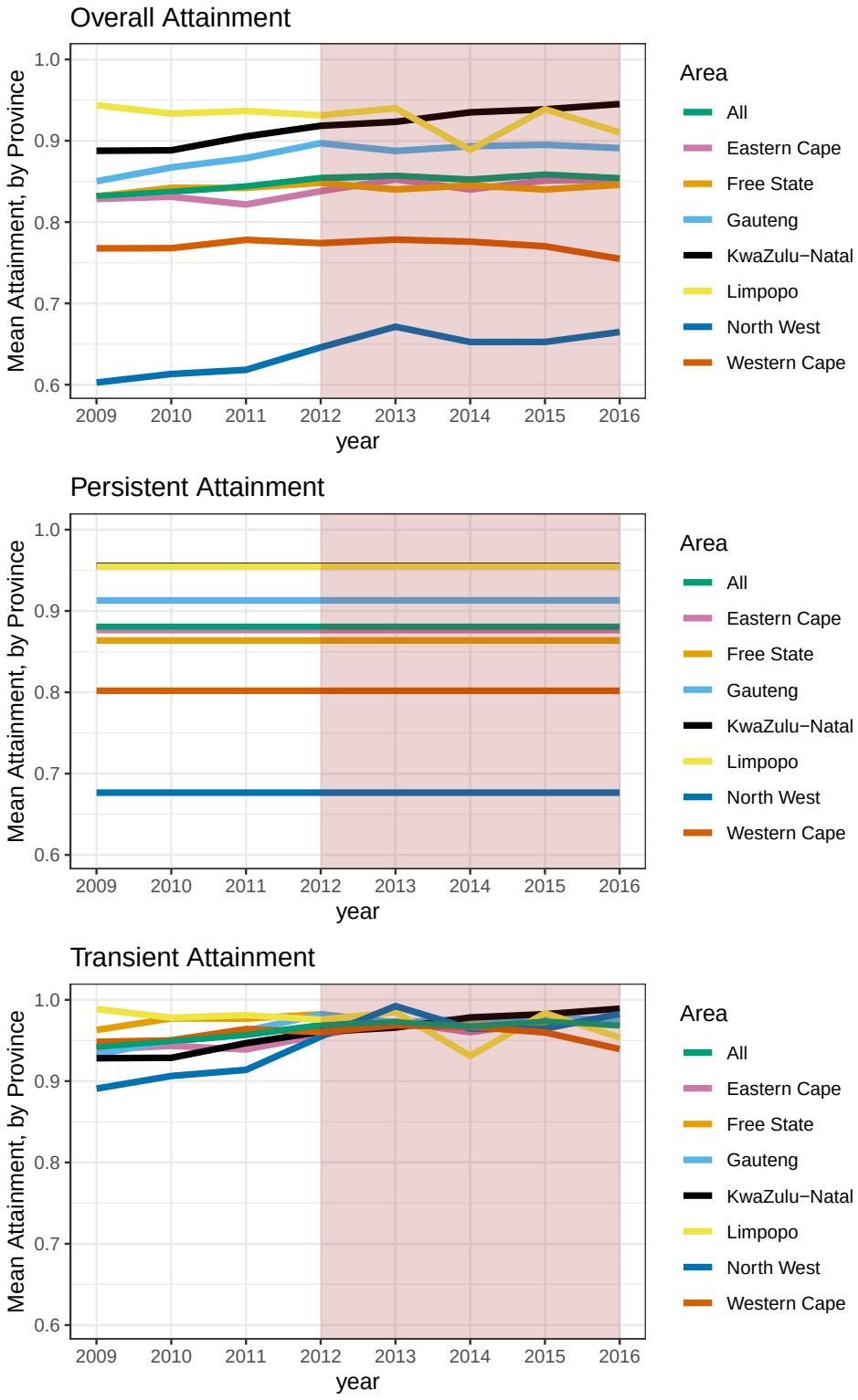

Figure 5: Mean Attainment by Area and over Time

about 10% – even though the growth slowed down by the end of the period. This could be connected to the successful merger between Potchefstroom University of Christian

