Using Instrumental Variables to Determine the Efficacy of Two Bridging Programs that Operate at the University of KwaZulu-Natal

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Abstract

The vast majority of black African students enrolling at higher education institutions come from township schools where a lack of resources and teacher training create environments of rote learning which give students only a superficial understanding of some of the linguistic and numeracy concepts needed to successfully complete a university degree. To address this problem universities have put in place additional teaching programmes designed to bridge this gap. This paper examines the efficacy of two programmes that operate in the Faculty of Science at the University of KwaZulu-Natal. The one programme `sacrifices' a year of credit-bearing study towards a particular degree by offering a broad range of courses aimed at preparing students for normal entry into the faculty in their following year of study. The other allows the student to take an extra year to complete their first year of study with additional teaching support being given to help them cope with their studies. Using regression adjustment techniques and a Heckman treatment selection model to control for a possible selection bias that can occur with observational studies, it was found that both of these bridging programmes actually help to increase the throughput rate of students in this faculty with a stronger effect being reported for the foundation programme based students.

Keywords: treatment effect, regression adjustment, Heckman treatment selection model

Introduction

South Africa has a highly polarised education system. On the one hand we have a cohort of privileged students who are able to attend private or Model C schools. For the vast majority of mainly black African students, however, education takes place in vastly under-resourced township schools where a lack of teacher training often leads to superficial engagement with texts, and , rote learning designed to deliver correct `answers' rather than give students an understanding of the thought processes behind the derivation of the answer, is the norm. As a consequence Scott, *et al*. (2013) found, only 18% of all school leavers manage to qualify for entry into a higher education institution (HEI). Amongst those who manage to qualify for entry into a HEI, one third drop out in their first year of study and only 45% eventually manage to complete their studies. In order to address this problem, academic development (AD) programmes have been established with the aim of improving the academic performance of students from under-resourced backgrounds. One of the primary objectives of this paper is to determine how successful two University of KwaZulu-Natal (UKZN) based academic development programmes are in helping to bridge the articulation gap that exists between what is being taught at a township school and what is required to successfully complete degree at UKZN. In particular, one needs to be sure that whatever treatment effects are being observed, that these effects (in our case the two bridging programmes) are not confounded by the presence of other variables that may also be causing students to perform better than they would have if they had not been bridged.

The Importance of a Student's First Year of Study

Studies conducted by Pantages and Creedan (1978), Seymour (1993), and Pascarella and Chapman (1983) have all found that students who obtain good grades during their first semester of study are far more likely to persist to graduation than those who do not. The 'memory of a critical moment or event' it would seem 'clusters more heavily' in the first few weeks of one's tertiary learning experience (Light 2001: 204). Instead of waiting for students to `find their own feet', the above evidence would support the need to be proactive and provide students with as much upfront support as possible to exploit the 'window of opportunity' and assist student learning.

Approaching this question from a different angle, research also indicates that the cognitive skills and behavioural patterns needed for the successful completion of a degree need to be entrenched during the first year of study. In a use-of-time based study conducted by Schilling (2001), first-year students were each given a beeper. At various points in time throughout their academic career the beeper was activated and they were asked to record what they were doing. Results from this study showed that the amount of time students spend on their studies during their first year is a strong predictor for the amount of time that they would spend on their studies during their senior years. Bridging programmes therefore need to be implemented as soon as a student enters university. In this paper I compare the performance of two bridging programmes; one that `sacrifices' a year of credit-bearing study towards a particular degree by offering a broad range of courses aimed at preparing students for normal entry into the faculty in their following year of study, and another which allows the student to take an extra year to complete their first year of study with support teaching. Because the government funds these two programmes differently it is useful to know which of the two models works best, and whether student in either of these programmes would actually perform better (or worse) than if they had no access to support. Associating access to a bridging programme with a particular form of treatment, one of the primary objectives of this paper is to determine what the outcome would have been for a treated individual had they not received the treatment. In other words, would a student who has been bridged have performed better (or worse) had one allowed them to enrol as normal entry students in the faculty?

Bridging Programs: A Brief History

Developmental Summer Bridging Programs (DSBP) form the bulk of academic development programmes in the United States. Ramirez (1997), Weismann, Bulakowski and Jumisko (1997), Boylan and Saxon (1999), and Ackerman (1990) all indicate that DSBPs have the potential to help students succeed with their college based studies. Most of these studies however are not able to follow the progress of students towards the actual completion of a degree. Instead their conclusions are drawn from a questionnaire completed by students who attend bridging programmes (Santa Rita & Bacote 1997; Rollnick *et al*. 2008; and Maggio *et al*. 2005).

In the United Kingdom, academic development programmes have focused primarily on bridging the gap that exists between the British 13-year based schooling system and a 12-year system that is common in most other countries in the world. Students are given basic catch-up courses in a particular field of study with no credits actually accrued towards the completion of a particular degree. In these so-called international foundation programmes (IFP), the emphasis is therefore on equipping students for normal entry into mainstream programmes of study rather than the providing supplemental teaching in a course that earns credits towards a particular degree at a particular university.

