

Throughput in the UCT Actuarial Science programme: a microcosm of the profession's transformation challenge

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ABSTRACT

We employ survival analysis to investigate throughput rates, and certain demographic and educational factors that exert a significant influence on them, in the Actuarial Science programme at the University of Cape Town. The results contextualise the huge transformation challenge facing the profession, and also point to some of the features of the educational landscape which have the power to overcome them.

KEYWORDS

Throughput; transformation; actuarial profession; higher education; University of Cape Town

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1. BACKGROUND AND OVERVIEW

1.1 Background

1.1.1 More than 20 years into South Africa's democracy, the country finds itself grappling with the structural inequalities that are apartheid's legacy. The privileges granted to the white population under apartheid (and colonialism) continue to be reflected in income dynamics, secondary education, access to tertiary education and the leadership and ownership structures of corporate South Africa (McIntosh et al., 1988; National Planning Commission, 2012; Badat, 2010; Spaull, 2013; Butler, 2016).

1.1.2 We use the term ‘transformation’ in the South African context in the sense proposed by De Vos: to describe the necessary institutional and inter-personal changes required to alter these structural dynamics.¹ The notion is underpinned by key values of diversity, inclusivity and equity (Horwitz & Jain, 2011). Transformation is frequently reduced to issues of race and gender profile—a facet we term ‘demographic transformation’. Whilst these changes are important, and are reflected in employment equity legislation² and industry charters,³ the notion of transformation extends further to issues of institutional culture (Tabensky & Matthews, 2015), systemic racism and sexism (Badat, 2010),⁴ and shifting the broad lived experience of South Africans.⁵

1.1.3 These challenges are mirrored within the South African actuarial profession, both in the structures of the profession itself and within actuarial employers. In 2017, 710 out of 1 151 (62%) of Fellow actuaries are both white and male.⁶ Demographic change so as to be more representative of the broader South African population is hampered by structural barriers which are aggravated by the long qualification process. This should not be the basis for complacency but rather an impetus to ensure that structural barriers for black and women candidates are removed. The consequences of the demographic profile of the profession are far-reaching: the dominance of the profession by a single group gives rise to the risk of a lack of diversity in thinking, an absence of role models, the perception of gate-keeping and limited participation of black and women actuaries in leadership roles (Ramjee et al., 2013; 2014; Enderstein, 2015).

1.1.4 The path to qualifying as an actuary is a long and gruelling one, characterised by numerous professional examinations⁷ and relatively low pass rates.⁸ In the South African context, the norm is for candidates to complete an undergraduate degree in Actuarial Science (Naidoo, 2008), followed by a period of simultaneous work experience and studying. Students completing a degree, and obtaining sufficiently high grades in relevant subjects at an accredited university can be exempted from writing particular professional

1 De Vos, P (2010). What do we talk about when we talk about “transformation”? Retrieved from <http://constitutionallyspeaking.co.za/what-do-we-talk-about-when-we-talk-about-transformation-2/>

2 Broad-Based Black Economic Empowerment Amendment Act 2003 (Act No. 53 of 2003), as amended by the B-BBEE Act 46 of 2013

3 Department of Trade and Industry (2016). Draft amended financial sector code: Codes of good practice on Broad-based Black Economic Empowerment. *Government Gazette*

4 Department of Higher Education and Training (2013). *Green paper for post-school education and training*

5 De Vos, P (2010). What do we talk about when we talk about “transformation”? Retrieved from <http://constitutionallyspeaking.co.za/what-do-we-talk-about-when-we-talk-about-transformation-2/>

6 Murphy-Harris, R (2017) Opening plenary. Actuarial Society of South Africa Annual Convention, Sandton

7 The Actuarial Society of South Africa (‘The Society’) currently requires students to pass 13 examinations, to complete a three-year period of experiential learning and to complete a professionalism course in order to be admitted as a Fellow member of the profession. www.actuarialsociety.org.za/StudentZone/Educationalrequirements.aspx

8 www.actuarialsociety.org.za/StudentZone/Examresults.aspx

examinations.⁹ The role of universities in actuarial education is therefore a key one in the current paradigm.

1.1.5 Tensions between students and university structures were heightened during 2016 and remain elevated as frustrations with the slow pace of transformation have come to the fore. Student protests have encompassed a wide range of issues relating to the demographic profile of university staff, the institutional culture of previously-advantaged universities and the need for decolonisation of the curriculum¹⁰ (Naicker, 2016; Karodia et al., 2016). Universities have a key role to play in broader societal transformation, both via the mechanisms of economic development and “wider social purposes” (Badat, 2010).¹¹

1.2 Overview

1.2.1 We focus our research on assessing the success of a particular university programme, namely that offered by the University of Cape Town (UCT). This institution was chosen both because of the existence of prior literature analysing Actuarial Science students' performance at UCT (see section 2) and because of the authors' involvement at UCT, which provided access to data.

1.2.2 The ‘success’ of an undergraduate Actuarial Science programme is taken to include, at least, the following metrics:

- the production of qualified actuaries;
- throughput to graduation with an Actuarial Science degree; or
- more generally, throughput to graduation with any degree.

1.2.3 We investigate throughput rates (i.e. how likely is it that students entering the Actuarial Science programme will graduate with an Actuarial Science degree), and the demographic and educational factors that appear to differentially influence success. We also address the issue of whether this likelihood is acceptable, or whether it suggests the necessity for some strategic action by the UCT Actuarial Science department.

1.2.4 Central to the transformation challenge faced are the differentials in success rates along key dimensions, notably race, gender and home language. In the South African context, these facets are inextricably linked to other factors affecting success such as economic background, first in the family (or community) to enter university and university readiness. In addition, the relative success of students who are funded by the South African Actuaries Development Programme (SAADP), the largest single funder of Actuarial Science studies in the country,¹² is of interest, as is the relative success of those who are registered at UCT in the Education Development Unit (EDU).¹³ These initiatives are discussed in Section 2.

9 www.actuarialsociety.org.za/student-zone/exceptions/

10 Ludski, W (2015). International solidarity for Fees Must Fall. *The Journalist*. Retrieved from www.thejournalist.org.za/spotlight/international-solidarity-for-fees-must-fall

11 Department of Higher Education and Training (2012). Green paper for post-school education and training

12 www.saadp.co.za

13 www.commerce.uct.ac.za/EDU

1.2.5 Given the available data, no attempt has been made in this paper to track the progress of UCT graduates towards qualification as actuaries. This is of importance for the profession and the university programme and is therefore a natural and important extension of the research presented below.

1.2.6 The quality of the graduates produced (which may include factors such as work readiness, technical and normative skills, leadership capability as well as ethical and social responsibility) is also of key importance (Chetty, 2012), but measurement of these domains falls outside of the scope of this paper.

2. UCT ACTUARIAL SCIENCE PROGRAMME

2.1 Both of the authors of this paper are affiliated with UCT and were consequently able to secure access to the detailed data required to undertake the analysis. In addition, the UCT programme has been subject to prior research which enables comparisons over time. Of relevance are Dorrington and Vergeest (1988), Slattery et al. (2000) and Ramjee et al. (2013). Ideally, the analysis should be repeated at other universities.

2.2 The historical background to the UCT actuarial science programme, as well as a description of the relevant degrees offered, can be found in Appendix A.

2.3 Both SAADP and the EDU represent significant demographic transformation initiatives at UCT. The impact of these initiatives (if any) is important to assess as this informs the future strategies employed both at UCT and at other universities.

2.4 The vision of SAADP is “to be a significant role player in improving the demographics of the actuarial profession in South Africa”.¹⁴ SAADP is a not-for-profit organisation that funds the tertiary studies of actuarial students using donor funds. Its overall aim is to increase the number of black actuaries in South Africa. It is a scholarship programme, not a bursary programme. This means that students have no work obligations tied to the funding, nor is there any requirement to pay back the funding. The programme is currently funded by SASRIA as well as a number of actuarial employers. SAADP funds students at three universities, at each of which is appointed a full-time SAAADP programme co-ordinator.

2.5 The EDU is a unit at UCT that seeks to enable degree completion. Resources are targeted at “students who have experienced gaps and disparities in both education and life experiences”.¹⁵ A variety of (non-financial) mechanisms are employed to support students (Pym, 2013a). The philosophy of the EDU is to leverage student capabilities and internal resources, as opposed to focussing on remedying so-called deficits (Pym, 2013a).

