The effect of selected academic development programmes on the academic performance of academic development students at a South African university: An empirical analysis

by

Leonard Cowper Smith

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Abstract

The case studies that make up this thesis cover the three largest academic development programmes at the University of Cape Town. A variety of statistical methods are used to estimate the effect of educational interventions in selected first- and second-year academic development courses on the academic performance of academic development students in these courses and through to graduation, relative to mainstream students.

In general, research in this area in South Africa and internationally has been characterised by small sample sizes and a lack of statistical rigour. Few studies control for the range of independent variables that can affect students' academic performance, in addition to the academic development programme or course, and the great majority ignore the sample-selection problem that arises in the selection of students for academic development and mainstream programmes.

The theoretical rationale underpinning this thesis is informed by the postpositivist and evidence-based approaches to empirical investigation. Demographic, academic and other data for some 9000 students for the years 1999–2005 was obtained from the university's data base and academic departments. Statistical techniques including multivariate analysis and propensity score matching are used in an attempt to finesse the problems associated with the use of non-experimental data as students are selected into different courses and programmes.

The key findings, subject to the caveats associated with the use of non-experimental data, are that the educational interventions included in the first-year academic development courses offered by the university's three largest academic development programmes are effective in improving academic development students' academic performance in selected first- and second-year courses relative to mainstream students, conditional on the selected control variables. The same is true of the educational interventions included in selected second-year courses. The effect of the educational interventions included in the first-year courses, however, does not have a statistically significant impact on academic development students' graduation rates relative to mainstream students, conditional on the selected control variables.

A note on "race"

South Africa's Population Registration Act (Act 30 of 1950) made it mandatory for people in South Africa to be classified into a variety of population groups, for example "white", "black", "Indian" and "coloured". This Act was repealed in 1991 and no similar classificatory legislation currently applies.

However, for equity purposes the University of Cape Town's application form asks South African citizens and permanent residents applying to study to declare their population group: black, coloured, Indian, white or Chinese.

Therefore, in the context of this thesis the terms "white", "Indian", "black" and "coloured" refer to this self-declaration. It is likely that the majority of students declare themselves to belong to the same "population group" as that to which their parents and other family members were consigned by the pre-1994 apartheid state.

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Abbreviations and acronyms

AARP	Alternative Admissions Research Project
ADP	Academic development programme
ADU	Academic Development Unit
ASP	Academic Support Programme
ASPECT	Academic Support Programme for Engineering in Cape Town
BCom	Bachelor of Commerce
BSc	Bachelor of Science
CADP	Commerce Academic Development Programme
CASP	Commerce Academic Support Programme
CEM1000W	Whole-year first-year mainstream course in chemistry
CEM1009H	Whole-year first-year academic development half-course in chemistry
CEM1010F	First-semester first-year academic development half-course in chemistry
CEM2007F	First-semester second-year mainstream course in chemistry
CEM2008S	Second-semester second-year mainstream course in chemistry
CHED	Centre for Higher Education Development
ComB01	BCom (General)
ComB03	BActSc (Actuarial Science)
ComB04	BBusSc (Business Science)
ComB06	BCom (Accounting)
ComB07/17	BCom (Economics and Law)
ComB08	BCom (Information Systems)
ComB12	BCom (PPE)
ComB13	BCom (Economics and Finance)
ComB16	BCom (Accounting and Law)
CPP	Career Preparation Programme
CUT	Central University of Technology
DET	Department of Education and Training
DOE	Department of Education
EBE	Faculty of Engineering and the Built Environment
ECO1010F	First-semester first-year mainstream course in microeconomics
ECO1010H	Whole-year first-year academic development course in microeconomics
ECO1010S	Second-semester first-year mainstream course in microeconomics
ECO1011S	Second-semester first-year mainstream course in macroeconomics
ECO2003F	First-semester second-year mainstream course in microeconomics
ECO2004S	Second-semester second-year mainstream course in macroeconomics
ECP	Extended Curriculum Programme
EDP	Extended Degree Programme
EDU	Education Development Unit
EFP	Engineering Foundation Programme
END1007W	Whole-year first-year academic development course in mathematics
END1008Z	Credit-bearing language and communication course for ASPECT students
Eng FL HG	English first language (HG)
Eng SL HG	English second language (HG)
ESCOS	Engineering Stream in the College of Science
GEPS	General Entry for Programmes in Science
GPA	Grade Point Average

HESA	Higher Education South Africa
HG	Higher Grade
HRD	Houses of Representatives and Delegates
MACH	Mathematics Achievement Test
MAM1003W	Whole-year first-year first-semester mainstream course in mathematics
MAM1005H	Whole-year first-year first-semester academic development half-course in mathematics
MAM1006H	Whole-year first-year second-semester academic development half-course in mathematics
MAM2080W	Whole-year second-year mainstream course in mathematics
Math HG	Mathematics (HG)
Math SG	Mathematics (SG)
MCOM	Mathematics Comprehension Test
Model C	State schools reserved for the white population prior to 1994
MSAT	Mathematics section of the Student Admissions Test
MVA	Multivariate analysis
Narset	National Access and Retention in Science, Engineering and Technology
NBT	National Benchmark Tests
NMMU	Nelson Mandela Metropolitan University
NSC	National Senior Certificate
OLS	Ordinary least squares
PBS	Pre-University Bursary Scheme
PGDA	Post Graduate Diploma in Accounting
PPE	Politics, Philosophy and Economics
Private	Private schools
PS HG	Physical Science (HG)
PS SG	Physical Science (SG)
PSM	Propensity score matching
PTEEP	Placement Test in English for Educational Purposes
RCT	Randomised control trials
SAT	Student Admissions Test
SciADP	Science Academic Development Programme
SFP	Science Foundation Programme
SG	Standard Grade
TASP	Texas Academic Skills Program
TUCE	Test of Understanding College Economics
UCT	University of Cape Town
UFP	University Foundation Programme
UFS	University of the Free State
UK	United Kingdom
UKZN	University of KwaZulu-Natal
UNIFY	University of the North Foundation Year
UNIN	University of the North
USA	United States of America
WC	Western Cape Province
WISPE	Wits Integrated Study Programme for Engineering