Academic development (AD) programmes in South Africa have their origin in the relaxation of apartheid policies in the early 1980s when historically white universities began to admit small numbers of black students. Because the apartheid government attempted to control the number of black students which universities could admit, these AD programs focused primarily on achieving academic equality rather than bridging the gaps that exists between township school education and universities. Following the IFP model, students were required to pass a series of non-credit bearing courses which 'prepared' them for tertiary study. At no stage were they allowed to accrue credits towards the completion of a particular degree. Students in these foundation programs however increasingly began to feel that they were being marginalised as second-class citizens in the university environment. To help overcome this stigma, AD programmes with a focus on augmentation began to emerge which allowed students to take two years to complete what for others would be a normal first year of credit-bearing study. Additional classes and remedial support were given to help them cope with their studies (Gee 1990; Bourdieu 2002; Vygotsky 1978; Mabila, *et al*. 2006).

Are these Programmes Effective?

Most South African studies address academic support at selected courses rather than degree levels. For example, Curtis and De Villiers (1992) assessed courses offered in economics, mathematics, and chemistry at the University of the Witwatersrand. Smith and Edwards (2007), Smith (2012), and Smith (2013) focused on courses at the University of Cape Town offered in economics, mathematics, and chemistry. They all found that the AD courses had a significantly positive impact on the academic performance of AD students when compared with that of their peers in a comparable mainstream course. Wood and Lithauer (2005) found that students entering a foundation programme at the Nelson Mandela Metropolitan University Foundation Programme (UFP) performed better in their later degree studies than directly admitted students with similar academic profiles. Onsongo (2006) reported similar findings for students enrolling in a first year Engineering course at The University of Witwatersrand. Hay and Marais (2004) also reported similar results for students enrolling in a career preparation programme at the University of Free State.

In possibly the most comprehensive nation-wide study of all, Scott, *et al*. (2013) found that AD programmes are successful not only in 'widening access' but also in 'improving student performance' in most of the universities in South Africa. In particular, they compared the performance (during the first year of study) of all students in a bridging programme with normal entry students in all the universities in South Africa. The results that are given in Table 1 relate to a cohort of students who entered university for the first time in 2011.

Table 1: Success rates during first year of study by broad subject area: 2011

	Bridging students	Normal entry students
Commerce	69%	68%
Humanities	70%	76%
Science, Engineering and Technology(SET)	66%	72%

Source: Scott, *et al*. 2013.

The discrepancy of 6% between the success rates of the bridging and normal entry students in the SET sector would suggest that the bridging programmes in this sector are possibly not helping students to successfully complete a degree in this field of study. Such a naïve comparison, however, suffers from a serious drawback in that it does not adjust the result for a possible selection bias that may arise because I am comparing students who enter a bridging programme with a completely different cohort of students who have gained normal entry into the faculties. This observed effect needs to be adjusted for other socio-economic background factors that may also distinguish a bridged student from a normal entry student. Once this has been done using for example the regression adjustment method which will be outlined in the next section, a judgement call can then be made regarding the efficacy of the bridging programme. If one is not able to observe enough confounding variables to achieve this objective, then a Heckman selection model can be used to determine an appropriate treatment effect for the bridging programme.

Many South African studies that focus on this area have chosen to ignore the above selection bias problem (Grayson 1996; Hay & Marais 2004; Wood & Lithauer 2005; Onsongo 2006; and Downs 2010). A notable exception is a study conducted by Smith (2009) on first-year academic development courses at the University of Cape Town where graduation was used as an output variable for the study. Similar studies conducted in other countries have also chosen to ignore the sample-selection effect that may arise when comparing the performance of students in bridging programmes with those in normal entry programmes (Schoenecker, *et al*. 1998; Zeegers & Martin 2001; Bowen & Bok 1998; Etter, *et al*. 200;, Berkner, *et al*. 2002; Jenkins & Boswell 2002; and Bahr 2008).

Statistical Methodology

Let T_i denote a treatment indicator variable which I will set equal to one if student *i* is allowed to enrol for a bridging programme and set equal to 0 otherwise. Let Y_i denote a response variable for this paper. It now becomes important to make a clear distinction between the outcome Y_i that one is actually able to observe and two potential outcomes that one would like to be able to observe; namely the response variable $Y_i(0)$ that would be recorded if student *i* were not bridged and the response variable $Y_i(1)$ that would be recorded if the <u>same</u> student were to be bridged. Being able to observe both potential outcomes would allow a treatment effect for student *i* to be estimated using

$$\Delta_i = Y_i(1) - Y_i(0)$$

Because I can only observe one of these potential outcomes one can at best hope to estimate, at a population based level,

$$\text{ATE} \equiv E\{Y_i\ (1)\text{-}\ Y_i(0)\}$$

which represents an <u>average</u> treatment effect for an individual who is being randomly drawn from this overall population. One can also estimate, at a population based level,

$$\text{ATT} \equiv E\{Y_i\ (1)\text{-}\ Y_i(0)|T_i\text{=}1\} \quad (1)$$

which represents an average treatment effect for an individual who is randomly drawn from the <u>treated</u> section of our population. Because I am interested in determining whether (or not) a bridging programme is successful, it is the estimated value of ATT which will be more relevant for our study. If ATT turns out to be significantly positive in value then students in the bridging programme are recording outcomes for Y_i that are on average higher in value than those they would have recorded had they not been bridged.