¹⁴ www.saadp.co.za/index.php/component/content/article?id=12

¹⁵ www.commerce.uct.ac.za/EDU

2.6 The performance of UCT Actuarial Science students was first interrogated in the literature by Dorrington and Vergeest (1988), who found inter alia that:

- UCT graduates tended to perform better than those of other South African universities in the professional examinations.
- The proportion of female students in the first-year cohort was between 10% and 15% in the period from 1984 to 1988.
- While the proportion of black (broadly defined) students grew over the period of investigation, the proportion of black African students remained “negligible”.¹⁶

2.7 Slattery et al. (2000) provided a follow-up to this study, offering the following key insights:

- The programme had continued to grow significantly, with an average of 68 new entrants each year in the period 1995–1999, compared with 29 in the period 1985–1989 and 7 in the period 1970–1979.
- The proportion of female first-year students had risen from the 10%–15% reported by Dorrington and Vergeest (1988) to an average of 24% over the years from 1995 to 1999.
- In the period 1997–1999, more than half of the new first-year cohort was black, with the black African contingent having grown to around 20%; however, only half of these were South Africans.
- No significant trend, upward or downward, was detected in exemption rates.
- In general, UCT graduates tended to outperform those of other universities in the professional examinations (significantly for some subjects, and more narrowly for others).

2.8 While both of the above papers addressed the profile of the student base by race and gender, the primary focus of both was overall performance, and no attempt was made to establish whether there was differential performance along demographic lines. Home language was also not considered as a factor, presumably because the overwhelming majority of first-year Actuarial Science students would have spoken English as a home language in the 1980s and 1990s.

2.9 Ramjee et al. (2013) undertook an analysis of relative academic performance and persistency between male and female students. They found that the proportion of entrants who are female had increased over time (to 36.6% in 2010–2011) but that persistency rates (i.e. the rate of progress to later academic years) for female students were lower than for male students.

¹⁶ The question of racial classification is a vexing problem in South African academic research, but obviously a necessity in the context of historic and prevailing disparities in wealth and access to resources. The term ‘black’ is typically used to refer either to South Africans of African ethnicity, or more broadly to those groups of South Africans denied a political voice under apartheid. We have made an effort to specify what is meant in each instance when referring to past literature; ¶4.4 defines how the term is used in the analysis presented in this paper.

3. FACTORS INFLUENCING ACADEMIC SUCCESS

There are numerous factors that influence the success of students in tertiary education, both as enablers of and barriers to success. In this section we explore the factors identified in the literature, both locally and internationally, which are relevant to the context of this paper. We confine our attention to these main factors, as a comprehensive review of the literature on academic success is neither possible within the scope of this paper nor necessary to lay the foundation for what follows.

3.1 Stereotype Threat

3.1.1 Stereotype threat is a widely recognised phenomenon where the existence of negative stereotypes serves to impair the performance of stigmatised individuals (Schmader et al., 2008). The literature argues that awareness of the existence of negative stereotypes induces fear of fulfilling them and ultimately shapes intellectual identity and performance (Steele, 1997). Importantly, it is not a necessary condition for an individual to believe the stereotype is true or to believe that they personally verify the stereotype in order to experience stereotype threat (Bell et al., 2003).

3.1.2 The seminal works in this area identify negative stereotypes relating to the academic performance of both women (Spencer et al., 1999) and black students (Steele & Aronson, 1995; Aronson et al., 1998). Stereotype threat as it relates to race is highly relevant in the South African context where notions of intellectual inferiority were central to apartheid structures. This is particularly so in mathematical disciplines. Verwoerd is quoted as saying “What is the use of teaching the Bantu child mathematics when it cannot be used in practice?” (Khuzwayo, 2005). In the context of the actuarial profession, stereotype threat as it applies to women is equally resonant (Ramjee et al., 2013). The existence of negative stereotypes relating to the mathematical ability of girls and women is well known (Spencer et al., 1999), and is seen as a major challenge in the so-called STEM (Science, Technology, Engineering and Mathematics) disciplines (Shapiro & Williams, 2012).

3.2 Language and Literacy

3.2.1 The language of instruction at UCT is English. However, when UCT students on campus are asked to self-declare their home language, there are 70 different languages that emerge (Paxton, 2013). This collision between the linguistic diversity of the students and the classroom presents challenges for the efficacy of student learning (Paxton, 2013). Students need to master key English terminology and language before they are able to engage with learning concepts (Paxton, 2009).

3.2.2 The Actuarial Science programme follows a professional syllabus which is designed in English, and so it follows that all else being equal, those without a strong command of the language are at an academic disadvantage coming into the programme.

3.2.3 There are also issues of identity that arise for those who come from a home-language background that is not English (Paxton, 2013). In addition to the prejudices associated with race and gender, language introduces an additional dimension to the sense of ‘otherness’ that students entering the Actuarial Science programme may experience.

3.2.4 Language is a key area where student support is necessary. Support interventions can range from the use of language labs or writing centres (Riley, 2013), development of glossaries of technical terms (Paxton, 2009), pedagogical approaches which are language-sensitive (Paxton, 2013) and separate language courses (Nomdo, 2013).

3.3 Secondary Education

3.3.1 Disparities in the quality of secondary schooling persist between race groups in South Africa (Fiske & Ladd, 2004; Yamauchi, 2005; Van der Berg, 2005). This has an impact on access to university, particularly in Actuarial Science where entrance requirements are high and programmes typically attract the top five per cent of school leavers (Slattery et al., 2000). For those who do meet the entrance requirements for Actuarial Science,¹⁷ differentials in the levels of preparedness for tertiary education remain a barrier to success (Nomdo, 2013).

3.3.2 These disparities in preparedness highlight the need for academic support.

3.4 Institutional Culture

3.4.1 A high proportion of black students at UCT are first-generation students; that is, they “come from home contexts in which no family member has previously attended a higher education institution” (Pym, 2013a). The challenges faced by first-generation students are well-documented in international literature (Billson & Terry, 1982; Lohfink & Paulsen, 2005; Spiegler & Bednarek, 2013). The proportion of students who are first-generation varies between countries (Spiegler & Bednarek, 2013); South Africa lies on the high end of the spectrum given the scale of recent societal change. First-generation students have been found to experience higher rates of attrition, even where academic preparedness is accounted for: this points to the cultural challenge faced by these students (Warburton et al., 2001; Luzeckyj et al., 2011; Lohfink & Paulsen, 2005). Students can be thought of as lacking the necessary cultural capital to navigate the university environment (Luzeckyj et al., 2011). They also lack the advantages of intergenerational knowledge (Luzeckyj et al., 2011).

3.4.2 In addition, UCT is an historically white institution; this history shapes the dominant culture of the institution (Pym, 2013a). The lack of familiarity with tertiary education, being far from home and the cultural dissonance that students experience when they enter the university system give rise to experiences of alienation (Pym, 2013a). This in turn “often produces intense loneliness and a loss of voice, self-esteem and purpose” (Pym & Kapp, 2013). Butler (2016) describes universities such as UCT as “institutions as sites of assimilation rather than integration, where discomfiting language, culture, and values predominate”.

3.5 Financial Support

3.5.1 The ongoing #FeesMustFall protest and debate have highlighted the financial vulnerability of students at South African universities. A significant proportion of

¹⁷ www.commerce.uct.ac.za/Pages/Admission-Requirements

students come from poor and/or rural backgrounds and face severe financial constraints. Examples of issues faced by students include long travel times to campus, unreliable transport, poor housing conditions, hunger (and inadequate nutrition) and poor access to supplementary materials.

3.5.2 An additional dimension is the stress and anxiety that arises in relation to financial obligations, including anxiety related to the risk of losing access to funding (for example, where funding is merit-based as opposed to need-based) (Lohfink & Paulsen, 2005). International research has found that financial support has a significant effect on the persistence of first-generation students in particular (Lohfink & Paulsen, 2005), presumably because they have reduced access to alternative forms of financial support.

3.5.3 The positive impact of financial support can be further enhanced when it is coupled with relationships that assist students with navigating the university system (Lohfink & Paulsen, 2005).

3.6 Psycho-social Support

3.6.1 The need for psycho-social support for students is particularly acute in the South African context where there is a high proportion of first-generation students, where there are language and cultural barriers, and where students are at risk of stereotype threat. Pym and Kapp (2013) highlight the importance of harnessing student agency, creating a sense of belonging and a “home away from home”. These efforts can serve to reduce student vulnerability.

3.6.2 Pym (2013b) highlights the link between academic support and psycho-social support by describing teaching approaches that create a learning community and consciously develop social connectedness.

4. DATA

4.1 UCT student data (both demographic and academic) were provided by the university’s Institutional Planning Department (IPD). A number of choices needed to be made about the scope of the data in order to facilitate the required analyses, the most important of which are the following:

- The universe of students consists of all who at any point in their academic careers were part of the Actuarial Science programme in the Commerce Faculty. Note that this implies that students who spent their entire academic careers in the Science Faculty were excluded from the analysis. Given the closure of the BSc programme and the divergence in entrance requirements over the years, we believe that this exclusion provides the most representative view of throughput. Furthermore, given that SAADP students have overwhelmingly been placed in the BBusSc programme, and EDU students exclusively so, this is also the most appropriate basis for a comparison of the relevant performance of these student groups. (A very small number of SAADP students who were in the Science Faculty throughout were however included in the analysis, for the sake of completeness.)