Chapter 1

Introduction

> "What is the use of teaching the Bantu mathematics when it [*sic*] cannot use it in practice?" (Verwoerd 1953, col. 3585)
>
> "There is no place for him [the Bantu] in the European community above the level of certain forms of labour. For that reason it is of no avail for him to receive a training, which has as its aim absorption in the European community, where he cannot be absorbed." (Verwoerd 1954, p. 24)

In 1948 South Africa's National Party won its first general-election victory. Its primary objective was to secure political and economic power for white people in general, and white Afrikaners in particular. To this end the government of the 1950s introduced a raft of legislation designed to remove "non-whites" from the body politic, to ensure the social separation of the different "population groups", and to secure the fruits of economic growth for the white population (Davenport 1977, pp. 259–60).

Among the chief aims of the promoters of apartheid were to ensure that each "population group" lived in a separate area, attended separate schools and churches, and met only in the workplace. Here job reservation laws protected white workers – certain occupations being reserved for them alone (Davenport 1977, p. 275).

In 1953, the then Minister of Native Affairs, Dr H.F. Verwoerd, introduced the Bantu Education Act (Act 47 of 1953) (Scott et al. 2005). In a speech to parliament he made it clear that black children would be taught only those skills necessary for a life of servitude in the 87.0% of South Africa reserved for the white population. Unsurprisingly, the white population group received the lion's share of the funds earmarked for education (Case and Deaton 1998, Fedderke et al. 2000, Seekings and Nattrass 2005, Feinstein 2005, Giliomee 2009).

The inherent contradictions of such a political and economic system contributed to its collapse. From the early 1960s the revolt against the system gathered pace and by the late 1970s the Nationalist government had begun to adapt the system of apartheid to the economic and political realities of the day.

It was at about this time that universities, which, with few exceptions, had catered for white students only in terms of government legislation, were allowed to admit increasing numbers of black, Indian and coloured students. The four historically white English-speaking universities – Cape Town, Natal, the Witwatersrand and Rhodes – took the lead (Boughey 2007, Scott 2009). It is not surprising that black, Indian and coloured students found it difficult to adjust to the academic demands being made of them; their poor school education had done little to prepare them for the rigours of academic study.

In response to this situation the four universities introduced academic support (AS) (foundation, access, remedial, augmented, slow steam, extended curriculum, bridging) programmes into selected faculties: usually engineering, science and commerce (Kloot et al. 2008, Rollnick 2010).[1] These programmes started at different times and took a variety of forms, and represented a reactive response by the universities as they wished to improve the access and retention of black, Indian and coloured students. Extra tutorials, bridging courses, and additional courses, usually in English and mathematics, were the norm. The expressed aim of such interventions was to enable students to cope with university curricula (Volbrecht 1999, Scott 2009). Even at this early stage Scott (1986) argued that AS programmes were inhibiting the transformation of the universities by diverting pressure for fundamental change.

However, it was not long before the AS model was called into question (Walker and Badsha 1993, Scott 2009). This model made the student the problem. It was the student who was underprepared or who lacked the means to cope with the demands of academic study; the problem was not the curriculum and those who taught it. The AS programmes made it possible for universities to continue their existing practices. They acted as a buffer protecting academic staff from the need to change both their curricula and their teaching practice (Volbrecht 1999).

[1] In the United States access to tertiary education is facilitated by the Community Colleges and in the UK by the

Throughout the 1980s the number of black, Indian and coloured students admitted to the historically white universities remained relatively small (Scott et al. 2005). However, by 1990 the writing was on the wall for the apartheid state. In a democratic South Africa the number of black, Indian and coloured students attending the historically white universities could be expected to increase substantially. Also, the legacy of the underfunding of schools attended by black, coloured and Indian children, and the practice of discriminatory education, would be felt for some time to come.[2]

It also came to be accepted that white students were also "disadvantaged" as a result of their exposure to the South African government's policy of Christian National Education which was explicitly designed to encourage the development of obedience and respect for authority (Lynch and Letcher 1974, Nzimande 1988). Like their "non-white" peers, white students were encouraged to regurgitate the stories told to them by their teachers. A spirit of independent inquiry was discouraged in apartheid South Africa.

These developments called for a positive response from the universities. As a first step, *academic support programmes* were renamed *academic development programmes*. This recognised the obligations of universities to develop the inherent abilities of students. Secondly, the universities were encouraged by the academic development (AD) community to change the manner in which they delivered the curriculum. Rather than focusing on AS programmes (running alongside mainstream[3] programmes) to enable students to cope with the demands of academic life, universities were encouraged to change the content of their degrees and their processes of delivery (Moulder 1991).

As of 1994 the government stepped up its funding of AD programmes and courses as it wished to promote access to the tertiary sector by educationally disadvantaged students in the interests of its policy of transformation (Boughey 2010). In particular, Warren (1998) connects the shifts in the University of Cape Town's (UCT) attitude to the role of AD programmes to the change in government policy.

[2] Educational disadvantage is attributable to the environment in which a person has been forced to undergo his or her educational experiences, and is not a result of a lack of intellectual capacity (Scott et al. 2005).
[3] "Mainstream" refers to those courses that makeup the standard three- and four-year degree programmes in the Faculties of Humanities, Commerce, Engineering and the Built Environment, Science, Law and Health Sciences (Volbrecht 1999).