Regression Adjustment Based Methods

If students are randomly assigned to a bridging course, then simply subtracting the average response of bridged students for Y_i from those that have not been bridged will produce an unbiased estimate for the treatment effects ATE and ATT that I want to determine. Applying ordinary least squares methods to the following regression model

$$Y_i = \beta_0 + T_i\delta + e_i \quad (2)$$

the parameter estimate that one obtains for δ will also provide one with an unbiased estimate for both ATT and ATE.

Assignment to a bridging programme however is not being done on a random basis. Students have to satisfy certain criteria before they become eligible for entry into a bridging programme. Consequently students in the bridged and non-bridged groups may differ not only with respect to the `type' of treatment that they receive but also with respect to other socio-economic and educational based background variables which determine the type of entry that is required from them for entry into the faculty. From an estimation point of view, these background variables X_i may be causing the error term e_i in (2) to become correlated with the treatment indicator variable T_i. Known as an omitted variable bias problem, the estimate that one wants to derive for δ in (2) may become biased and inconsistent.

A regression adjustment method attempts to overcome this problem by including enough variables X_i in the following model

$$Y_i = \beta_0 + T_i\delta + X_i\beta_1 + e_i \quad (3)$$

so that the treatment indicator variable T_i eventually becomes uncorrelated with the error e_i in (3). Ordinary least squares estimation can then be applied to (3), to produce an unbiased estimate for δ and thus for ATE.

Heckman's Treatment Selection Model

If one cannot find enough variables X_i to include in (3) so as to overcome the omitted variable bias problem that is referred to above, then an instrumental variable will have to be used to help derive a consistent estimator for δ (Angrist, *et al*. 2001). A variable Z_i is said to form an instrumental variable for our problem if it is correlated with the treatment assignment variable T_i but uncorrelated with the error term e_i that has been given in (3). Finding such a variable (or collection of variables) is often a very difficult process primarily because I do not actually observe e_i and therefore cannot empirically test for any correlation between Z_i and e_i. Instead, its use often has to be justified on theoretical grounds (Sovey and Green 2011).

To overcome this problem, Heckman (1979) developed another modelling approach that first corrects for a possible sample selection bias in one's treatment effect by fitting a probit model to one's treatment assignment variable T_i. More specifically, with u_i denoting a N(0, σ^2) error term, a probit model sets T_i=1 if

$$X_i\gamma + Z_i\theta + u_i > 0 \quad (4)$$

and T_i=0 otherwise. The estimated value that one obtains for T_i can then be substituted as an instrument in the following model

$$Y_i = X_i\beta + \delta T_i + e_i \qquad (5)$$

with ordinary least squares then employed to derive a consistent estimate for δ. To allow for a possible correlation structure between the treatment assignment variable T_i and Y_i, the error terms u_i and e_i that appear in (4) and (5) are assumed to have a bivariate normal distribution with

$$\begin{pmatrix} e_i \\ u_i \end{pmatrix} \mid T_i, X_i,\ Z_i \sim \mathrm{N}(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{pmatrix}) \qquad (6)$$

Details of this two-stage least squares fitting procedure can be found in Briggs (2004) and Wooldridge (2002). Because of issues associated with identification, one needs to make sure that at least one variable Z_i can be found that affects the treatment assignment process (4) but not the outcome equation (5).

Our Dataset

This study followed the progress of 5014 students wanting to enrol for a BSc degree in the Faculty of Science at the University of KwaZulu-Natal (UKZN) over the period 2007 to 2012. Prior to 2009, entry into the faculty was restricted to students who achieved a total matric point score of at least 34 points for their school leaving subjects. In 2004, a Centre for Science Access (CSA) was created to help students who narrowly missed gaining direct entry into the faculty to enrol for one of two possible bridging programmes depending on the type of results they achieved in their school leaving exams. Those who managed to obtain a total of at least 28 Matric points were allowed to enrol for a 4-year augmented programme which allowed them to take an extra year to complete what for normal entry students would be their first year of study. Parallel classes, additional tuition material, and an academic literacy module were run to help them cope with the mainstream courses that they would be taking together with the normal entry students.

Weaker students who come from township schools and had not managed to obtain at least 28 matric points for their school leaving examinations were allowed to enrol in a 4-year foundation programme in which the first year was dedicated to basic catch-up courses in science, mathematics, and academic literacy with no actual credit being accrued towards the completion of a particular degree. Because this foundation programme focuses on `fixing ' the problem before formal study in the faculty begins, it became interesting to find out, in this study, if this approach is more successful than the augmented approach which focuses on `lending a helping-hand' during the first year of formal study in the faculty.

TABLE 1: Student enrolment according to year of entry in the Science faculty.

Year of first entry	2007	2008	2009	2010	2011	2012	Total
Non-bridging	336	331	537	490	446	362	2502
BSc Foundation	203	205	195	254	232	277	1366
BSc Augmented	195	180	163	186	194	228	1146

The figures that appear in Table 1 show how the proportion of students enrolling in a bridging programme have increased steadily over the period 2007 to 2012. A breakdown according to race, gender, and other important background variables is given in Table 2. Because one needs to include as many potentially confounding variables as one can in the analysis, the binary variables that I have used for Residence and Financial Aid indicate whether a student has been given some form of residence-based accommodation or financial help during their university studies. Studies conducted by Agar (1990), Barnsley and Liebenberg (2000), and Rollnick, *et al*. (2008) all seem to indicate that these variables may have an important effect on future performance in higher education.