— Given that one of the primary objectives of this exercise is to analyse the performance of SAADP students, we restricted our analysis based on the start date of that programme. The first SAADP cohort was seen at UCT in 2003, but since two of that cohort had started at UCT the previous year, we included in our dataset all students commencing studies in 2002 or later.

4.2 The continuation of funding from SAADP for individual students is assessed on a regular (at least annual) basis, and students must meet minimum performance standards in order to retain their funding. This creates obvious analytical classification difficulties: should students who lose funding be treated as SAADP students throughout, not at all, or only for the years in which they were actually funded? The latter would create unwarranted analytical complexities, and hence we decided to classify such students as having been SAADP students throughout. It should also be noted that there will be a positive selection effect from those students selected for funding at later stages in their studies, in that such selection will have been based on strong academic performance.

4.3 Following application of the above approach, and many hours of careful data sanitisation, a total of 2346 students were included in the analysis, of whom 186 were classified as SAADP students.

4.4 It is worth noting that students at UCT self-declare their race, with the data offering the following six categories: black, white, coloured, Indian, Chinese and unknown/prefer not to classify. We have further identified international students (i.e. those who are neither South African citizens nor permanent residents) as a separate category. For the purposes of classification for survival modelling later in this report, we have used two broad-brush categories: black, combining students self-identifying as black, coloured, Chinese or Indian, consistent with employment equity legislation, and non-black, combining the white, unknown (including those who choose not to self-classify) and international categories. Unless the context clearly indicates otherwise, this is how the terms 'black' and 'non-black' should be interpreted in this paper.¹⁸

4.5 Demographic Profile

4.5.1 It is instructive to investigate the changing demographic profile of the UCT Actuarial Science student base over the years, but the numbers must be interpreted in the light of the comments made above, notably the omission of students who were in the BSc

¹⁸ The terminology used to draw broad demographic distinctions along racial lines is inevitably going to be clumsy. We wish to avoid the more customary 'white' and 'non-white' labels both because of their inaccuracy and because they imply the definition of a group with respect to its negation of a norm of 'whiteness'. The 'black' and 'non-black' categories are perhaps only marginally preferable, especially as the non-black group includes some international students of black African ethnicity, but in the absence of an obviously superior set of labels, they will have to serve the purpose in this paper.

programme throughout. The total number of students covered by this analysis by year is set out in Figure 1. While there will be some understatement of numbers in the years prior to 2010, this gives an indication of the growth in the size of the undergraduate programme.

4.5.2 For the balance of this section, when breaking down the profile by race, gender and home language, we examine the distribution of these indicators among new entrants to the programme in each year rather than total numbers. This avoids any distortions emanating from differences in time to graduation between the groups under consideration.

4.5.3 The demographic profile of new entrants by race is depicted in Figure 2. As expected, there has been a significant increase in the proportion of black (narrowly defined in this instance, i.e. South African black African) students from around 15% of the intake in the early years of this investigation to roughly a third in recent years (the slight apparent dip in 2014 and 2015 is partly related to the increasing size of the ‘unknow’ category: though still a small proportion, more and more students are declining to self-identify by race, which will complicate the analysis of demographic trends in the future). The proportion of white students has declined from around 40% in the early years to about 20%, and of Indian students from roughly 25% to 20%. While moving toward a more representative distribution, these figures are far removed from the national demographic distribution and much work remains to move the profile closer to that of the broader population.

4.5.4 The gender profile of the Actuarial Science new entrant base has likewise shifted, but at a slower rate: the balance has changed from approximately 70:30 in 2002

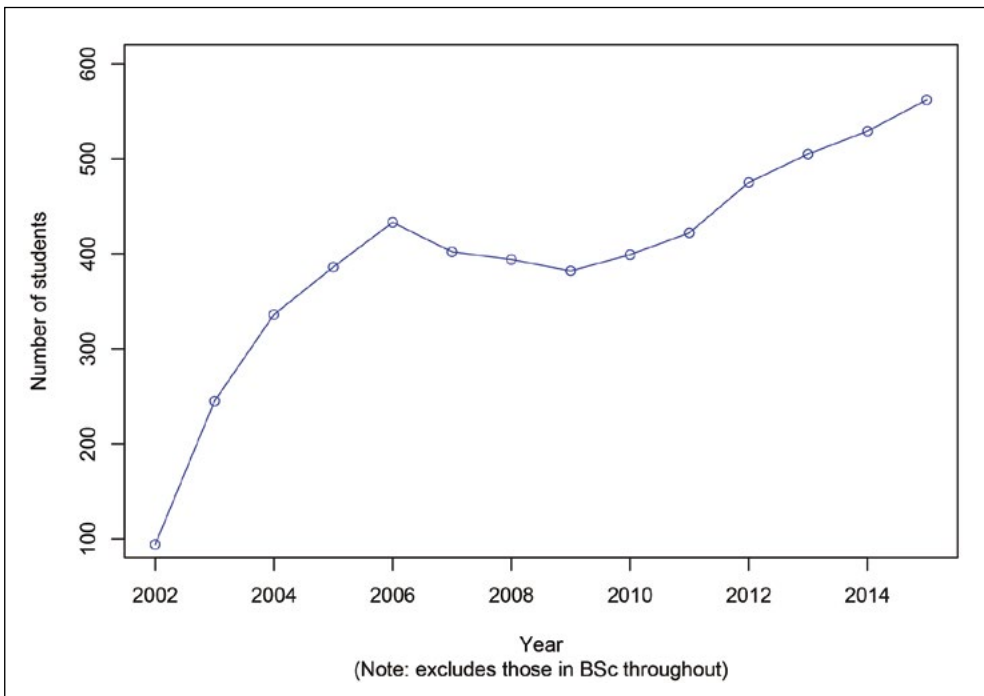


FIGURE 1. Total number of Actuarial Science students in investigation data, by year

to 65:35 currently, as shown in Figure 3. Clearly, further strides are necessary to move towards a more equal gender split in the student base, which will be a prerequisite for a more equal distribution of qualified actuaries down the line. Ramjee et al. (2013) reported that in 2010, just 15% of Fellow members of the Actuarial Society of South Africa were women—statistics for 2017 indicate that this has risen to 24%.¹⁹ This is not dissimilar to experiences in international actuarial bodies.²⁰ It is clear that the difficulties in recruiting and retaining female students are felt across race groups: Figure 4 shows that the gender split is similar in the subsets of black (broadly defined) and SAADP new entrants (though much more volatile for SAADP because of the smaller numbers).

4.5.5 Finally, we examine the distribution of home language over the period of investigation. Figure 5 depicts the changing distribution of home language of UCT new entrants. While the majority still speak English as a home language, since 2011 between 40% and 45% of UCT new entrants declare their home language as something other than English.

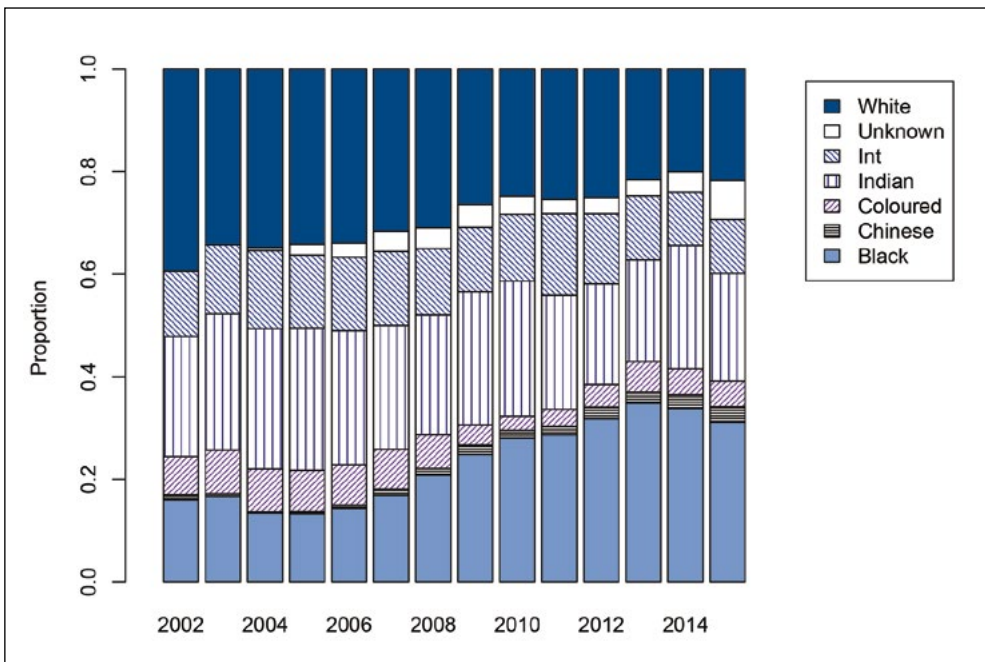


FIGURE 2. Breakdown of Actuarial Science new entrants by race

19 Murphy-Harris, R (2017). Opening plenary. Actuarial Society of South Africa Annual Convention, Sandton.

20 Howes, M. Editorial. *Actuary Australia*, 73 (September 2002); M de Valois. *Actuarielle. The Actuary*, September 2007