In 1997 the Narset (National Access and Retention in Science, Engineering and Technology) Report compared the characteristics of 21 foundation programmes (Kotecha et al. 1997), and by 2001 Pinto (2001) was able to identify more than 40 AD programmes run by 23 universities and 15 technikons. This suggests that by this time nearly every South African tertiary institution was making some provision for its educationally disadvantaged students including the previously white Afrikaans-speaking and the black, coloured and Indian universities.

Since the 1990s universities have grappled with the issues surrounding the construction and delivery of AD programmes and courses. However, despite the pervasiveness of these interventions, and the cost of their implementation, it is fair to say that the efficacy of the programmes and courses in improving students' academic performance is largely unknown (DOE 2006, Kloot 2011).[4]

There are two main reasons for this unsatisfactory state of affairs. Firstly, much of the early literature is devoted to the description of AD courses and programmes (Kloot 2011). See for example, Bradley (1984), Allie (1987), Kotecha and Rutherford (1987), Volmink (1987), Sharwood (1992), Zaaiman (1998), Parkinson (2000), Hay and Marais (2004), Holtman and Marshall (2008) and Grayson (2010). Secondly, many of the later studies employ descriptive statistics rather than using more rigorous statistical methods. For example, the academic performance of AD students is described and is compared to the academic performance of mainstream students, or to the academic performance of AD cohorts in previous years. No statistical analysis is employed to control for any variables that could also affect students' academic performance, or to control for the differences between each year's cohorts.[5] See, for example, Grayson (1997), Hay and Marais (2004), Downs (2005), Wood and Lithauer (2005), De Klerk et al. (2006), Downs (2006), Onsongo (2006), Downs (2010), and Lubben et al. (2010).

[4] Seymour (2001) reports that the cost of remediation programmes in the USA is $1.5 million per annum, and that increased enrolment has been coupled with higher rates of attrition.
[5] Further discussion of this topic can be found in Smith and Edwards (2007), Smith (2009a), Smith (2009b), and Smith and Ranchhod (forthcoming).

There are, however, a few studies that are an exception to this rule. Curtis and De Villiers (1992) used multivariate analysis (MVA) to compare the academic performance of commerce students attending a bridging programme at the University of the Witwatersrand with the academic performance of mainstream students at the same university, conditional on their admission rating. De Villiers and Rwigema (1998) used ordinary least squares (OLS) analysis with a binary dependent variable to test whether students on an AD programme outperformed a comparable group of mainstream students through to graduation. Edwards (2000) used MVA to estimate the success of an introductory first-semester economics course for academically disadvantaged students at UCT, and Van der Flier et al. (2003) analysed the academic performance of AD students at the University of the North (UNIN) relative to a comparable group of mainstream students. With the exception of these four studies there is little empirical research aimed at identifying the key determinants of academic success for AD and mainstream students using statistical methods.

There is an extensive literature on the theory, structure and implementation of educational development (support, basic skills, remedial or remediation) programmes in community colleges and universities in the United States (Kulik et al. 1983, Ignash 1997, Simpson et al. 1997, Hagedorn et al. 1999, Jenkins and Boswell 2002, Kozeracki 2002, Bettinger and Long 2004, Bueschel 2004, Jones and Gellene 2005, Attewell et al. 2006, Botch et al. 2007, Bueschel 2009). Remediation refers to coursework offered below college level in higher education institutions (Merisotis and Phipps 1998) and there is some overlap with AD programmes in terms of the participation of non-traditional students taking these courses (Attewell et al. 2006). However, Grubb and Kalman (1994), Adelman (1999), Boylan and Saxon (1999), Levin (1999), Roueche and Roueche (1999), Merisotis and Phipps (2000), Grubb (2001), Bettinger and Long (2005), Lesik (2007), Levin and Calcagno (2008), and Bailey (2009) claim that relatively little research has been undertaken to test the efficacy of these programmes, and that many studies do not use the most appropriate research design.

Nevertheless, there is research that suggests there are benefits to students who attend remediation programmes. Students who complete remedial courses are more likely to pass mainstream courses, and they are less likely to drop out (higher persistence rates) relative to comparable students who do not take these courses (Kulik et al. 1983, Freeman 1984, Weissman et al. 1997, Schoenecker et al. 1998, Boylan and Saxon 1999, Congos and Schoeps 1999, Etter et al. 2001, Bettinger and Long 2004, Bentley and Gellene 2005, Attewell et al.

2006, Lesik 2007, Bahr 2008, Shields et al. forthcoming). That said, there are dissenting voices that suggest that remediation programmes are largely ineffective in improving students' academic performance (Little Hoover Commission 2000, McCabe 2003, Bailey 2009, Viadero 2009).

The low graduation rates across South Africa's tertiary education sector are a grave cause for concern (Scott et al. 2007). Therefore, it is important to be able to show whether the educational interventions incorporated in AD courses and programmes are effective in improving students' academic performance through to graduation. It is also not unreasonable to assume that many students on mainstream courses and programmes would also benefit from a similar array of educational interventions. In this context Rollnick (2010, p. 50) notes that "students entering by alternate routes are often regarded as high risk and it would be interesting to know how their success rate compares with mainstream students". This statement has particular resonance, for it is the chief purpose of this thesis to develop methods to make just such a comparison.

This thesis aims to answer the following four questions:

a. What statistical methods can be used to estimate the effectiveness of AD programmes and courses?

b. What is the impact of the educational interventions included in AD courses on the academic performance of AD students in selected first- and second-year courses, relative to mainstream students?

c. What is the impact of the educational interventions included in the first-year AD courses on the graduation performance of AD students relative to mainstream students for each of the selected programmes?

d. What are the chief determinants of academic performance, through to graduation, for AD and mainstream students?