TABLE 2: Student demographics based on enrolment figures in the Faculty of Science over the period 2007 to 2012.

Baseline covariates	**Foundation**	**Augmented**	**Non-bridged**
Male =1/Male=0	735/631	709/437	1266/1236
African=1/African=0	1332/34	1138/8	1291/1211
Residence=1/Residence=0	723/643	810/336	691/1811
Financial Aid=1/Financial Aid=0	753/613	764/382	894/1608
OBE =1/OBE=0	1163/203	951/195	2166/336

Prior to 2008, students writing their final school leaving subjects were able to do so at a higher, standard, or lower grade level. From 2008 onwards, a National Senior Certificate was introduced and the previously graded levels for each subject collapsed into a single level paper. To capture this effect in our analysis, the variable that I have called OBE (Outcomes Based Education) in Table 2 represents a binary 0/1 variable that I have set equal to one if the student matriculated post 2008. With the phasing out of the senior certificate in 2008, the requirement for entry into the augmented 4-year programme was changed to a total matric point score of at least 22 points (excluding the Life Orientation course) for the school leaving examinations. Entry into the Foundation programme was restricted to learners who had managed to obtain a total matric point score of at least 16 points (excluding the Life Orientation course) for these examinations.

Total Matric Point Score

Entry into a university is usually restricted to students who are able to achieve a particular point score for all their matric leaving exams. Generally speaking, a total of seven subjects have to be written with the following method of scoring being used for each subject.

Point Score	**Subject Mark (%)**
7	**80-100**

6	**70-79**
5	**60-69**
4	**50-59**
3	**40-49**
2	**30-39**
1	**0-29**

Many studies indicate that matric point score may be an unreliable indicator of future success in higher education. (Dawes, Yeld & Smith 1999; Grussendorff, Liebenberg & Houston 2004; Miller & Bradbury 1999). Nevertheless it is important that one control for such a variable because it serves as a proxy for a set of unobservable variables that may be confounding the treatment effect which I want to measure in this study. Table 3 contains a summary of the matric point scores recorded by the foundation, augmented, and normal entry students in our collected dataset.

TABLE 3: Matric point score summaries.

Program	**Number**	**Mean**	**Standard deviation**
Foundation	1366	26.74	3.25
Augmented	1146	28.30	3.12
Normal entry	2502	34.63	4.75

School Quintile

Schools in South Africa have been grouped into quintiles based on socio-economic background with a Quintile 1 school classified as the most disadvantaged and a Quintile 5 school the most privileged in terms of resources and teaching opportunities. To capture this effect I have used a binary variable quint5 to distinguish a student who has been able to attend a privileged school (quint5=1) from someone who has not (quint5=0). Table 4 shows to what extent students from a poorer school background are being enrolled in a science based bridging programme at UKZN.

TABLE 4: Proportion of students that come from a Quintile 5 school.

Program	**Proportion**	**Total**
Foundation	0.08	1366
Augmented	0.05	1146
Normal entry	0.51	2502

Our Response Variable

One could consider using the total number of courses that have been failed for the first time as a response variable for this paper. A reviewer of this paper has however correctly pointed out that some sort of correction will need to be made for the number of years that a student has spent studying for a particular degree. One could consider successful graduation as being a desirable response variable for this study but one would be throwing away a large number of observations from one's dataset; namely all the students who have dropped out from their studies or who were still busy with their studies when the data collection process ended. For this reason

$$Y = \frac{Total\ number\ of\ credit\ bearing\ courses\ passed - Total\ number\ of\ credit\ bearing\ courses}{Total\ number\ of\ years\ spent\ at\ university} \quad (7)$$

has been used as a response variable for this paper. Essentially Y represents a per annum based `rate of progress' with positive valued outcomes for this response variable indicating better performers. For example, a student wanting to finish a 3 year degree typically has to complete a total number of 48 courses. If this student wants to complete their degree in the minimum prescribed period of time (and with no other course failures) then they must record) an outcome

$$Y = \frac{48-0}{3} = 16$$

for this response variable.

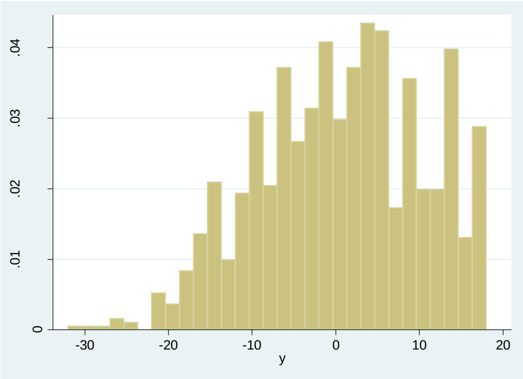

FIGURE 1a: Recorded outcomes for Y : Augmented students only.