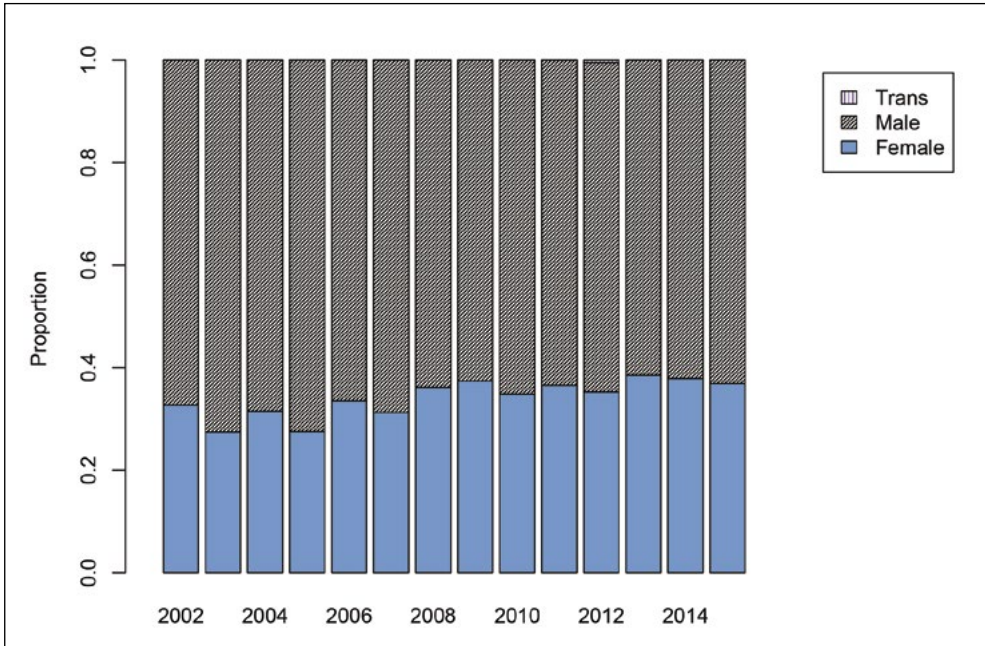


FIGURE 3. Breakdown of Actuarial Science new entrants by gender

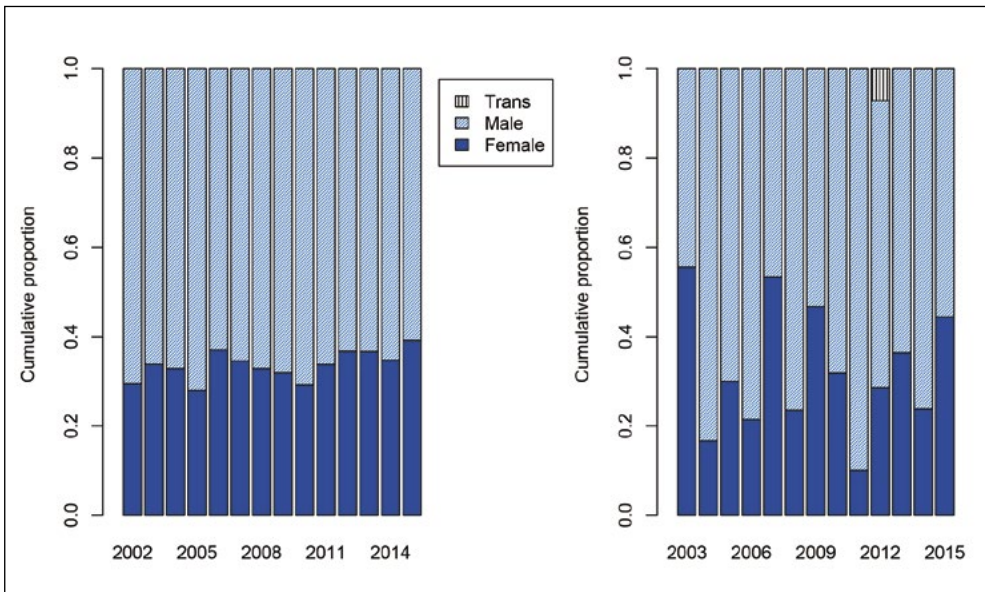


FIGURE 4. Breakdown of black (left) and SAADP (right) Actuarial Science new entrants by gender

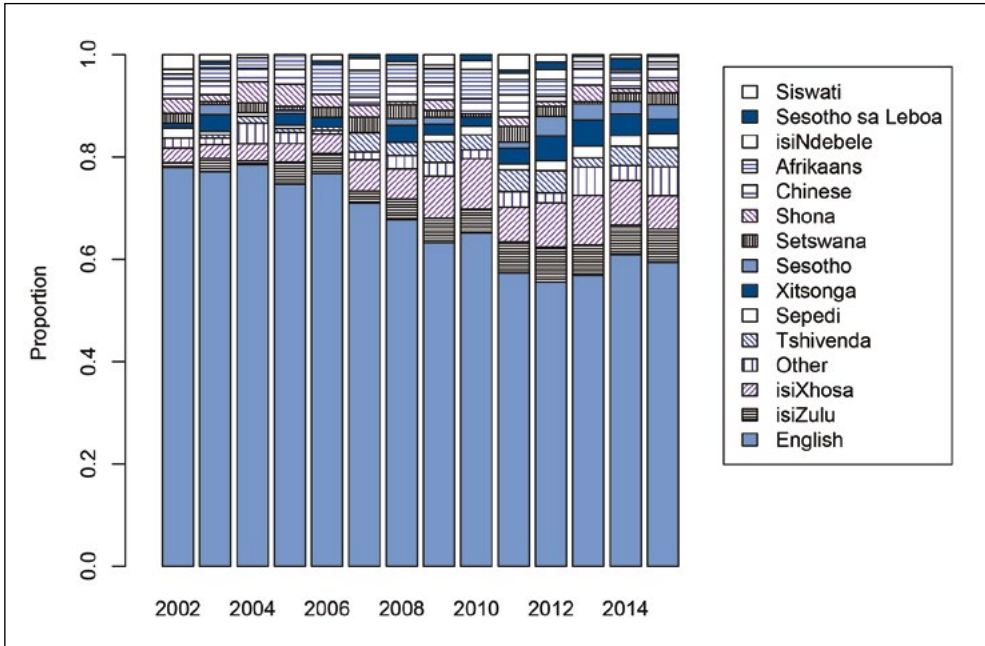


FIGURE 5. Breakdown of Actuarial Science new entrants by home language

5. THROUGHPUT ANALYSIS

All analysis reported below was carried out in the R statistical software environment (R Core Team, 2016).

5.1 Survival Model

5.1.1 Difficulties in performing throughput analysis arise from the right-censoring of data in two ways: (1) where a student has not yet exited the academic programme (i.e. is still studying), and (2) where a student has exited for non-academic reasons (discussed in ¶¶ 5.1.3.1 and 5.1.3.2). This right-censoring is accounted for by the Kaplan–Meier estimator of a survival function, where the outcome of interest in a throughput study is, for example, survival in the programme until key milestones on the path to graduation with an Actuarial Science degree.

5.1.2 Having passed the selection hurdle to be admitted to the UCT Actuarial Science programme, the most significant stumbling blocks come at the end of the first academic year. At this point students must have met a set of minimum requirements in order to proceed to the Financial Mathematics (A201) course and the rest of the second-year programme, and thereafter a further set of requirements in order to proceed to the third year. For the purpose of this study, Actuarial Science students taking Financial Mathematics are defined as being in their second academic year and those taking Models (A202) and Contingencies (A203) are defined as being in their third academic year. Accordingly, we choose as the key milestones progression to second year, progression to third year and ultimate graduation. We estimate a survival function $S(t)$ where $S(1) = 1$ (all admitted students experience at

least some of the first academic year), $S(2)$ is the probability of survival to second year, $S(3)$ the cumulative probability of survival to third year and $S(4)$ the probability of eventual graduation for a student admitted to first year in Actuarial Science. Note that there is no intermediate probability of survival to fourth year, since we are including graduation from both three- and four-year programmes in our measure of eventual success.

5.1.3 GRADUATION WITH ANY DEGREE

5.1.3.1 The Actuarial Science programme is academically demanding, and consequently has a deliberate policy of casting the net wider at first-year level, balancing the aims of access and throughput. As such it should be no surprise that the programme will have one of the highest attrition rates at the university. It is, however, worthwhile reminding the reader that those who leave the Actuarial Science programme do not usually end up dropping out of university entirely. To illustrate this, in this section we estimate a Kaplan–Meier survival function where survival to graduation, of any sort, is the benchmark (we return in section 5.1.4 to our focus on completion of the Actuarial Science programme). Accordingly, students still studying in undergraduate programmes at UCT in 2016 or who left the university without compulsion were treated as right-censored observations. It is appropriate to treat observations in this way only if the censoring is non-informative, i.e. there is no information about the likelihood of further progression conveyed by the censored observation. It is unambiguously appropriate to treat those still studying as right-censored observations, but the treatment of non-compulsory exits in this way deserves some justification.