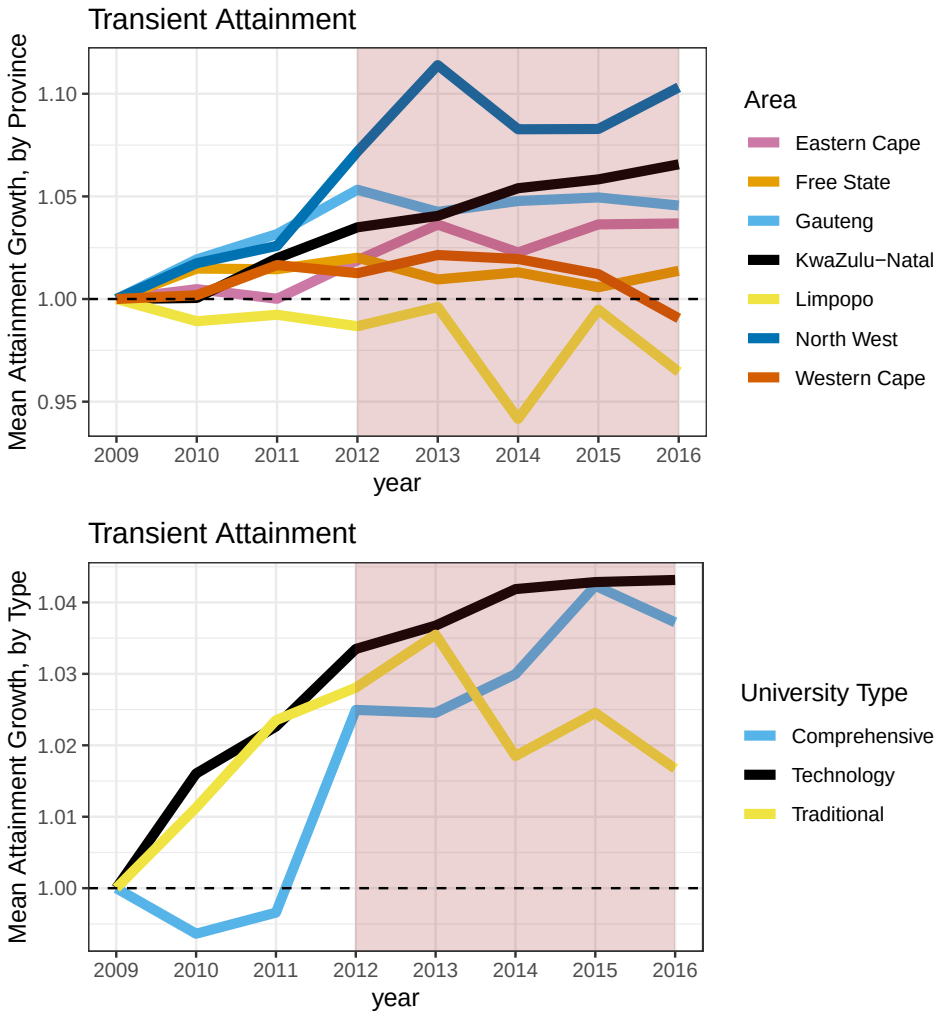

Figure 6: Catch-up by type of university and region

Higher Education and the University of Bophuthatswana. The same effect of the merger program could be attributed to the universities located in KwaZulu-Natal. A slight improvement was observed for Free State but has been declining since 2013. Limpopo's universities on the other hand saw lower attainment on average over time. The failure to catch up by Limpopo must be a result of the uneven economic development of this province relative to its counterparts.

5.2 Determinants of Universities' achievement

This section analyzes the effect of environmental variables or determinants on universities' underachievement. The marginal effect of say variable Z measures the change in underachievement given the change in this variable Z and holding everything else

Table 2: Descriptive statistic of the marginal effects on underachievement

Variable	Type	Mean	SD	Min	Max
Time	Comprehensive	−0.0121	0.00967	−0.0549	−0.00204
Time	Technology	−0.00829	0.0127	−0.0607	-2.66×10^{-5}
Time	Traditional	−0.0009	0.000234	−0.00148	−0.000489
Z1	Comprehensive	0.522	0.418	0.0881	2.37
Z1	Technology	0.231	0.355	0.000741	1.69
Z1	Traditional	−0.114	0.0297	−0.189	−0.0622
Z1 / Z2	Comprehensive	−0.0866	0.0694	−0.393	−0.0146
Z1 / Z2	Technology	0.0089	0.0137	2.86×10^{-5}	0.0652
Z1 / Z2	Traditional	−0.013	0.00338	−0.0214	−0.00706

fixed. We include the three main determinants: (1) time, (2) government funds, and (3) government funds divided by student fees. The summary statistics of these variables are presented in Table 1. Because these variables enter the specification in interaction with one another, the separate coefficients are not informative, and therefore additional calculations are required to infer the direction of the marginal effects.

Table 2 presents the summary of the marginal effects using methods described in section 4.2 and Figure C1 (Appendix C) visualizes them. The desirable circumstance is that the marginal effect is negative since it would imply that this variable reduces underachievement, i.e., improves attainment. Table 2 suggests that attainment has been increasing over time for all types of universities, which we also found in the previous section. It means that both conditionally on other variables (in the previous sections) and unconditionally attainment has been improving over time.

Government funds (Z_1) had differentiated effects on underachievement. It had a positive effect on underachievement at traditional universities, however, more government funds were detrimental to attainment for both comprehensive and technology universities. This however is not the full story about the government funds. If we consider the proportion of government funds to student fees (Z_1/Z_2), it also had varying effects on underachievement. The traditional and comprehensive universities benefited from the increase in this ratio, while the increase was detrimental to technology universities' attainment.

5.3 Attainment and International Rankings

This section examines the results of multidimensional attainment in the context of international rankings. It is crucial to underscore that university rankings, both globally and within individual countries, are influenced by specific criteria, such as research intensity

or a focus on teaching. Unlike many previous studies, this paper considers education not merely as a sector but as a foundational societal element, aiming to advance all five dimensions of original university goals.

Table 3 presents data on the persistent attainment and median transient attainment values for each university in our sample. The second column classifies each university into its respective cluster. Our analysis includes the three most prominent international rankings: THE, QS, and URAP. Notably, rankings are available for all but one research-intensive university and for half of the universities focused on technical training. Conversely, rankings are almost nonexistent for universities that combine research and technical training. Furthermore, it is observed that most rankings emphasize academic performance and, to a lesser extent, employment outcomes. However, none of these rankings address all five goals set by Department of Higher Education and Training (DHET) for universities aimed at societal transformation.