The AD programmes that are the focus of this thesis are the three largest at the UCT: the Commerce Academic Development Programme (CADP) located in the Commerce Faculty;

the Academic Support Programme for Engineering in Cape Town (ASPECT) located in the Faculty of Engineering and the Built Environment; and the General Entry for Programmes in Science (GEPS) located in the Faculty of Science.

This thesis builds on the work of Smith and Edwards (2007); they tested the efficacy of an AD course in first-year microeconomics at the UCT, relative to a comparable group of mainstream students. In their study the efficacy of the AD course was measured in terms of students' success in first-year microeconomics, and in subsequent courses in macroeconomics and microeconomics, using selected control variables. The key findings were that students on the AD course outperformed mainstream students by an average of 15.0 percentage points for the structured/essay questions in the first-year microeconomics examination, and by an average of 12.0 percentage points for the structured/essay questions in the *second-year* microeconomics examination. The latter result suggests that the skills acquired in the first-year AD course in microeconomics persists into further years.

This thesis makes a number of advances to the literature in this area. Firstly, it is broad in scope, covering the three largest AD programmes offered by the UCT. The data for selected cohorts from 1999–2005 is pooled, in contrast to the Smith and Edwards (2007) study, which used only data for the 2001 cohort.[6] Several studies in the field have used pooled data in order to increase sample size. See, for example, McFate and Olmsted (1999), Lourens and Smit (2003), Zhang et al. (2004), Bentley and Gellene (2005), Tai et al. (2006), Lewis and Lewis (2007), Sadler and Tai (2007), Tai et al. (2007), Kennepohl et al. (2010), Potgieter et al. (2010), Ciufo (2011), and Min et al. (2011). A larger sample size makes it possible to evaluate the effectiveness of the educational interventions in improving students' academic performance for several different years and it also makes it possible to generate a more robust set of results.

Secondly, the samples used in the case studies presented in this thesis are unusually large. In general, studies of the determinants of academic performance, in economics courses at least, tend to use relatively small samples. For example, a survey of 15 studies undertaken in the United States, and reported in the *Journal of Economic Education* over the period 2000 to 2007, showed sample sizes ranging from 57 to 1011 observations, with a mean of 449

[6] This period was chosen as it takes at least seven years for all students to pass through the system.

observations.[7] For six studies of commerce and economics students at South African universities, which identified some of the determinants of academic performance, the sample sizes range from 26 to 813 observations, with a mean of 526 observations.[8] For five studies focusing on AD students undertaking business economics and economics at South African universities, the sample sizes range from 177 to 424 observations, with a mean of 311 observations.[9] The sample sizes for the case studies analysed in this thesis range from an average of 1854 observations for the first-year studies, 1780 observations for the second-year studies, to 3040 observations for the graduation studies, in contrast to an overall mean of 443 observations for the studies cited above.

Thirdly, the Heckman two-step estimator (Heckman, 1979) is used to account for the sample-selection problem that arises, as not all the students who start the course write the final examination. Omitting these students from the estimations may bias the results. That said, the omission of the students who did not write the final examination did not have a material impact on the results reported in this thesis.

Fourthly, two methods of statistical analysis, propensity score matching (PSM) and multivariate analysis (MVA), are used to test whether the educational interventions incorporated in the first-year AD courses are effective in improving the academic performance of AD students relative to their peers on the mainstream in individual first- and second-year courses, and through to graduation.

These four advances make it possible to generate a more robust set of results than was previously the case.

This thesis is structured as follows: Chapter 2 describes the context of the study and Chapter 3 the methodology and research design. Chapter 4 reviews the literature, and Chapter 5 outlines the empirical specification and describes the construction of the data bases. Chapters

[7] Chizmar (2000), Ziegert (2000), Ashworth and Evans (2001), Marburger (2001), Arias and Walker (2004), Bosshardt (2004), Sowell (2004), Anstine and Skidmore (2005), Krohn and O'Connor (2005), Grove et al.(2006), Marburger (2006), McPherson (2006), Stanca (2006), Swope and Schmitt (2006), and Alston and Nowell (2007).
[8] Hesketh et al. (1994), Edwards (2000), Smith (2004), Van Walbeek (2004), Parker (2006), and Smith and Edwards (2007).
[9] Curtis and De Villiers (1992), De Villiers and Rwigema (1998), Edwards (2000), Smith (2004), and Smith and Edwards (2007).

6 to 8 contain the analysis of the data for the first-year, second-year, and graduation case studies. Chapter 9 discusses the findings and concludes the thesis.

Chapter 2

Context for the study: Academic development programmes at UCT (CADP, ASPECT and GEPS)

2.1 Academic development programmes (ADP) in South Africa

Academic development (AD) and support (AS) programmes and courses have been used extensively in South African higher education institutions over the last 25 years (Kloot et al. 2008, Scott 2009, Rollnick 2010, Kloot 2011). These have taken a variety of forms, including bridging courses, extra tutorials, foundation courses, extended curriculum, and additional courses in English and mathematics (Walker and Badsha 1993, Volbrecht 1999, Edwards 2000, Scott et al. 2005, Rollnick 2010). Kloot (2011) notes that the AD programmes and courses did not remain static; they tended to evolve over time and become more integrated with mainstream programmes.