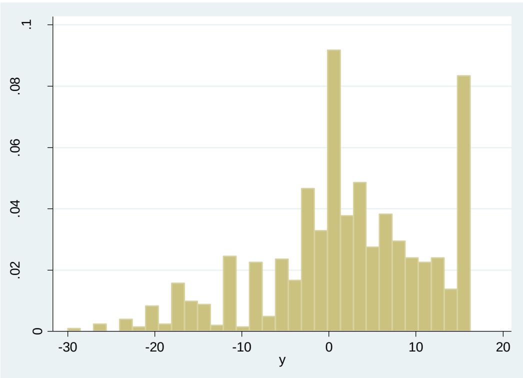

FIGURE 1b: Recorded outcomes for Y: Foundation students only

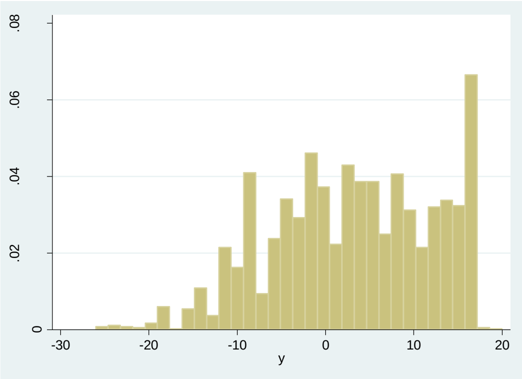

FIGURE 1c: Recorded outcomes for Y: Normal entry students only

The outcomes that have been recorded by the augmented, foundation, and normal entry students are given in Figures 1a-c respectively. In view of what has just been said, the spikes that appear around the recorded outcome of Y=16 represent students who have graduated (or are on track to graduate) in the minimum prescribed period of time.

Results

I begin by comparing the efficacy of a bridging programme with that of a normal entry programme. No distinction is made between a student who is being bridged in a foundation or in an augmented programme. After some conclusions are drawn, a separate analysis is be done for foundation versus normal entry students and augmented versus normal entry students.

Bridging versus Normal Entry Programmes

Table 5 indicates that students who are not being bridged on average perform better (in terms of our chosen response variable Y) than students who are being bridged. If the assignment to a bridging programme was actually done on a completely randomised basis then one could conclude that neither of the bridging programmes are actually helping students to perform better than would be the case if they had not been put into a bridging program.

Interestingly enough, the foundation students appear to do better than their augmented counterparts. The stigma associated with being a foundation student does not seem to affect their performance when compared with those of the augmented students who are doing credit bearing courses (in their first year of study) alongside the normal entry students.

Assignment to treatment in our context however is clearly not being done on a randomised basis. Students who are assigned to a bridging programme simply do not have enough matric points to gain normal entry into the faculty. They also differ significantly from normal entry students with respect to the school environments from which they come plus other background variables which may bias the results that I have observed in Table 5. Before a final judgement call can be made regarding the efficacy of a bridging programme, an appropriate adjustment or control for the other confounding variables needs to be made using the methods that have been outlined earlier. Once this adjustment is made, the estimate that I have obtained for ATT provides an appropriate measure for the effect of a particular type of bridging programme on the treated subpopulation.

TABLE 5: Descriptive statistics relating to our chosen response variable.

	Number	Mean(Y)	Standard Deviation(Y)
Foundation students	1366	2.011	9.539
Augmented students	1146	0.601	9.910
Non-bridged students	2502	3.051	9.098

Fitting the regression adjustment model that has been given in (3) to all the covariates that have been listed in the first column of Table 6 produced the parameter estimates that appear in the second column of the table. Having a higher total matric point count, receiving some form of financial aid, and matriculating under the new post-2008 single grade schooling system (OBE=1), point towards a better performance amongst all students in the sample. The result that has been observed for OBE is interesting because it allows one to argue that whereas before 2008, students with potential may have been forced (in township schools) to do mathematics and science at a standard or lower grade level which would have then prevented them from gaining access to a university based institution, the introduction of a single grading system now allows students with potential to gain entry into a university where they are performing better than their pre-2008 counterparts.

TABLE 6: Parameter estimates obtained from the fitting of the regression model that has been given in equation (3).

Covariates	Parameter estimate	95% confidence interval
Bridged	2.377*	[1.689, 3.064]
OBE	1.292*	[0.627, 1.957]
Male	-0.293	[-0.795, 0.209]
African	-0.979*	[-1.738, -0.219]
Residence	-0.142	[-0.785, 0.501]
Financial aid	3.030*	[2.472,3.589]
Matric Points	0.592*	[0.529, 0.655]
intercept	-18.970*	[-21.518, -16.422]

* denotes significant at 5% level

Focusing now on the average treatment effect for bridging on students who are being treated, the ATT estimate in Table 7 suggests that students in both bridging programmes actually perform better than they would have had they not been placed in a bridging program. Quadratic and interaction effects were also added to the model with a similar set of results. The ATE estimate in the table refers to an average effect on a student who has been randomly selected from the entire population of all students and not just those who have been put on a bridging programme.

TABLE 7: Treatment effect estimates.

Treatment effect	Estimate	Robust standard error	95% Confidence Interval
ATE	1.236	0.429	[0.395, 2.077]
ATT	2.639	0.391	[1.872,3.406]

Foundation versus Augmented Programme Performance

Because the emphasis of bridging in the augmented programme is placed on supplemental teaching whereas the foundation program chooses to `sacrifice' the first year of teaching to fill in the gaps that arise from the students' secondary education, a comparison of respective performances with that of normal entry students would also be of interest in this study.

Figure 2a shows how the outcome recorded for our chosen response variable Y improves as the total matric point count of a student who is on the augmented programme increases in value. This is to be expected because a student's total matric point score should in some way reflect their underlying level of academic ability. When looking at the performance of the foundation students, however, Y does not necessarily increase with the total matric point count of these foundation based students. Either the total matric point count does not serve as a reliable indicator for future performance, or the single year being spent bridging the gap is actually helping foundation based students with a lower matric point count to perform as well as their colleagues who have a higher matric point count.