The Research-Intensive Universities are consistently ranked higher than other South African universities in international Rankings. However, with the exception of the University of Witwatersrand, they show a much lower persistent attainment of the five goals. As we have observed above the universities that combine research and technical training on the second, most persistently efficient universities in South Africa. And the universities that do not appear in the international Rankings, or a beer at the bottom of the ranking (e.g., THE 2011-2024 or URAP) exhibit the highest persistent attainment of all the goals, determined by DHET.

Research-Intensive Universities ('red') in South Africa consistently achieve higher positions in international rankings compared to other South African institutions. However, with the exception of the University of Witwatersrand, these universities demonstrate notably lower persistent attainment of the five goals identified by the DHET. In contrast, universities that integrate research and technical training emerge as the second most persistently efficient institutions in the country. Furthermore, universities that either do not appear in international rankings or are ranked at the lower end (e.g., in THE 2011-2024 or URAP) exhibit the highest persistent attainment of all DHET-determined goals.

Table 3: Attainment and International Rankings

University	Cluster[1]	Attainment		THE						QS			URAP[4]
		Pers.[2]	Tra.[3]	2011-24	Teaching	Research	Citations	Income industry	Intern. outlook	2006-24	Empl. outcome	Alumni outcome	
Rhodes U	Red	0.69	0.97	9						9	50		10
Stellenbosh U	Red	0.53	0.94	2	28	36	60	7	53	3	54		4
U of Cape Town	Red	0.80	0.92	1	30	36	87	88	81	1	93	87	1
U of Pretoria	Red	0.70	0.95	5	26	26	29	64	50	5	56	57	5
U of Witwatersrand	Red	0.93	0.96	2	27	23	76	100	70	2	89	87	2
Cape Peninsula U of Technology	Blue	0.98	1.00										16
Central U of Technology	Blue	0.98	0.98										
Durban U of Technology	Blue	0.98	1.00	11									13
Tshwane U of Technology	Blue	0.98	0.99	13									12
U of Venda	Blue	0.96	0.98	13									18
Vaal U of Technology	Blue	0.98	1.00										21
Walter Sisulu U	Blue	0.96	0.95										
Nelson Mandela U	Green	0.93	0.96										14
North West U	Green	0.68	0.96	7						7			7
U of Fort Hare	Green	0.93	0.97										
U of Johannesburg	Green	0.96	0.96	4	19	24	36	43	56	4	39	40	6
U of KwaZulu-Natal	Green	0.95	0.97	5	25	31	50	41	59	6	44		3
U of Limpopo	Green	0.95	0.98										15
U of South Africa	Green	0.92	0.98	11	18	11	14	32	38	8			11
U of Western Cape	Green	0.89	0.99	7	19	18	36	33	61	10			8
U of Zululand	Green	0.94	0.91										20
U of the Free State	Green	0.75	0.97	9						11			9

[1] The data are taken from https://businesstech.co.za/news/lifestyle/657671/these-are-the-south-african-universities-with-the-best-employment-outcomes/, https://www.timeshighereducation.com/world-university-rankings/2018/world-ranking, https://www.topuniversities.com/employability-rankings/2018, and https://en.wikipedia.org/wiki/Rankings_of_universities_in_South_Africa;

[2] Red is Research-Intensive Universities, Green is Technical Training, Blue is Research-Intensive Universities & Technical Training;

[3] Persistent;

[4] Transient;

[5] University Ranking by Academic Performance.

Table 4: Rank Correlation Between Attainment and International Rankings

Ranking	Attainment	
	Persistent	Transient[1]
THE 2011-2024 Rank	0.31	0.69
THE teaching	-0.36	-0.79
THE research	-0.21	-0.64
THE citations	-0.07	-0.50
THE Income industry	0.21	-0.36
THE International outlook	0.00	-0.14
QS 2006-2024	-0.09	0.60
QS Employment outcome score	-0.24	-0.43
QS Alumni Outcome	-0.18	-0.55
University Ranking by Academic Performance (URAP)	0.37	0.47

[1] Median value over all years

To further corroborate the relationship between attainment and international ranking, we analyzed the ranking correlation coefficients between persistent attainment and rankings, as well as transient attainment and rankings. The results of this analysis are presented in Table 4. Two rankings, THE 2011-2024 and QS 2006-2024, exhibited relatively strong correlations with transient attainment. The URAP rankings correlated with transient attainment at only 0.47. These rankings are overall rankings. Individual rankings, which focus on specific aspects such as teaching, research, or international outlook, sometimes exhibited even negative correlations with transient attainment. The primary advantage of the methodology employed in this paper is the disaggregation of overall attainment into persistent and transient components. We observed that transient attainment is generally not correlated with international rankings. The correlations, whether negative or positive, were very low and hence uninformative.

6 Concluding remarks and Discussion

Having inequality in mind at all levels of society, the Department of Higher Education and Training in South Africa is tasked to address inequalities in Post-School Education and Training through the implementation of chapter nine in the National Development Plan. It has set several goals for public universities, which should move the country forward to a more equal society. In this study, we provide empirical evidence on the performance of higher education institutions by investigating the attainment of the five DHET goals for the public higher education sector by type of university in South Africa. We use modern frontier methods to disentangle overall attainment into short- and long-

run attainments, whereby we consider the type of university and geographical position, as well as explore the determinants of underachievement.