In general, students entering AD programmes at tertiary institutions are often seen as being educationally disadvantaged, under-prepared and in need of academic support. In short, they are required to make substantial adjustments to the academic, cultural and social demands of tertiary education. In the light of these assumptions about AD students, the aim of AD programme and courses is to enable students to cope with the demands of mainstream courses. To this end the educational interventions are designed to enable AD students to develop their literacy, quantitative and study skills, so that they are able to achieve success in a particular AD course, complete mainstream courses, and ultimately achieve a higher education qualification. In addition these educational interventions are also designed to facilitate students' epistemological access to each of their subjects.

Several authors have put forward their ideas as to what constitutes a successful AD or foundation programme. Pinto (2001) stresses the importance of access with success, Snyders (2003) identifies the principles that should underlie an effective foundation programmes in a comprehensive institute of higher education, and Grayson (1996) outlines an educational philosophy aimed at enabling disadvantaged students to succeed in tertiary science studies.

The black student intake represents a selected group as they are the top decile of their age group in terms of achieved academic performance (Scott et al. 2007). It follows that they must be expected to have a high level of potential to succeed. To take the view that any year's intake does not have the academic potential to make a success of their university career is to conflate the lack of academic preparedness with academic potential. The key function of AD programmes is to enable South Africa's tertiary institutions to meet the twin objectives of access to higher education and equity of outcomes (graduation) (Scott et al. 2005, Scott 2009). Currently, AD programmes across South Africa's tertiary institutions have a limited impact as they reach only 10.0% of the student body (Scott et al. 2007).

2.2 ADP in the faculties of Commerce, Engineering and the Built Environment, and Science

Students are placed into the three AD programmes on the basis of their academic performance in the matriculation examination, their educational and socioeconomic background, and whether they are reckoned to have the potential to achieve a degree given their exposure to a range of educational interventions.[10]

Students who come from educationally and socioeconomically disadvantaged backgrounds and who have not achieved the required number of matriculation points to attend a mainstream programme qualify for an AD programme. Thus the range of matriculation points exhibited by AD students is less than for mainstream students. A small proportion of students in each year's cohort apply directly to an AD programme. Some of those accepted have sufficient matriculation points to qualify for one of the mainstream programmes.

2.2.1 Commerce Academic Development Programme (CADP)

The CADP is a unit of the Academic Development Unit (ADU) in the Centre for Higher Education Development (CHED).

[10] AD students are assessed on the basis of some combination of interviews, referees' reports and school academic performance relative to their peers.

Prior to 1982 all students at UCT took mainstream courses; no additional support was given to students from educationally and socioeconomically disadvantaged backgrounds. In 1982 the university introduced the Commerce Academic *Support* Programme (CASP) which was renamed the Commerce Academic *Development* Programme (CADP) in 1987. AD students were required to attend additional (supplementary) courses to help them compensate for critical gaps in their education, for example a whole-year English language course and double-period economics and accounting tutorials that ran alongside the mainstream courses.

However, even with this support, students from academically disadvantaged backgrounds struggled to pass the mainstream courses. Contributing factors were the pace of the one-semester courses and the students' poor quantitative, writing, study and English-language skills. The university responded to this situation in 1995 by introducing a four-year Bachelor of Commerce (BCom) degree for CADP students. This allowed both the Department of Accounting and the School of Economics to introduce first-semester introductory courses in accounting and economics, respectively. However, AD students continued to struggle with the pace of the single-semester first-year mainstream courses as their relative deficiencies with respect to learning, English language, writing and quantitative skills were not adequately addressed in the first-semester introductory courses. Therefore, in 1999 the CADP introduced whole-year first-year courses in microeconomics, accounting, statistics and information systems.

Students who successfully completed the four first-year courses moved on into mainstream courses. No additional support was given to the CADP students; they were left to "sink or swim". However, from 2003 onwards the CADP introduced workshops for students doing courses in second-year microeconomics and macroeconomics.

Economics

All mainstream students in the commerce faculty must take the first-year courses in microeconomics (ECO1010F) and macroeconomics (ECO1011S).[11] In addition, most commerce students are also required to do the second-year courses in microeconomics

[11] F (first-semester course), S (second-semester course), W (whole-year course), H (whole-year half-course)

(ECO2003F) and macroeconomics (ECO2004S). The economics courses that are the focus of this thesis are first- and second-year microeconomics.

The AD whole-year course in first-year microeconomics (ECO1010H) includes short modules on quantitative techniques, graphical analysis, and introductory macroeconomics, in addition to what is covered in the mainstream first-year microeconomics course, which mirrors that of the single-semester mainstream courses in microeconomics: the first-semester (ECO1010F) and second-semester (ECO1010S) courses. Some 80.0% of students who attend ECO1010S are repeating the first-year microeconomics course, having failed ECO1010F in the first semester. The ECO1010H course was convened by the same person for the period 2000–2005. This person was also responsible for delivering most of the lectures.

There are several important differences between the AD course (ECO1010H) and mainstream courses (ECO1010F and ECO1010S) with respect to the structure, content and teaching approach. The ECO1010H course runs over two semesters as opposed to a single semester, five lectures are offered per week as opposed to four, and classes are small (80 to 120 students) relative to the size of mainstream lecture groups (150 to 400 students). Greater emphasis is placed on using the tutorial system as a vehicle to develop students' meta-learning skills. A weekly double-period language and communication tutorial, consisting of about 25 students, is used to improve students' essay-writing skills, and their referencing and comprehension techniques. Further, prior to a weekly double-period economics tutorial (15 students) the students are required to complete and submit written answers to a set of structured/paragraph questions. These are graded by the tutor and the marks contribute towards the students' final mark. In addition students work through a selection of exercises, including multiple-choice, paragraph/structured/essay, true/false, fill-in, calculation, and case-study questions during the tutorial. In contrast, the economics tutorials offered by the mainstream courses pay less attention to the development of students' meta-learning skills. Each week, students attend a single-period tutorial during which various multiple-choice and structured/essay-type questions are discussed.