5.1.3.2 Non-compulsory exits from the university include students transferring to other universities, voluntarily dropping out of their studies or being prevented from continuing by financial constraints or events such as death, disability or family responsibility. It is possible that certain of these causal factors, such as choosing to drop out or financial need, may be associated with reduced likelihood of academic progression. Hence, we have treated as right-censored observations only those voluntary exits with clean academic records, i.e. where the students in question would have been entitled to continue in the programme by right; this is considered appropriate as this number would include, for example, students who transferred to another university. By contrast, those who would have been granted a concession to continue or to change programme, or who would have had to appeal to the Readmissions Committee to return to UCT, were counted as drop-outs from the cohort.

5.1.3.3 The Kaplan–Meier estimates of the survival function are given in Table 1 and shown graphically in Figure 6—the dotted lines represent 95% confidence intervals around the estimates, suggesting a casualty rate of approximately 3 in every 40 entrants to the programme.

TABLE 1. Kaplan–Meier estimates: all degrees

	Estimate	s.e.	95% CI
S(2)	0.969	0.004	(0.962,0.976)
S(3)	0.942	0.005	(0.933,0.952)
S(4)	0.926	0.006	(0.915,0.937)

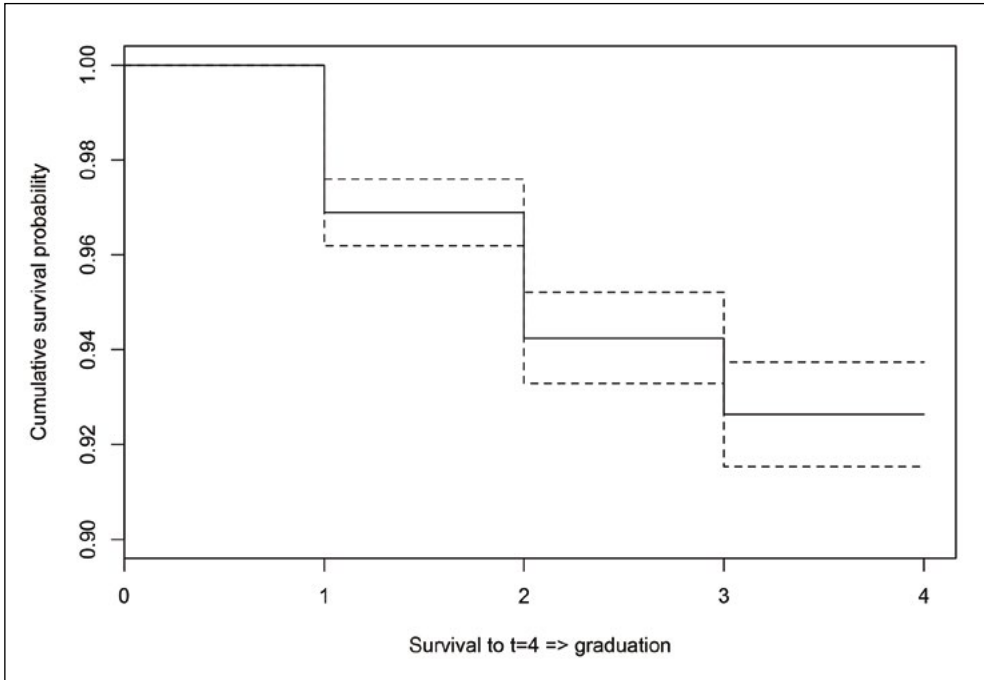


FIGURE 6. Kaplan–Meier estimate for graduation with any degree

5.1.4 GRADUATION WITH AN ACTUARIAL SCIENCE DEGREE

5.1.4.1 Our primary analytical objective is, however, success rates measured against the objective of graduation with an Actuarial Science degree. We treat as right-censored data any voluntary exit from UCT, limited as defined above, while a member of the Actuarial Science programme as well as those still in the Actuarial Science programme in 2016. The definition of exits now expands to take into account the incidence and timing of exit from the Actuarial Science programme.

5.1.4.2 The end point of graduation with an Actuarial Science degree includes those who exited with a BSc (Actuarial Science) degree as well as those who graduated in the Quantitative Finance specialisation.

5.1.4.3 The Kaplan–Meier estimates of the Actuarial Science survival function are given in Table 2 and shown graphically in Figure 7. These may be interpreted as indicating that a new Actuarial Science student sitting in her first lecture has an approximately 2-in-5 chance of getting through to graduation. There would be an upper limit to this success rate, beyond which one could not go without being unduly restrictive in first-year selection. This will inevitably result in turning away some students capable of successfully pursuing an actuarial career and harm the broadening of access that is critical for demographic transformation of the profession.

TABLE 2. Kaplan–Meier estimates: Actuarial Science degree

	Estimate	s.e.	95% CI
S(2)	0.654	0.010	(0.635,0.673)
S(3)	0.497	0.011	(0.477,0.518)
S(4)	0.405	0.011	(0.384,0.427)

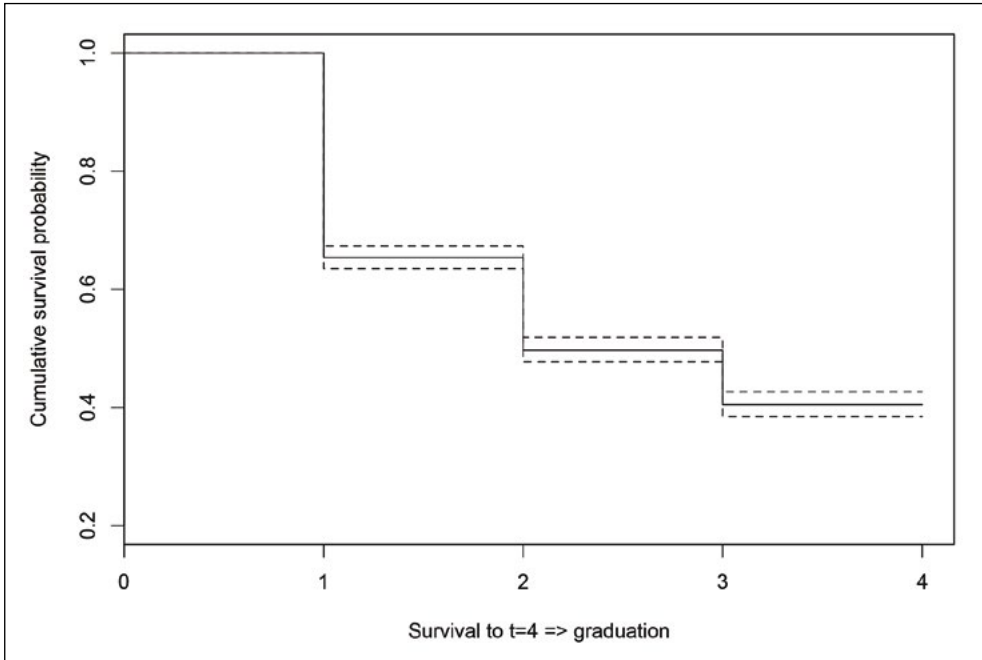


FIGURE 7. Kaplan–Meier estimate for graduation with Actuarial Science degree

5.1.5 CONTRIBUTION OF DEMOGRAPHIC AND FUNDING INDICATORS TO HAZARD

5.1.5.1 In addition to evaluating overall throughput rates, we also wish to understand the impact of key indicators on these. Of particular interest are the demographic variables of race, gender and home language. We know that black and female South Africans are massively under-represented in the actuarial profession, and significantly poorer throughput for them will clearly be an inhibitor to the progressive correction of this imbalance. It was also reported above that an increasing proportion of UCT students do not have English as a home language, and we might suppose this to be a likely indicator of progression likelihood, given the medium of instruction and assessment. The other important dimension that we consider is SAADP funding.

5.1.5.2 In order to examine the effect of these factors on survival probability, we employ them as covariates in a proportional hazards model of the sort proposed by Cox (1972), which takes the form $\lambda(t; x_i) = \lambda_0(t) e^{\beta x_i^T}$, where $\lambda(t; x_i)$ represents the hazard function for an individual i , $\lambda_0(t)$ is a baseline hazard function, x_i is a vector of covariates for

i , and β is a set of coefficients to be estimated in the model. The hazard function measures a force of decrement which determines the probability of failing to survive to the next stage, and the covariates in this instance are indicators for broad race grouping, gender, home language (English or other) and whether or not funded by SAADP.