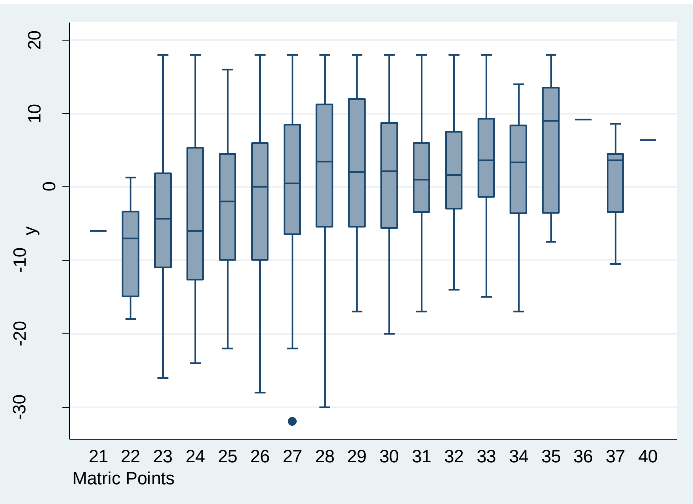

FIGURE 2a: A Box- whiskers plot for students in the augmented programme.

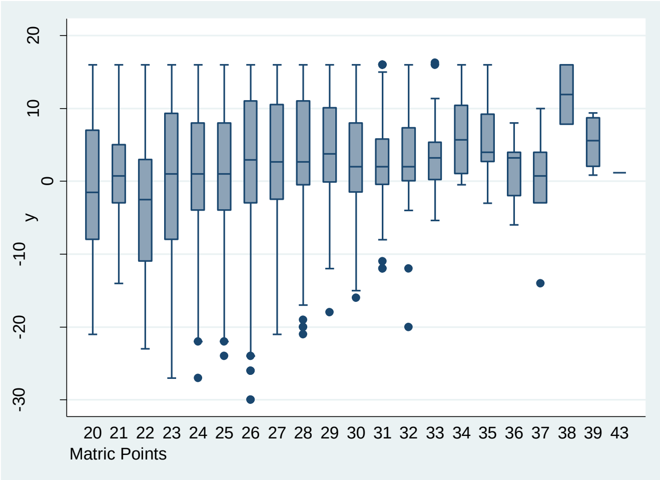

FIGURE 2b: A Box- whiskers plot for students in the foundation programme.

Because some of the confounding variables affecting the estimation of a possible treatment effect may be unobservable to us, Heckman's model structure as outlined in equations 4-6 has been applied to two different problems; one where I want to compare the performance of foundation students with normal entry students and the other where I want to compare the performance of augmented with those of normal entry students.

Foundation versus Normal Entry Students

Table 8a contains the parameter estimates that result from fitting equation (5) to a dataset comprising the foundation programme students (the so-called treated group) and the normal entry students. Stata 14 was used to generate the results that appear in the table. Only gender and residence appear to be statistically insignificant predictors for our response variable Y. Furthermore, the Wald test being highly significant indicates that a good model fit has been achieved.

Table 8b contains the parameter estimates for equation (4) that determine the assignment to treatment probability for this model structure.

The negative value that I have obtained for matric point count supports a selection effect that I know is true for foundation students, namely that the probability of assignment to the foundation programme increases if you have a lower (rather than higher) matric point count. The variable quint5 that appears in the table is a 0/1 indicator variable that I have set equal to 1 if the student was able to attend a more privileged quintile 5 school. Matquint represents an interaction term between the matric point count of the student and quint5. Both of these effects are not significant in the assignment to treatment process once one has accounted for a total matric point count in one's analysis.

The estimate for ρ that appears in Table 8a, being significantly negative in value, indicates that any unobservable confounding variables that increase the probability associated with being assigned to a foundation programme, will also tend to decrease the value of our response variable Y.

Table 8a also contains an estimate for ATT. Being significantly positive in value indicates that students in the foundation programme will record (on average) a value for Y that is 5.175 points higher than would be the case if these <u>same</u> students were admitted as normal entry students into the faculty. Therefore, the foundation programme is clearly having a beneficial effect on the students who are admitted into that programme.

TABLE 8a: Parameter estimates obtained from fitting model (5).

Covariates	Parameter estimate	95% confidence interval
Bridged	2.377*	[1.689, 3.064]
OBE	1.075*	[0.322, 1.828]
Male	0.087	[-0.464, 0.638]
African	-1.126*	[-1.921, -0.331]
Residence	-0.052	[-0.783, 0.678]
Financial aid	3.097*	[2.464,3.729]
Matric Points	0.708*	[0.609, 0.808]
intercept	-23.367*	[-27.232, -19.503]
ρ	-0.167	[-0.276, 0.053]
ATT	5.175*	[3.433,6.916]

Wald statistic: 597.84; p-value=0.001

TABLE 8b: Parameter estimates obtained from fitting model (4).