We found that universities of technology provide the best access to higher education regardless of student gender and race while traditional universities possess the best quality of academic staff coupled with significant improvements in the diversity of academics. Hence, they (traditional universities) command better success rates compared to their counterparts. The situation of the public higher education sector in the country is worrisome given the results show an overall underachievement of goals regardless of university type and province, associated with log-run underachievements. Public universities in South Africa are more likely to benefit from addressing structural and regulatory problems.

Most notably, our findings indicate that internationally recognized university rankings do not correlate with the achievements reported in this paper. This observation is neither unexpected nor should it be disheartening for the Department of Higher Education and Training. Popular university rankings primarily emphasize academic performance, a trend also reflected in most studies examining attainment in South African universities and other countries. We argue that efficiency analyses should be more comprehensive, encompassing all aspects of universities' activities.

The findings can be used to implement attainment-enhancing policies, that are specific to each university class, geographic area, and type of attainment. For instance, low persistent attainment can be tackled by addressing rigidities in the academic workforce, replacing outdated machinery and equipment as well as developing strategies for curriculum reform, and implementing reforms in basic education, especially in early childhood development. This calls for a more structural approach that policymakers need to adopt to remove possible sources of low persistent attainment. These actions have a sense of urgency in traditional universities. For geographic areas, improvements can be achieved through the speedy implementation of notable aspirations of chapter nine in the NDP using the District Development Model.

Additional research avenues could be pursued to address the limitations inherent in our study. The acknowledged limitation in the existing literature on higher education efficiency is the lack of reliable quality metrics. An enhanced dataset, encompassing all South African universities, would markedly augment the scope of our analysis. This limitation, in turn, opens up opportunities for future research, such as delving into the interplay between educational performance and its impact on the economy, particularly in terms of underachievement and its connection to macroeconomic fundamentals such as unemployment.

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7 Appendix

A Data descriptions

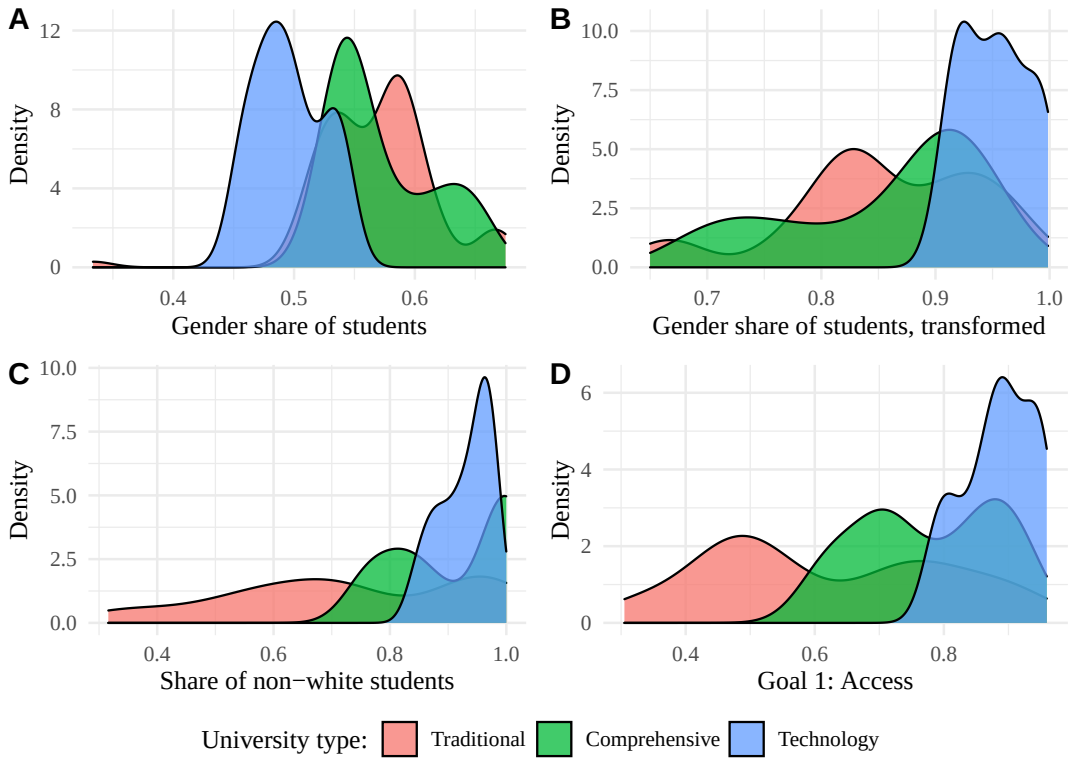

Figure A1: Department of Higher Education and Training Goal 1: Access

Notes: Panel A shows the densities of raw data of gender share of students ($ShSt_g$) by type of university. Panel B shows densities of the transformed share $ShSt'_g = 1 - |0.5 - ShSt_g|/0.5$, which shows how far the $ShSt_g$ is from the desired level of 0.5. Panel C shows the densities of shares of non-white students ($ShSt_{nw}$). Panel D presents densities of the product of shares of non-white students and transformed gender shares ($Y_1 = ShSt_{nw} \times ShSt'_g$) by the type of university. The larger Y_1 implies better access.