5.1.5.3 The Cox estimates are set out in Table 3.²¹ The exponentiated coefficients shown give an estimate of the proportionate impact of exhibiting that particular characteristic, all else held equal, on the hazard. For example, the exponentiated coefficient for race suggests that *ceteris paribus* a black student experiences a hazard rate 40% greater than a non-black student, and is significantly less likely to proceed to the next stage. It is further clear from the estimates that female students and those who do not speak English as a home language are at considerable disadvantage. The p-values (under the null hypothesis of no effect, i.e. a zero coefficient) confirm that all of these effects are highly statistically significant.

TABLE 3. Cox proportional hazard estimates

Covariate	Coefficient	Exp(coef)	s.e.	p-value
Race (black)	0.345	1.412	0.059	<0.001
Gender (female)	0.143	1.154	0.058	0.013
Home language (non-English)	0.330	1.391	0.059	<0.001
SAADP	-0.665	0.514	0.116	<0.001

5.1.5.4 SAADP funding, by contrast, is associated with considerably better outcomes for academic progression and ultimate graduation: all else being equal, a SAADP student experiences a hazard rate which is only a little more than half that of non-SAADP students. Again, this effect is highly significant. The impact of this is illustrated visually in Figure 8, in which the improvement in survival probabilities is illustrated by estimating the survival function for a 'typical student' (reflecting the distribution of the student base by race, gender and home language), and differentiating only on the criterion of SAADP funding. The confidence intervals, while wider around the SAADP estimates because of the smaller number of students, do not intersect with those of the non-SAADP students, confirming the statistical significance of this effect.

5.1.5.5 In Figure 9 we show a comparison between the survival curves of a black female SAADP student from a non-English-speaking home and a 'typical' non-SAADP student; this is a powerful visual indication of the value of SAADP membership. It shows that the lower end of the 95% confidence interval for a SAADP student who displays all of the demographic characteristics shown above to be significant indicators of academic underperformance is in line with the median outcome for a 'typical' non-SAADP student.

5.1.5.6 It should, however, be noted that some portion of the differential SAADP effect may be due to selection. Although comparison of overall matric performance is complicated by the award of symbols rather than percentages prior to 2010, a comparison of

21 The single transgender student was removed from the data for this analysis.

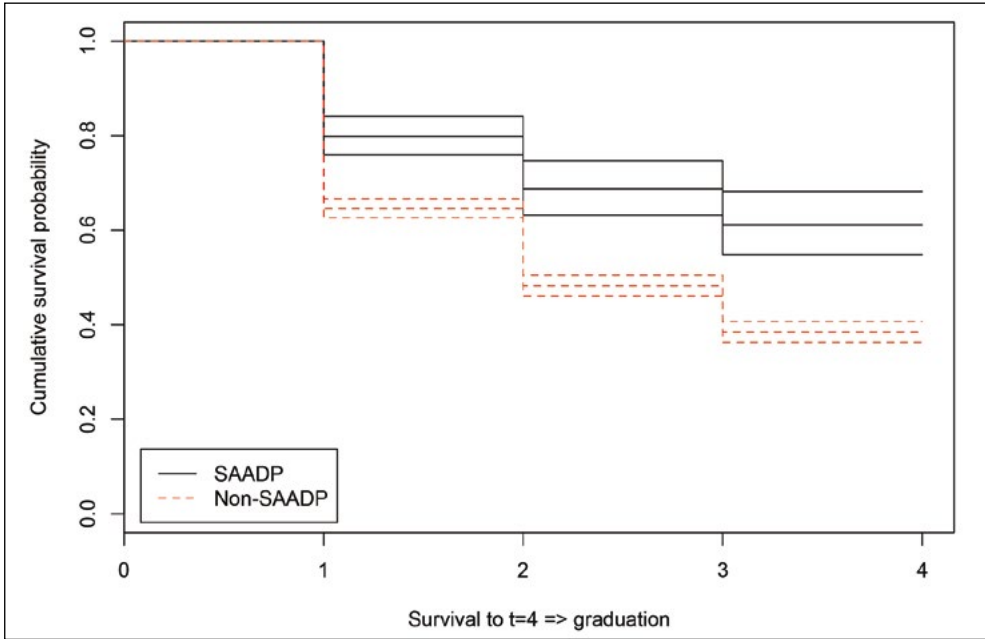


FIGURE 8. Survival function estimates for SAADP and non-SAADP 'typical' students

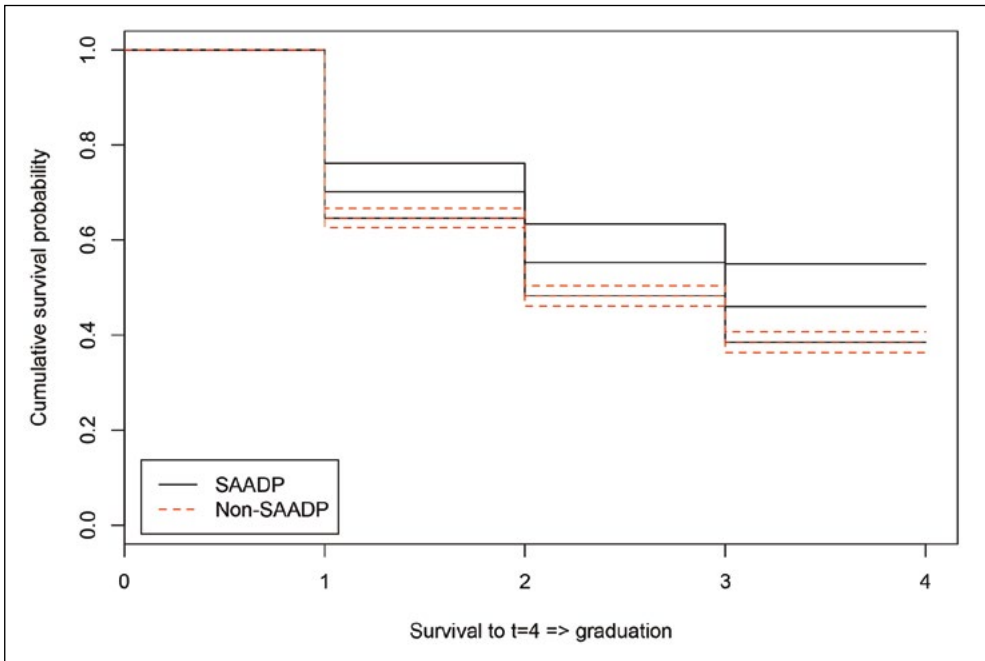


FIGURE 9. Survival function estimates for black female non-English-home language SAADP student and non-SAADP 'typical' student

SAADP students admitted since 2010 reveals an average matric Mathematics mark of 91.9%, which is higher than the 90.5% achieved by other black students over the same period (the difference is statistically significant at the 5% level).

6. ANALYSIS CONFINED TO 2010–2016

6.1 The year 2010 saw three significant changes in the academic landscape for UCT's Actuarial Science programme:

- this was the first intake with a high proportion of National Benchmark Test (NBT) results (70% completion for the 2010 intake, compared to 5% in 2009);
- the BSc programme was dissolved and a BCom option introduced; and
- the Education Development Unit (EDU) Actuarial Science programme was established, following the success of the EDU programme in other disciplines in the Commerce faculty.

6.2 The NBTs were commissioned by Higher Education South Africa (now Universities South Africa) to measure academic preparedness for the demands of first-year university studies.

6.3 Entrance to UCT Actuarial Science is based on meeting minimum thresholds in both the National Senior Certificate (NSC) results and the NBTs. The former is encapsulated in the IPD data by a single number, the Faculty Points Score, which is the outcome assessed against the threshold. Unfortunately, a couple of complications make it impossible to use this indicator for analytical purposes at present:

- the way in which points are calculated changed several times over the course of the period of investigation, and considerable additional data and effort would be required to obtain a consistent statistic across the years (this is further complicated by a generally-accepted view that the standard of the NSC has been progressively, if slowly, declining); and
- the score recorded in respect of a student who applied to another faculty as her first-choice programme is calculated in accordance with that faculty's specifications, which differ from those of the Commerce faculty.

6.4 We do however have NBT results (Academic Literacy, Quantitative Literacy and Mathematical Literacy) from 2010, and could add these to the list of covariates considered in the Cox proportional hazards model. The problem is that we then significantly reduce the number of data points, from 2 346 to 1 083.²² We also have NSC results for some individual subjects, of which Mathematics and English are the two of most interest, being those used individually in the admission criteria.

6.5 Consistently with the treatment of other variables, we create binary groupings for each of the three NBTs: Academic Literacy, Quantitative Literacy and Mathematical Literacy.

²² There were 1 217 entrants from 2010 onwards; of these, 134 did not have complete NBT results.

Students are assigned to one of the two groups according to whether each NBT score is above or below the median for all students in our sample. The distribution of NBT results is shown in Figure 10.

6.6 Effect of EDU Programme

6.6.1 In the first instance, we replace SAADP membership with EDU membership in our model. The reason for doing so is that simultaneous use of both indicators presents a multicollinearity problem: there is a significant overlap between the two groups and, indeed, for the past several years, all new SAADP students have been placed in the EDU programme. The results are set out in Table 4.