Covariates	Parameter estimate	95% confidence interval
Matric Points	-0.258*	[-0.278, -0.237]
Quint5	0.629	[-1.197, 2.456]
Matquint	-0.054	[-0.116, 0.008]

Augmented versus Normal Entry Students

Table 9a contains a set of parameter estimates that result from fitting model (5) to a dataset comprising the augmented programme students (the so-called treated group) and the normal entry students. Only gender and residence appear to be statistically insignificant predictors for our response variable Y. Furthermore, the Wald test being highly significant indicates that a good model fit has been achieved.

The estimate I obtained for ρ is not significantly different from zero implying that I have no unmeasured confounding variables in our model structure. The positive effect that I observed for ATT indicates that the augmented programme is also helping students to perform better than they would have had they been given normal entry into the faculty. Comparing this effect (ATT=1.945) with the larger effect that I obtained for the foundation students (ATT=5.175) suggests however that the foundation programme is benefitting students more than the augmented programme.

TABLE 9a: Parameter estimates obtained from fitting model (5).

Covariates	Parameter estimate	95% confidence interval
Bridged	2.144*	[0.669, 3.613]
OBE	0.649	[-0.136,1.435]
Male	-0.446	[-1.027, 0.135]
African	-1.121*	[-1.979, -0.263]
Residence	0.391	[-0.414, 1.197]
Financial aid	2.759*	[2.097, 3.422]
Matric Points	0.677*	[0.591, 0.763]
intercept	-21.667*	[-25.123, -18.211]
ρ	-0.059	[-0.153, 0.035]
ATT	1.945*	[0.524,3.365]

Wald statistic: 726.84; p-value=0.001

TABLE 9b: Parameter estimates obtained from fitting model (4).

Covariates	Parameter estimate	95% confidence interval
Matric Points	-0.220*	[-0.238, -0.202]
Quint5	0.028	[-1.867, 1.925]
Matquint	-0.044	[-0.107, 0.018]

Concluding Remarks

My main purpose in this paper was to determine whether the two bridging programmes that are being run in the Faculty of Science at the University of KwaZulu-Natal are effective in helping students who come from disadvantaged school backgrounds to adjust and eventually succeed in the completion of their studies at this institution. Using the per annum based rate of progress variable that appears in (7) as a response variable, other background variables (besides the assignment to a bridging programme) may be confounding the treatment effect which one observes. The estimates that I obtained for ATT suggests that both the foundation and augmented programmes are helping students to perform better than they would had they been allowed normal entry into the faculty - with the effect being far stronger for the foundation based students. For students wanting to enrol in a science-based bridging programme at UKZN, the above results suggest that it is far better to run a bridging program that sacrifices an initial year of study to bridge the gap caused by township school education, than it would be to run an augmented programme which allows the students to spend their first two years of study doing what for others would be a normal first year of study but with support teaching and additional learning materials.

References

Ackermann, S.P. 1991. The Benefits of Summer Bridge Programs for Underrepresented and Low-income Students. *College and University* 66,4: 201-208.

Agar, D. 1990. Non-traditional Students: Perceptions of Problems which Influence Academic Success. *Higher Education* 19: 435-54.

Angrist, J.D. & A.B. Krueger 2001. Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments. *The Journal of Economic Perspectives* 15,4: 69-85.

Bahr, P.R. 2008. Does Mathematics Remediation Work: A Comparative Analysis of Academic Attainment Among Community College Students. *Research in Higher Education* 49,5: 420–450.

Barnsley, S.A. & M. Liebenberg 2000. The Identification of Factors that Place Students in a Science Foundation Programme at Risk for Academic Failure and Some Suggestions for Appropriate Psychological Intervention. Conference Proceeding of the Society for Student Counselling in Southern Africa (SSCSA), October 2000, University of Natal, Durban.

Berkner, L.S. & E.F. Gataldi 2002. *Descriptive Summary of 1995–96 Beginning Postsecondary Students: Six Years Later*. Washington DC, USA: U.S. Department of Education.

Bourdieu, P. 2002. Forms of Capital. In Biggart, N. (ed.): *Readings in Economic Sociology*. Malden, Mass: Blackwell.

Bowen, W.G. & D. Bok 1998. *The Shape of the River: Long-term Consequences of Considering Race in College and University Admissions*. Princeton, New Jersey, USA: Princeton University Press.

Boylan, H.R. & D.P. Saxon 2010. What are We Going to do About It? *Journal of Developmental Education* 34,2: 36-37.

Briggs, D.C. 2004. Causal Inference and the Heckman Model. *Journal of Educational and Behavioral Statistics* 29,4: 397–420.

Curtis, P.J.D. & J. de Villiers 1992. The Academic Effectiveness of a Bridging Year for Commerce Undergraduates. *Development Southern Africa* 9, November: 457–470

Dawes, P., N. Yeld & M.J. Smith 1999. Access, Selection and Admission to Higher Education: Maximizing the Use of the School-leaving Examination. *South African Journal of Higher Education* 13: 97-104.

Downs, C.T. 2010. Increasing Equity and Compensating Historically Academically Disadvantaged Students at a Tertiary Level: Benefits of a Science Foundation Programme as a Way of Access. *Teaching in Higher Education* 15,1: 97-107.

Etter, E.R., S.L. Burmeister & R.J. Elder 2001. Improving Student Performance and Retention via Supplemental Instruction. *Journal of Accounting Education* 18,4: 355–368.