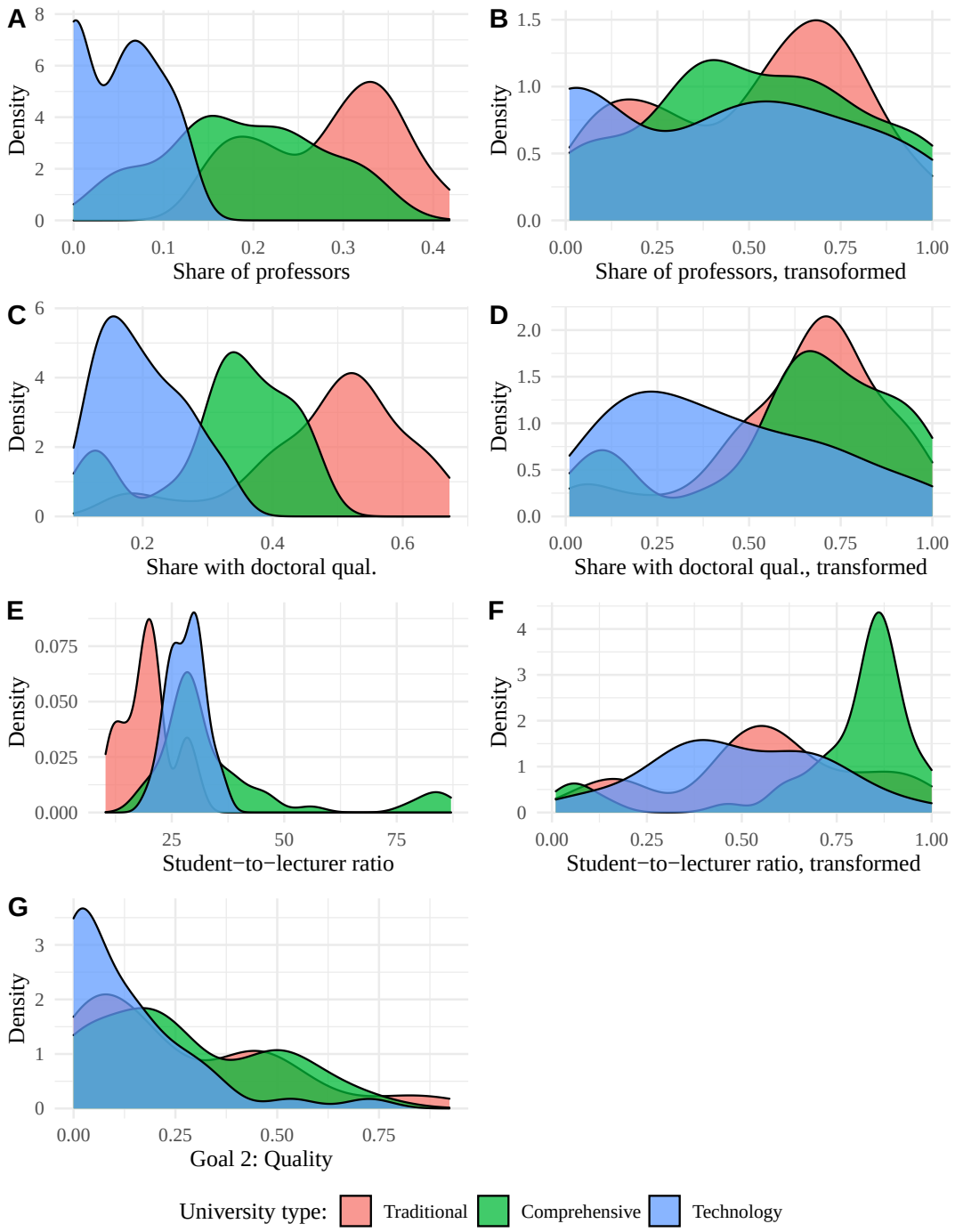

Figure A2: Department of Higher Education and Training Goal 2: Quality

Notes: Panel A shows the densities of raw data of the share of academics who are professors (ShA^U_{pr}) by type of university U. Panel B shows densities of the transformed share $ShA^{U'}_{pr} = (ShA^U_{pr} - min^U_{pr})/(max^U_{pr} - min^U_{pr})$, where max^U_{pr} and min^U_{pr} are university specific maximum and minimum shares of professors. Panel C shows the densities of raw data of the share of academics with doctoral qualification (ShA^U_{dr}) by type of university U. Panel D shows densities of the transformed share $ShA^{U'}_{dr} = (ShA^U_{dr} - min^U_{dr})/(max^U_{dr} - min^U_{dr})$, where max^U_{dr} and min^U_{dr} are university specific maximum and minimum shares of academics with doctoral qualification. Panel E presents densities of the student-to-lecturer ratio SL^U by type of university U. Panel F shows densities of the transformed ratio $SL^{U'} = 1 - (SL^U - min^U_{SL})/(max^U_{SL} - min^U_{SL})$, where max^U_{SL} and min^U_{SL} are university specific maximum and minimum student to lecturer ratios. Panel G presents densities of the product of the three transformed variables ($Y_1 = ShA^{U'}_{pr} \times ShA^{U'}_{dr} \times SL^{U'}$) by the type of university. The larger Y_2 implies better quality.