6.6.2 EDU membership shows up as a positive contributor to throughput, although it is significant only at the 10% level. Race and home language remain strongly statistically significant, but interestingly, gender is no longer significant in this model, which is limited to post-2010 data. This is consistent with gender becoming a less influential factor as time progresses. This appears to be an encouraging sign, but the data do not of course permit such strong inferences to be drawn without some caution.

TABLE 4. Cox proportional hazard estimates 2010–2016, including EDU

Covariate	Coefficient	Exp(coef)	s.e.	p-value
Race	0.435	1.545	0.103	<0.001
Gender	0.118	1.125	0.085	0.169
Home language	0.275	1.316	0.092	0.003
EDU	-0.175	0.839	0.100	0.079

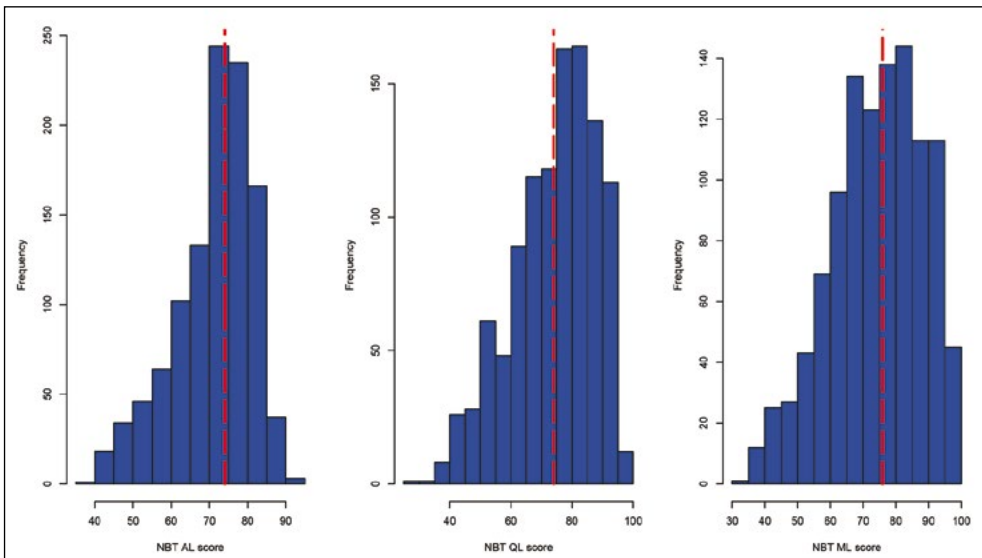


FIGURE 10. Distribution of NBT results

6.7 Inclusion of NBT Results

6.7.1 If the model is extended to incorporate each of the three NBTs, the coefficients outlined in Table 5 emerge.

TABLE 5. Cox proportional hazard estimates 2010–2016, including EDU and NBTs

Covariate	Coefficient	Exp(coef)	s.e.	p-value
Race	0.301	1.352	0.106	0.005
Gender	0.055	1.057	0.087	0.526
Home language	0.092	1.096	0.099	0.351
EDU	-0.222	0.801	0.102	0.028
NBT (AL)	-0.219	0.803	0.099	0.027
NBT (QL)	0.027	1.028	0.102	0.788
NBT (ML)	-0.674	0.509	0.096	<0.001

6.7.2 Race remains a highly significant variable in the model, but now home language, in addition to gender, no longer emerges as significant, with its effect presumably subsumed by the NBT result effects. The Mathematical Literacy result comes out as the most significant indicator, with Academic Literacy also significant at the 5% level ($p=0.027$). The Quantitative Literacy result does not appear to have any significant predictive ability.

6.7.3 It should be noted that there will be some degree of multicollinearity present in these models due to, for example, positive correlations between the demographic indicators and the NBT results. A Principal Components Analysis of the data represented by the seven factors considered in the above model illustrates this graphically in Figure 11.

6.7.4 The left-hand figure indicates the loadings of each of the seven factors on the first two principal components of the data. The EDU and Race (highlighted in blue for easier identification) factors are so closely aligned that their labels and vectors are virtually indistinguishable (in fact, only from the fourth principal component do they show any meaningful departure from one another). Furthermore, Home Language loads very similarly on the first two principal components. Gender, however, is close to orthogonal to these three factors in these first two dimensions. As expected, the Mathematical Literacy and Quantitative Literacy NBT results load very similarly, hence it is not surprising that only one of them shows up as significant in the model above. It was however something of a surprise that the significant factor was Mathematical Literacy, given a widespread belief amongst UCT educators that success in this NBT is largely a function of the quality of mathematical education at school, with Quantitative Literacy giving a better indication (so it was thought) of raw quantitative ability.

6.7.5 The right-hand figure shows that the first two principal components account for less than 60% of the variation in the data; six are needed to account for 90%. There is thus little potential for achieving more robust model fits through dimensionality reduction.

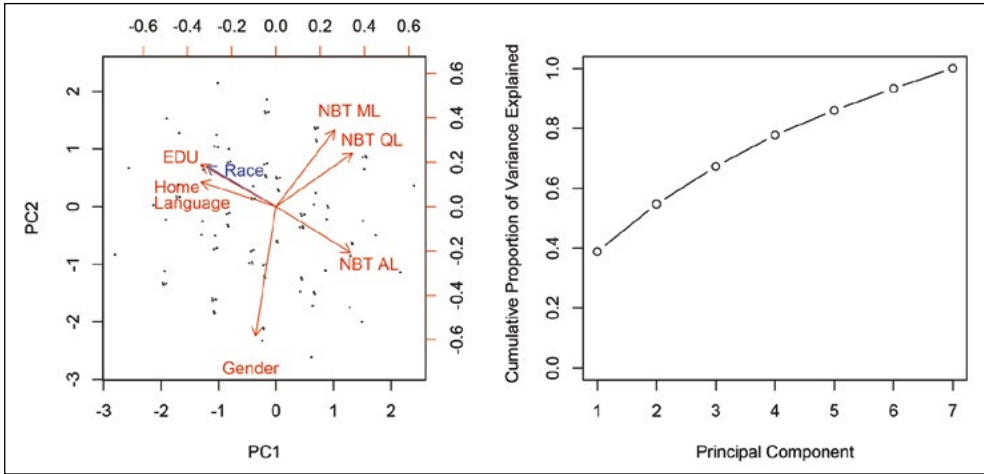


FIGURE 11. Principal Components Analysis of 2010–2016 data

6.8 Inclusion of NSC Results

6.8.1 Although we do not have a reliable and comparable indicator for overall performance in the matriculation examinations (or equivalent), we do have individual NSC subject results for Mathematics and English. We incorporate these into the model by forming binary groupings as follows:

- Mathematics above or below median mark.
- English group 1 consists of those who achieved 80% or above for English Home Language, while those who were below this mark or took English First Additional Language in Matric constituted Group 2.

6.8.2 The distribution of marks in the subjects is shown in Figure 12.

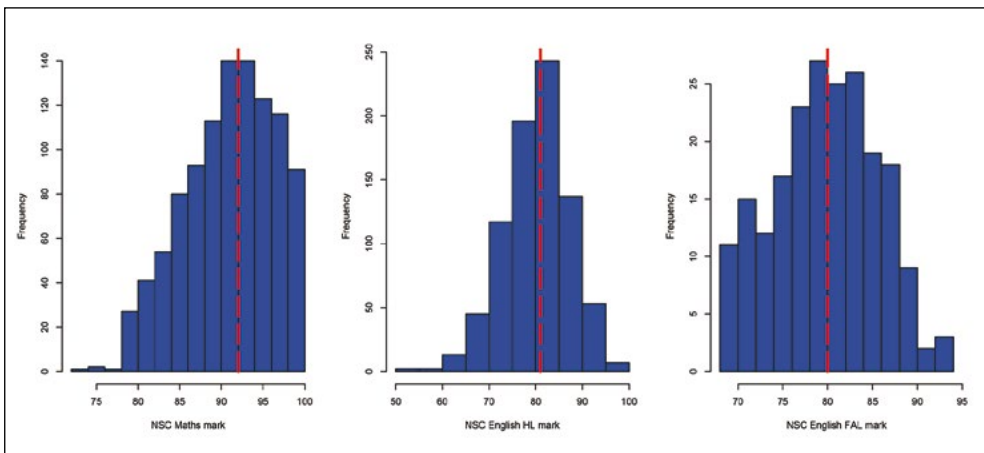


FIGURE 12. Distribution of NSC Mathematics and English results

6.8.3 By definition, we were only able to use those who took the NSC examinations, as opposed to those of other matriculation systems, in the sample for this final model, which further reduced our sample size to 1022. The extended model is shown in Table 6.