Grayson, D.J. 1996. A Holistic Approach to Preparing Disadvantaged Students to Succeed in Tertiary Science Studies. Part 1: Design of the Science Foundation Programme (SFP). *International Journal of Science Education* 18: 993-1013.

Grussendorff, S., M. Liebenberg & J. Houston 2004. Selection for the Science Foundation Programme (University of Natal): The Development of a Selection Instrument. *South African Journal of Higher Education* 18: 265-72.

Gee, J. 1990. *Social Linguistics and Literacies: Ideology in Discourse.* Basingstoke: Falmer.

Hay, H.R. & F. Marais 2004. Bridging Programmes: Gain, Pain or All in Vain. *South African Journal of Higher Education* 18,2: 59–75.

Heckman, J.J. 1979. Sample Selection Bias as a Specification Error. *Econometrica* 47,January: 153–161.

Jenkins, D. & K. Boswell 2002. *State Policies on Community College Remedial Education: Findings from a National Survey*. Education Commission of the States, Denver, Colorado, USA.

Light, R.J. 2001. *Making the Most of College: Students Speak their Minds.* Cambridge, Mass.: Harvard University Press.

Mabila, T.E., S.E. Malatje, A. Addo-Bediako, M.M.M. Kazeni & S.S. Mathabatha 2006. The Role of Foundation Programmes in Science Education: The UNIFY Programme at the University of Limpopo, South Africa. *International Journal of Educational Development* 26: 295-304.

Maggio, J., J.G. White, S. Molstad, & N. Kher 2005. Prefreshman Summer Programs' Impact on Student Achievement and Retention. *Journal of Developmental Education* 29,2: 2-33.

Miller, R. & J. Bradbury 1999. Academic Performance of English First and Second Language Students: Selection Criteria. *South African Journal of Science* 95: 30-4.

Onsongo, W.M. 2006. Assessing the Impact of Academic Support: University of the Witwatersrand First-year Engineering. *South African Journal of Higher Education* 20,2: 273–287.

Pantages, T.J. & C.F. Creedan 1978. Studies of College Attrition: 1950-1975. *Review of Educational Research* 48: 49-101.

Pascarella, E.T. & D.W. Chapman 1983. Validation of a Theoretical Model of College Withdrawal: Interaction Effects in a Multi-institutional Sample. *Research in Higher Education* 19: 25-48.

Ramirez, G.M. 1997. Supplemental Instruction: The Long-term Impact. *Journal of Developmental Education* 21,1: 2-28.

Rollnick, M., B. Davidowitz, M. Keane, A. Bapoo & L. Magadla 2008. Students' Learning-Approach Profiles in Relation to their University Experience and Success. *Teaching in Higher Education* 13,1: 29-42.

Rollnick, M. 2006. Successes in Science Access Internationally: A Survey of Programmes. Proceedings of the 14th Annual SAARMSTE Conference, Pretoria, University of Pretoria, South Africa.

Santa Rita, E. & J.B. Bacote 1997. The Benefits of College Discovery Prefreshman Summer Program for Minority and Low-income Students. *College Student Journal* 31,2: 161–173.

Schilling, K. 2001. Plenary Address. Presented at The Summer Institute on First-Year Assessment, Asheville, North Carolina.

Schoenecker, C., L. Bollman & J. Evans 1998. Developmental Education Outcomes at Minnesota Community Colleges. *AIR Professional File* 68: 1–16.

Scott, I., N. Ndebele, N. Badsha, B. Figaji, W. Gevas & B. Pityana 2013. *A Proposal for Undergraduate Curriculum Reform in South Africa: The Case for a Flexible Curriculum Structure*. Report of the Task Team on Undergraduate Curriculum Structure Discussion Document Council on Higher Education, Pretoria.

Seymour, D. 1993. Quality on Campus: Three Institutions, Three Beginnings. *Change* 25,3: 14-27.

Sovey, A.J. & D.P. Green 2011. Instrumental Variables Estimation in Political Science: A Readers' Guide. *American Journal of Political Science* 55,1: 188–200.

Smith, L.C. 2009. Measuring the Success of an Academic Development Programme: A Statistical Analysis. *South African Journal of Higher Education* 23,5: 1009-1025.

Smith, L.C. 2012. *The Effect of Selected Academic Development Programmes on the Academic Performance of Academic Development Students at a South African University: An Empirical Analysis.* PhD thesis, University of Cape Town.

Smith, L.C. 2013. Measuring the Impact of Academic Development Courses in First- and Second-year Chemistry. *South African Journal of Chemistry* 66,1: 189–199.

Smith, L.C. & L. Edwards 2007. A Multivariate Evaluation of Mainstream and Academic Development Courses in First-year Microeconomics. *South African Journal of Economics* 75,1: 99–117.

Vygotsky, L.S. 1982. *Thought and Language*. Cambridge, Mass.: MIT Press.

Weissman, J., C. Bulakowski & M. Jumisko 1997. Using Research to Evaluate Developmental Education Programs and Policies. *New Directions for Community Colleges* 100, 73-80. doi:10.1002/cc.10007.

Wood, L.A. & P. Lithauer 2005. The 'Added Value' of a Foundation Programme. *South African Journal of Higher Education* 19,5: 1002–1019.

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press.

Zeegers, P. & L. Martin 2001. A Learning-to-learn Program in a First-year Chemistry Class. *Higher Education Research & Development* 20,1: 35–52.

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