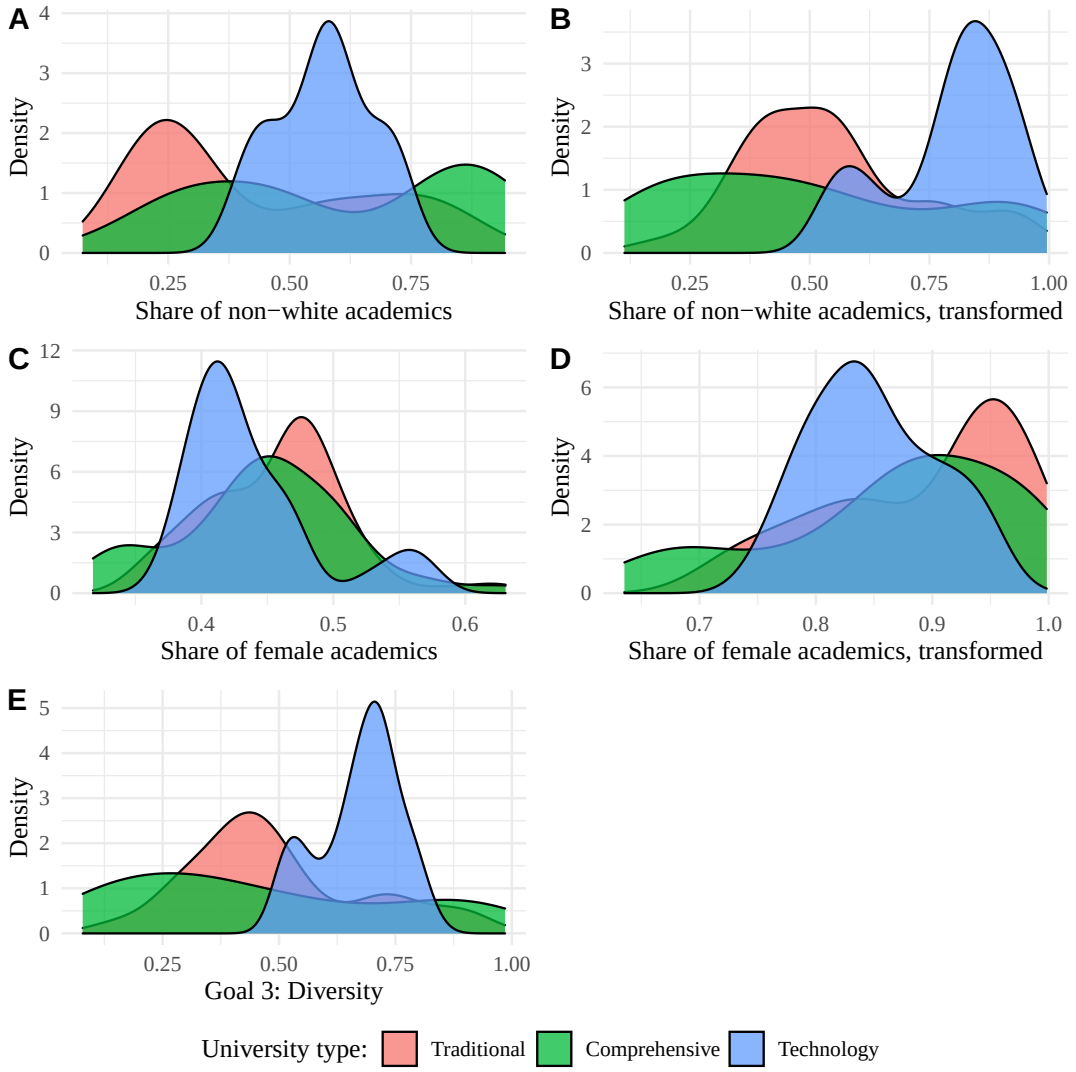

Figure A3: Department of Higher Education and Training Goal 3: Diversity of Academics

Notes: Panel A shows the densities of raw data of the share of non-white academics (ShA_{nw}). Panel B shows densities of the transformed share $ShA'_{nw} = 1 - |0.5 - ShA_{nw}|/0.5$, which shows how far the ShA_{nw} is from the desired level of 0.5. Panel C shows the densities of raw data of the share of female academics (ShA_f). Panel D shows densities of the transformed share $ShA'_f = 1 - |0.5 - ShA_f|/0.5$, which shows how far the ShA_f is from the desired level of 0.5. Panel G presents densities of the product of the two transformed variables ($Y_3 = ShA'_{nw} \times ShA'_f$) by the type of university. The larger Y_3 implies a larger diversity of academics.