TABLE 6. Cox proportional hazard estimates 2010–2016, including EDU, NBTs and NSC

Covariate	Coefficient	Exp(coef)	s.e.	p-value
Race	0.329	1.389	0.116	0.005
Gender	0.036	1.037	0.091	0.695
Home language	0.105	1.111	0.108	0.330
EDU	-0.255	0.775	0.104	0.015
NBT (AL)	-0.233	0.892	0.107	0.029
NBT (QL)	0.059	1.060	0.107	0.582
NBT (ML)	-0.525	0.592	0.106	<0.001
NSC Mathematics	-0.367	0.693	0.096	<0.001
NSC English	-0.033	0.967	0.103	0.747

6.8.4 The insights of the previous model remain unaltered, but we see further that the NSC Mathematics result is strongly predictive of success in the Actuarial Science programme, while (to our great surprise) the NSC English result does not appear to be statistically significant.

6.9 Model with Only Significant Variables

Table 7 shows the estimates including only those variables which emerge as significant from the above model.

TABLE 7. Cox proportional hazard estimates 2010–2016, only significant variables

Covariate	Coefficient	Exp(coef)	s.e.	p-value
Race	0.329	1.389	0.116	0.005
EDU	-0.255	0.775	0.104	0.015
NBT (AL)	-0.233	0.892	0.107	0.029
NBT (ML)	-0.525	0.592	0.106	<0.001
NSC Mathematics	-0.367	0.693	0.096	<0.001

7. DISCUSSION AND FURTHER RESEARCH

A number of key insights emerge from these results.

7.1 SAADP Success Story

7.1.1 A striking insight offered by this analysis is the extent of the success of the SAAD programme. Students sponsored by SAADP, even if we include those whose

funding was removed during the course of their studies, have significantly better outcomes than their non-SAADP counterparts, all else being equal. This is testament to the quality of the programme, which almost certainly has a multitude of dimensions. The key dimensions are, we believe, as follows:

- SELECTION: Students are selected through a competitive process, and so we would expect some positive selection effect to be displayed. However, it should be noted that SAADP students are drawn from a pool in which financial need and educational disadvantage are key factors, and indeed these play an important role in the selection process. This would tend to mute the selection effect somewhat.
- FINANCIAL SUPPORT: Freeing students from having to worry about funding and the financial burden on their families or their future selves will almost certainly have a significant psychological effect, and avoid anxiety which might otherwise hamper the educational process at university.
- PSYCHO-SOCIAL SUPPORT: Adapting to life at UCT, or indeed any university, constitutes a tough cultural adjustment for any student, but particularly those from poor or rural backgrounds, those who are first-generation students, or those where English is not the dominant language for communication. The existence of an on-the-ground co-ordinator allows for the creation of a community of students and provides very tangible and personal support. In addition there is a sense of family that comes from being part of the programme (supplemented since 2010 by simultaneous membership of the EDU family).
- ACADEMIC SUPPORT: Finally, it is reasonable to conclude that the additional academic support offered to SAADP students by way of extra tutorials, together with the academic mentorship offered by those SAADP students at more advanced stages of their studies, have had a significant positive impact on their success.

7.1.2 It is impossible to disentangle, in any quantitative sense, the relative contributions of any of these individual dimensions or, since 2010, to separate out the contribution of the EDU programme. Indeed, it is reasonable to suppose that the synergy that comes from them working in tandem is partly responsible for the positive results observed.

7.1.3 By contrast, in our experience, many corporate bursary programmes tend to rely on selection of the best students (thereby not taking a risk on those from disadvantaged backgrounds) and merely provide financial support (with dire financial consequences for those students who run into academic trouble—so the financial relief is coupled with added stress).

7.2 Value of the EDU

Similarly to SAADP, belonging to the EDU appears to have a significant positive effect on success. To the extent that recent generations of SAADP students have also been placed in the EDU, the SAADP effect is likely to be supporting the EDU effect. This is consistent with anecdotal evidence and supports the excellent reputation of the Commerce EDU at UCT.

7.3 The Information Content of NBT Results

The results indicate that the Academic Literacy and Mathematical Literacy NBT results have significant predictive power. This confirms qualitatively the appropriateness of using them as one aspect of the admission threshold, although it should be cautioned that we are examining here the differential impact of high and low NBT scores above a minimum threshold on throughput rates, rather than the appropriate level of the threshold. It provides an additional piece of information in identifying vulnerable students most likely to struggle at first-year level.

7.4 Importance of NSC Results

It is clear, as expected, that performance in matriculation-level Mathematics is a strong indicator of success in undergraduate Actuarial Science. A minimum performance in English has for some time been part of the UCT admission criteria, and its emergence as a factor without significance was something of a surprise, and worth further investigation.

7.5 The Ongoing Demographic Struggle

7.5.1 Sadly, but not unexpectedly, we find that being black, female or not having English as a home language appears to materially reduce the probability of eventual success in the Actuarial Science programme.²³ The very serious inequalities in our society, particularly in respect of secondary education, are still very much with us, and provide the context in which the effect of race in particular, and its very strong correlation with educational opportunity and quality, does not come as a surprise. These results accord with the literature relating to stereotype threat, language and literacy, first-generation students and the cultural dissonance and sense of alienation experienced by students.

7.5.2 While these effects do not come as a surprise, the real question is what we can do to counteract them. It is not within our power to change the distribution of secondary education resources, for example, or to equalise students' English-language abilities at the start of their first-year experiences. Much is already being done at UCT in the hope of levelling the playing fields, including:

- the introduction of the EDU programme which blends educational support with psychosocial support;
- encouraging the spreading of the degree over an extra year for students with weaker educational foundations, allowing extra time for the bedding down of concepts presented in the first and second academic years;
- a recent thorough revamp of the first-year Introduction to Actuarial Science syllabus, including course material and delivery (Enderstein, 2015); and
- the deliberate selection of a range of role models with whom all students can identify at events like orientation and Through the Looking Glass (an evening in which third- and

23 It may be tempting to conclude from the list of significant variables in the final model that Gender and Home Language are not material, but this is simply the statistical consequence of their being subsumed by other factors with which they are strongly correlated, notably NBT and NSC results.

fourth-year students are offered an opportunity to meet working professionals in a ‘speed-dating’ format).

7.6 Further Research

There are three key extensions of this research which are currently in the authors’ sights:

- The binary groupings for each of the variables under consideration may be too crude a division: for the Race variable, in particular, it may be worthwhile to consider black African students as a separate category. Other variables might merit similar further subdivision, although caution needs to be exercised to retain the simplicity and intuitive interpretability of the current model. Further analysis of the predictive power on English performance at matric level is also warranted.
- Implicit in the use of graduation as the key hurdle in this model is an assumption that all Actuarial Science degrees are, in a sense, equal. In the context of the ultimate goal of qualification as an actuary, however, the best indicator of the probability of success and expected time-frame for qualification is likely to be the number of exemptions achieved at university. A more nuanced analysis accounting for variation in the number of exemptions will be undertaken shortly.
- Finally, the incorporation of Actuarial Society data for UCT graduates, with ultimate qualification as the final hurdle, would be an immensely useful extension to this analysis.

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APPENDIX A

Background on the UCT Actuarial Science Programme

A.1 UCT was the first university in South Africa to offer an Actuarial Science degree. The programme commenced in 1968, and five years later, an agreement with the Institute of Actuaries and Faculty of Actuaries was reached. This agreement allowed, for the first time, for exemptions to be granted from the professional examinations on the basis of satisfactory performance in the corresponding university courses (Ramjee et al., 2013). For many years, students could register for either a Bachelor of Business Science (BBusSc) or a Bachelor of Science (BSc), respectively a four-year degree in the Faculty of Commerce or a three-year degree in the Faculty of Science.

A.2 In 2000, a Quantitative Finance specialisation was added as an option within the Business Science (Actuarial Science) programme, to meet an increasing demand for quantitative finance skills and to provide a natural foundation for the Master's programme in Mathematical Finance (then a Master of Science degree managed by the Department of Mathematics, and now a Master of Philosophy degree managed by the Actuarial Science department). The Quantitative Finance specialisation offers up to six exemptions and many graduates in this stream continue with the actuarial examinations after graduation; it is very much seen as an integral part of the Actuarial Science programme.

A.3 Several changes to this status quo took place in 2010.

A.3.1 The BSc programme, whose entrance requirements had over time drifted lower than those of the Business Science programme, with consequential impacts on success rates, was closed to new entrants.

A.3.2 A Bachelor of Commerce (BCom) programme was introduced, with the same entrance requirements as the Business Science degree, ensuring that a three-year exit option remained available to students.

A.3.3 The offering of the EDU was extended to include BBusSc and BCom Actuarial Science programmes. These programmes come in two forms:

- Augmented, in which students set out to tackle the degree over the minimum number of years (four for BBusSc and three for BCom), and
- Extended, in which the curriculum is rearranged with the intention of completion over one year greater than the minimum.

A.4 Consequently, there are now four undergraduate streams within the broader Actuarial Science programme: BBusSc and BCom, in both mainstream and EDU forms.