The greater number and duration of the tutorials gave ECO1010H students the opportunity to refine their understanding of the subject, and to develop their skills in answering different types of question. Tutors for both the economics and language and communication tutorials are chosen on the basis of their subject knowledge and pedagogic ability, and for the degree

of their commitment to enabling AD students to make a success of their microeconomics course. The relatively few tutors receive advice and support from the course convener both in tutor meetings and at other times when necessary. The performance of the tutors is monitored by the course convener and students submit evaluations of their tutors during the course. The aim of this support and assessment is to encourage tutors to perform to the best of their ability. In contrast, mainstream students are required to submit written work less frequently and their grades for these assignments do not count towards their final marks. Also, no language and communication tutorials are offered. Tutors receive less training and support compared to those leading the ECO1010H tutorials.

The assessment used also differs between the AD and mainstream courses. The forms of assessment used in ECO1010H include the tutorials, three essays, four tests and the final examination.[12] The tests include multiple-choice and structured/essay questions in the ratio of about 30 to 70. In contrast, students in the mainstream economics courses are not required to submit essays, and tests consist solely of multiple-choice questions.[13] The tests for the two courses are set to the same standard and from 2001 the ECO1010H and ECO1010S cohorts wrote the same final examination, consisting of multiple-choice and structured essay questions in the ration of $^{1}/_{3}$ to $^{2}/_{3}$, at the same sitting. Copies of previous test and examination papers were made available to both cohorts from short-loan in the university's main library.

Prior to 2003, AD students who successfully completed ECO1010H went on to the second-year mainstream microeconomics course (ECO2003F) where they did not receive any further academic support. Starting in 2003, a fundamental change was made to the ECO2003F course. Although the content remained much the same (consumer demand theory, theory of the firm, market structure, labour markets and welfare economics), a strong emphasis was placed on the use of mathematical techniques, rather than graphical analysis, to solve for equilibrium conditions under a variety of circumstances, for example utility maximisation, cost minimisation and profit maximisation. Students were also expected to use calculus to solve the Cournot, Stackelberg and Bertrand oligopoly models.

[12] The final mark is made up as follows: three essays at 5% each (15%), three tests at 5% each (15%), one test at 10% (10%), 20 written economics tutorials (5%) and the final examination (55%).
[13] The ECO1010F/S final mark is made up of the marks gained in two or three multiple-choice tests and the final examination. The tests count 45% of the final mark.

In general, AD students have a low level of mathematical ability as measured by their grades for mathematics and physical science in the matriculation examination. Therefore, it was decided to offer voluntary workshops to AD students undertaking ECO2003F, which ran once a week for two hours. Two activities predominated: the lecturer revised the key topics and concepts and students were led through a series of exercises, which gave them the opportunity to practise the key mathematical techniques.

2.2.2 Academic Support Programme for Engineering in Cape Town (ASPECT)

The ASPECT is a unit of the Academic Development Unit (ADU) in the Centre for Higher Education Development (CHED).

Pearce (2009) gives a comprehensive report of the history, development, principles, and constituents of ASPECT. It was established in 1988 as an extended degree programme for black and coloured students, having been preceded by a foundation-year programme, which did not prove to be a success. The focus of ASPECT's work is the first-year student. ASPECT is not an Education Development Unit (EDU), which has the brief of providing students with various levels of support through to graduation.

In 1999 a second programme, the Engineering Foundation Programme (EFP) was established to cater for prospective engineering students who had an even lower level of academic preparedness as measured by their performance in the matriculation examination than did ASPECT students. However, this programme did not prove to be successful and was closed in 2003.

ASPECT provides an alternative means of access to the Engineering and Built Environment (EBE) Faculty for students who come from educationally and socioeconomically disadvantaged backgrounds. These students, generally, do not achieve sufficient matriculation points to enable them to qualify for entry into the EBE Faculty. However, they are deemed to have the potential to achieve an engineering degree.

In general, ASPECT offers relatively small classes, excellent teaching, a supportive learning community, recognition of students' relatively poor level of preparedness, careful alignment of assignments with the content of the curriculum, and double contact time relative to the

mainstream cohorts. Groupwork in workshops is considered to be a key component of the programme. The focus is on active learning sessions rather than on having students sitting passively in lectures. The aim is to encourage interactive classroom engagement in the best traditions of cooperative and collaborative leaning. The tutors and mentors are usually second-year ASPECT students, who receive some informal training from the ASPECT lecturers before they take up their roles.

ASPECT students are required to take a credit-bearing language and communication course, END1008Z. The purpose of this course is to develop the literacy of the first-year students in the context of the engineering curriculum and profession, and includes modules on reading skills and academic essay writing, among others.

Mathematics

The engineering courses on which this thesis focuses are first- and second-year mathematics. The AD whole-year course in first-year mathematics (END1007W) is described by Pearce (2009, p. 11) as follows:

> In END1007W the teaching and assessing are multimodal. The teaching is a combination of formal lectures, workshops and tutorials. The workshops and tutorials include group-work and the formal lectures include a high degree of student-lecturer interaction. This permits the students more opportunity for self exploration of various mathematical topics rather than passive observation. ASPECT's large number of contact hours allows for both more lectures than are possible in a traditional course in addition to the workshops. Additionally, our tutorial is somewhat longer than the mainstream tutorial, at 3 hours rather than 2.
>
> The assessment takes the form of traditional class tests, problem sets and remediation assessment. The problem sets exist for two reasons; the first is that the short nature of the class tests means that no questions which take a long time to answer can reasonably be answered and the second is that a different type of mathematical activity can be addressed. The problem sets usually consist of a single tough problem which cannot be solved in a short time. The students are encouraged to work in groups to solve these problems – they are take-home problems due for return four days later. The students tend to achieve good results on these problems despite their challenging nature.