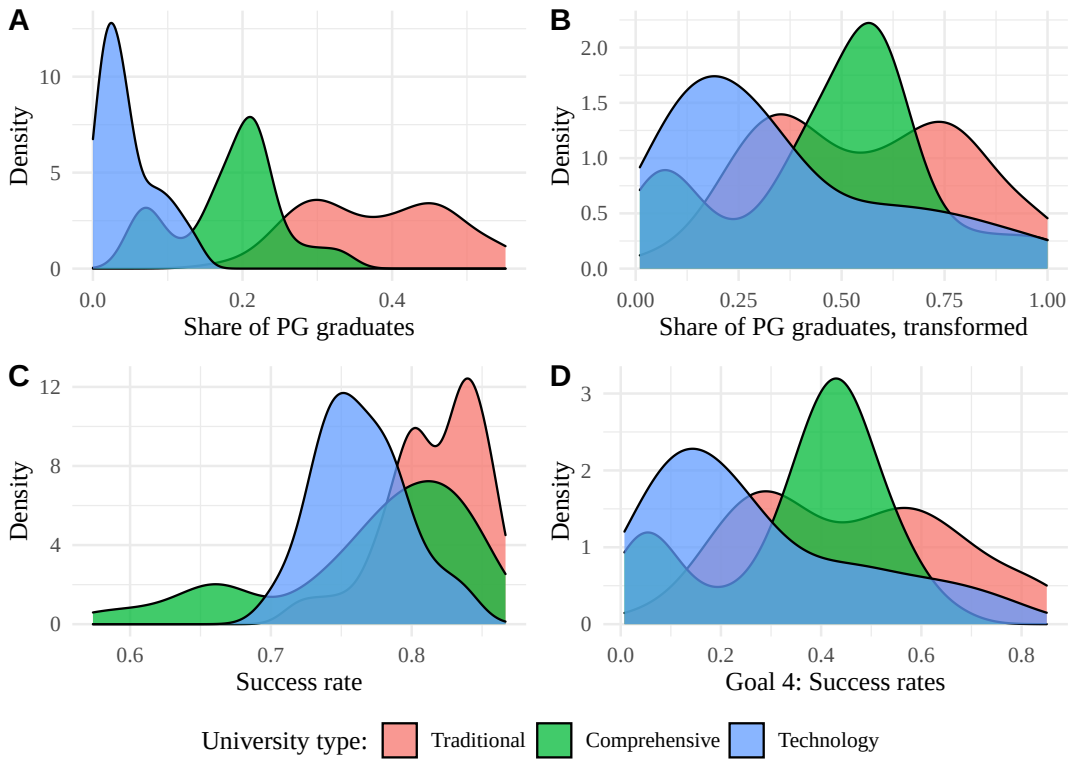

Figure A4: Department of Higher Education and Training Goal 4: Success Rates

Notes: Panel A shows the densities of raw data of the share of PG graduates (ShG_{pg}^{U}) by type of university U. Panel B shows densities of the transformed share $ShG_{pg}^{U'} = (ShG_{pg}^{U} - min_{pg}^{U})/(max_{pg}^{U} - min_{pg}^{U})$, where max_{pg}^{U} and min_{pg}^{U} are university specific maximum and minimum shares of PG graduates. Panel C shows the densities of shares of graduation success rate (ShG_{sr}). Panel D presents densities of the product of the transformed share of PG graduates and graduation success rate ($Y_4 = ShG_{pg}^{U'} \times ShG_{sr}$) by the type of university. The larger Y_4 implies a larger success rate.

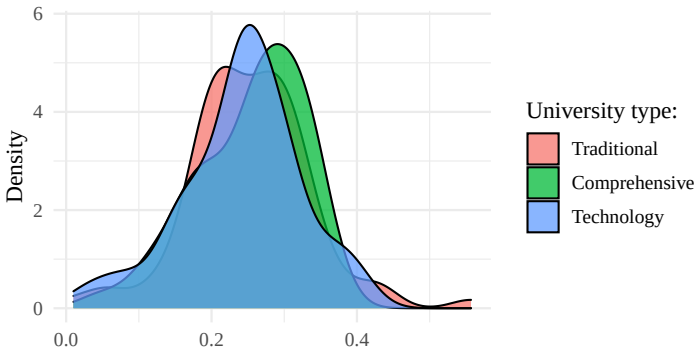

Figure A5: Department of Higher Education and Training Goal 5: Efficiency

Notes: The income-to-debt ratio was made positive by adding the absolute value of the smallest income-to-debt ratio of −0.166.

B Regression table

Table B1: University production function. Dependent variable: $-\log(y_1)$

Parameter	Coefficient	p-value
Education production frontier		
Intercept	-0.163	(<1e-9)
0.5*log(Y2/Y1)^2	-0.003	(0.135)
0.5*log(Y3/Y1)^2	0.043	(0.079)
0.5*log(Y4/Y1)^2	-4.0e-4	(0.982)
0.5*log(Y5/Y1)^2	-0.010	(0.668)
0.5*log(X1)^2	-0.214	(<1e-9)
0.5*log(X2)^2	-0.190	(<1e-9)
0.5*log(X3)^2	0.071	(<1e-9)
0.5*t^2	-0.003	(0.140)
t	0.003	(0.729)
D1	0.012	(0.094)
log(Y2/Y1)∗log(Y3/Y1)	0.007	(0.407)
log(Y2/Y1)∗log(Y4/Y1)	-0.003	(0.208)
log(Y2/Y1)∗log(Y5/Y1)	0.003	(0.681)
log(Y2/Y1)∗log(X1)	0.012	(0.137)
log(Y2/Y1)∗log(X2)	0.007	(0.440)
log(Y2/Y1)∗log(X3)	-0.014	(<1e-9)
log(Y3/Y1)∗log(Y4/Y1)	-0.023	(0.177)
log(Y3/Y1)∗log(Y5/Y1)	-0.001	(0.968)
log(Y3/Y1)∗log(X1)	0.087	(0.022)
log(Y3/Y1)∗log(X2)	-0.026	(0.731)
log(Y3/Y1)∗log(X3)	-0.038	(0.082)
log(Y4/Y1)∗log(Y5/Y1)	2.9e-4	(0.988)
log(Y4/Y1)∗log(X1)	-0.014	(0.588)
log(Y4/Y1)∗log(X2)	0.066	(0.003)
log(Y4/Y1)∗log(X3)	-0.038	(7e-4)
log(Y5/Y1)∗log(X1)	-0.003	(0.934)
log(Y5/Y1)∗log(X2)	0.015	(0.598)
log(Y5/Y1)∗log(X3)	-0.012	(0.322)
log(X1)∗log(X2)	0.310	(<1e-9)
log(X1)∗log(X3)	-0.062	(<1e-9)
log(X2)∗log(X3)	-0.060	(<1e-9)
1. Random effects component: $\log\sigma^2_{v_{0i}}$		
Intercept	-4.590	(<1e-9)
2. Persistent underperformance component: $\log\sigma^2_{u_{0i}}$		
Intercept	-2.827	(<1e-9)
University Type: 2	-2.419	(<1e-9)

(*continued on next page*)

Table B1 (*Continued*)

Parameter	Coefficient	p-value
University Type: 3	-4.443	(<1e-9)
3. Random noise component: $\log\sigma^2_{v_{it}}$		
Intercept	-10.582	(<1e-9)
4. Transient underperformance component: $\log\sigma^2_{u_{it}}$		
Intercept	-2.638	(0.043)
Trend	-0.111	(0.196)
Trend × University Type: 2	-0.421	(0.033)
Trend × University Type: 3	-1.174	(0.046)
University Type: 2	-5.185	(0.022)
University Type: 3	-26.438	(0.048)
Z_1	-5.682	(0.026)
Z_1 × University Type: 2	22.683	(0.001)
Z_1 × University Type: 3	47.837	(0.070)
Z_1/Z_2	-0.337	(0.701)
Z_1/Z_2 × University Type: 2	-2.411	(0.161)
Z_1/Z_2 × University Type: 3	1.782	(0.689)
Sample Characteristics		
N	22	
$\sum_{i=1}^{N} T_i$	176	
Sim. logL	345.91	

C Determinants of underachievement

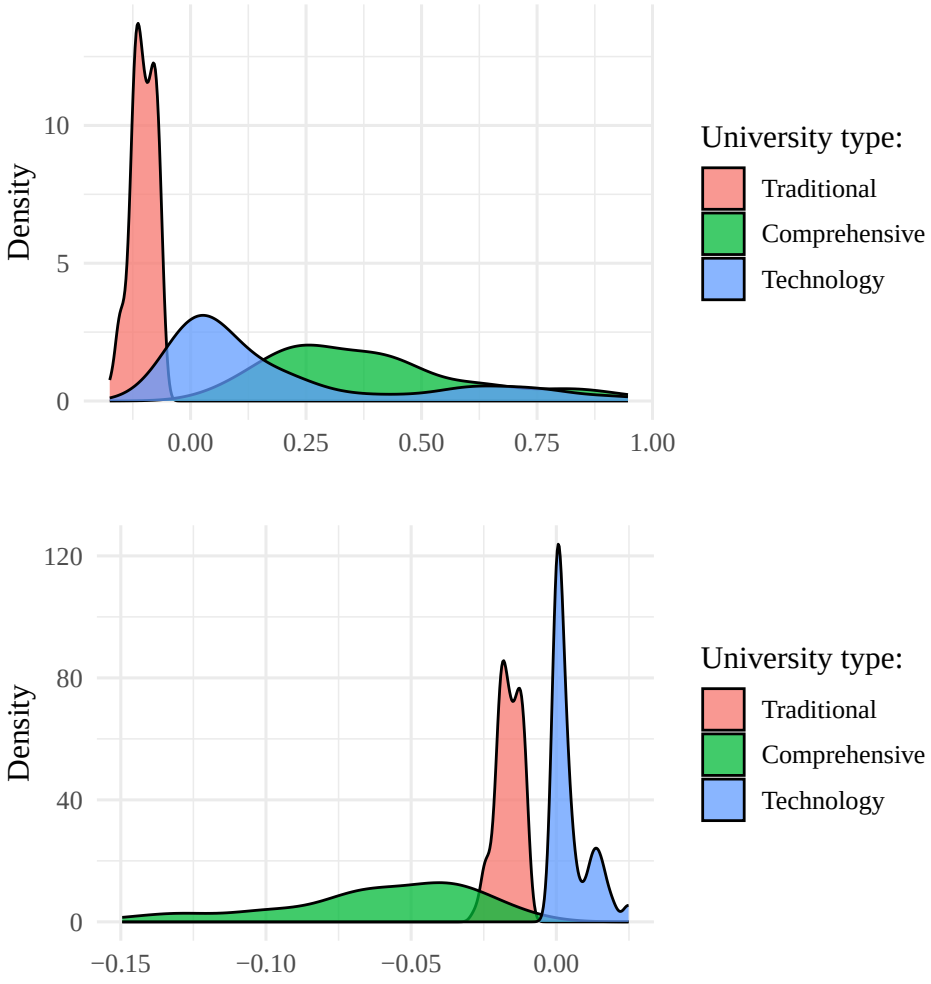

Figure C1: Marginal Effects by type of university

Notes: The upper panel is the ME of the Z_1 variable on underachievement (inefficiency), and the lower panel is the ME of the Z_1/Z_2 variable on underachievement (inefficiency).