In the period 1999–2005 the ASPECT and mainstream cohorts wrote the same class tests and final examination at the same sittings. ASPECT students who successfully complete END1007W go on to do the second-year whole-year mainstream course in mathematics, MAM2080W. However, given that ASPECT is a first-year programme, students receive no additional support when doing MAM2080W.

2.2.3 General Entry for Programmes in Science (GEPS)

The Science Academic Development Programme (SciADP) is a unit of the Academic Development Unit (ADU) in the Centre for Higher Education Development (CHED).

Allie (2009) gives a comprehensive report of the history, development, principles, and constituents of SciADP. It was started in 1986 as the Science Foundation Programme (SFP) and ran from 1986 to 1990. The SFP took the form of a number of one-year non-credit bearing foundation courses that preceded the degree. These included courses in mathematics, physics and chemistry. English language support was, and still is, a component of the physics course. Laboratory practicals were used to generate "writing intensive laboratory reports". These reports formed the basis of focused writing in the GEPS physics course.

In 1991 substantial changes were made to the SFP. Students were offered first-semester non-credit-bearing foundation courses in mathematics, physics and chemistry. Successful students went on to do second-semester credit-bearing courses in the same subjects, which also acted as "catch-net" courses for struggling mainstream students.

In essence the SFP became a two-year programme during which AD students completed the equivalent of the mainstream first-year courses. Thus SFP students were on a genuine extended four-year degree programme. The chief problem was that AD students struggled when doing the second-year mainstream courses.

In 1999 the Science Faculty introduced programmes as the means of structuring students' undergraduate career paths. The General Entry for Programmes in Science (GEPS) was established to cater for AD students, who were placed directly into the programme.

GEPS provides access to a Bachelor of Science (BSc) degree for students who have not met the faculty's entry requirements but who are deemed to have the potential to achieve a science degree (Lubben et al. 2010). It is flexible as it gives students a means of entry into all the programmes in the Science Faculty, and it delivers the curriculum to students at a differentiated pace up to the second-year level. GEPS students register for one of the degree programmes after their first year of study.

The target group are black students from across South Africa and coloured students from the Western Cape Province (WC). As is the case for EBE, it is also possible for students who are struggling with mainstream courses to move to the AD courses, where they can continue their academic career at a slower pace.

GEPS consists of whole-year first-year half-courses in mathematics, physics and chemistry, with an elective chosen from one of computer science, biology, and earth and environmental science. Lectures, workshops, tutorials and other supporting activities take up the contact time. The second half of the content of the mainstream courses is studied by GEPS students in their second year, either as a one-semester or whole-year course. After completing their first-year courses, GEPS students move to the mainstream courses where they are generally left to continue their studies without further academic support. There were no changes to the courses, or to the programme, in the period 1999–2005.

Chemistry

The science courses that are the focus of this thesis are first- and second-year chemistry. The AD course in first-year chemistry (CEM1009H) is described by Allie (2009, p. 14) as follows:

> Since a first year course in chemistry is a requirement for many programmes (majors) in the Science Faculty, there is a need for the CEM1009H course which caters for students considered to be underprepared for tertiary studies. It also provides an opportunity to a limited number of students with no secondary chemistry background to register for a chemistry course. The CEM1000W mainstream course does not cater adequately for these students as the pace is too fast and there is limited support in the form of tutorials. The CEM1009H course covers about 55.0% of the mainstream curriculum and is based

on a spiral approach.[14] Students are introduced to the most important basic concepts in chemistry. There is time to cover the basic concepts as well as to develop skills such as writing, data interpretation etc.

The CEM1009H course has five contact periods per week, three formal lectures and two small-group tutorials. In addition, there is a practical session each week. The course has been designed to integrate all facets into a coherent curriculum which is possible as the course convener does most of the teaching. Lectures are used to explain the content using carefully chosen examples to illustrate problem solving strategies where applicable. The approach is traditional, making use of an overhead projector and a blackboard rather than using electronic media to deliver the material. This allows a degree of spontaneity and flexibility which is not possible when using a Powerpoint presentation.

The tasks in the tutorials complement the lectures. The problem sets often contain examples which extend the coverage of the topics in the lectures. There are many questions which require discussion; this is more easily achieved in the small tutorial groups where the tutor is available to act as a facilitator. The tutorial sessions also allow students to interact more easily with models and other materials designed to enhance their understanding of the concepts. The lecturer acts as an additional tutor during the sessions and feedback from tutors is very valuable in that it alerts the lecturer to any issues which may need further clarification in the lectures.

Laboratory work has been designed to familiarise students with practical methods available to the chemist and to give them confidence in their ability to use these methods. The experiments give them opportunities to develop their manipulative skills as well as to handle modern instruments such as electronic balances and spectrophotometers. Students learn how to take careful measurements, to assess the precision of their findings and to describe the significance of their observations. Doing practical work also helps them to appreciate the experimental basis on which theoretical concepts are founded and thus enhance their understanding of chemical theory.

Tutors and demonstrators are an essential part of the teaching team as they facilitate learning in small groups. Well trained demonstrators and tutors will be more confident and effective in their roles. A one day workshop at the beginning of the year is the start of

[14] The spiral approach involves the following: start with the basic principles of a topic to lay the foundation and return to the topic later in the course and cover it in greater detail (personal communication from the course convener). See also Grove et al. (2008).

the training process, while weekly meetings with the demonstrators and tutors afford ongoing training. The tutors and demonstrators are given responsibility for running the activities of their group (14–16 students) which underlines their role as key members of the teaching team. Where possible, post graduate students, who themselves entered the chemistry department via CEM1009H, are recruited for this course since they are excellent role models for the students.

Students who pass CEM1009H go on to CEM1010F in the first semester of their second academic year. These two courses together cover the same material as the mainstream first-year course, CEM1000W. As regards assessment, students taking CEM1009H and CEM1010F are not required to answer multiple-choice questions in their final examination; they are required to respond in writing to structured questions. In contrast, the CEM1000W examination consists of structured and multiple-choice questions in the ratio of 2:1.

Successful AD and mainstream students, who wish to major in chemistry, go on to do the second-year courses, CEM2007F and CEM2008S. CEM2007F is a mathematics-based course, which includes physical chemistry and spectroscopy, and CEM2008S covers organic and inorganic chemistry. Historically, GEPS students have struggled with organic chemistry; additional tutorials were introduced in 2003 to provide further support to the AD cohorts.

2.3 Summary comments

First-year courses

The first-year whole-year course (ECO1010H) is taken by AD commerce students doing economics. This course is convened and taught by a designated AD lecturer. Students write the same final examination, at the same sitting, as do the mainstream (ECO1010S) cohorts. However, the in-course assessment differs between the two cohorts.

The first-year whole-year course (END1007W) is taken by AD engineering students doing mathematics. This course is convened and taught by a designated AD lecturer. Students write the same final examination and semester tests, at the same sittings, as do the mainstream cohorts (MAM1003W).

The first-year whole-year half-course (CEM1009H) is taken by AD science students doing chemistry. This course is convened and taught by a designated AD lecturer. Successful students go on to the second-year first-semester course (CEM1010F). These two courses are the equivalent of the whole-year mainstream course (CEM1000W). However, the means of assessment employed in the AD and mainstream courses differ from one another.

Second-year courses

Successful first-year economics students go on to ECO2003F. In the period 2000–2002, AD students were offered no additional academic support. In the period 2003–2005, workshops were offered to AD students with the express purpose of enabling them to cope with the more mathematical nature of the course.

Successful first-year mathematics students go on to MAM2080W, where they received no additional academic support.

Successful first-year chemistry students had the option of going on to CEM2007F and CEM2008S, where for the period 1999–2002 they received no additional academic support. However, in the period 2003–2005 workshops were introduced for the AD students doing CEM2008S, as they struggled to cope with organic chemistry.

Graduation performance

The purpose of the graduation studies is to establish whether the first-year courses offered by the three programmes improve the graduation rate of AD students relative to their peers on the mainstream.

Between 1999 and 2002 the CADP cohorts received no additional academic support after completing their first-year courses in a single year. However, from 2003 a small number of students attended the workshops offered in second-year microeconomics and macroeconomics. In the period 1999 to 2003, ASPECT students received no additional academic support after completing their first-year courses in a single year. In the period 1999 to 2004, GEPS students received no additional academic support after completing their first-

year courses over a period of two years, with the exception of the workshops offered to the very small number of GEPS students taking CEM2008S.

Chapter 3

Methodology and research design

The chief purpose of this thesis is to determine whether the first-year AD courses are effective in improving AD students' academic performance through to graduation. To this end use is made of the case study approach (Robson 1993, Case and Light 2011, Cohen et al. 2011). The effectiveness of the educational interventions incorporated in each of the three selected first-year AD courses is determined for each of the first- and second-year courses, and through to graduation. Thus there are nine case studies in all; three for each of the three programmes.

3.1 Methodology

The methodology used in this thesis is informed by the evidence-based approach to policy development and practice that has gained in influence since the 1980s. Rosenberg and Donald (1995) and Sackett and Rosenberg (1995) describe the impact of this approach in the medical field, and Slavin (2002) discusses its importance in the fields of educational research and practice. The key idea underpinning this approach is that any recommendations that are made with respect to policy and practice should be based on evidence that is best derived from sound research. Ideally, the research methods should conform as closely as possible to the experimental method, but failing that, the research should be as rigorous as possible. The evidence-based approach to research is not, however, without its critics. See, for example, Lather (2004), Hammersley (2005) and Howe (2009).

There are two types of experiment; the quasi- or natural experiment, and randomised experimental design (Goba et al. 2011). According to Meyer (1995) the term "quasi-experiment" comes from the field of psychology, and the term "natural experiment" from the field of economics. Both types of experiment examine outcome measures for treatment and control groups that have not been randomly assigned (Meyer 1995). Such experiments use variations arising in the treatment variable from changes in state laws, government draft mechanisms, or some other means, to obtain a variation (in the treatment variable) that is

plausibly exogenous (Maxwell and Looms 2003). For example, Bettinger and Long (2005) used the fact that colleges use different sets of criteria to decide who requires remediation (an exogenous variable) to identify students in remediation classes (treatment group) who could be compared to a similar set of underprepared students who had not been placed in remediation classes (control group).

According to Rhodes et al. (2001, p. 2), "the randomized experimental design is the gold standard for evaluation research." They go on to say that the "simplest version of this design requires that members of an eligible population be randomly assigned to either a treatment group or a control group. Provided that other factors do not contaminate the experiment, comparing the outcomes for the treated group and the untreated group provides an unbiased measure of the average treatment effect."

Unfortunately, it is difficult for ethical as well as practical reasons to use the experimental method to tackle the many different research questions that arise in the field of education (Zhu 1999, Diaz and Handa 2005). Diaz and Handa (2005, p. 319) note that "although experiments are the benchmark method for estimating the impact of social programmes ... they are seldom available because they are costly, raise ethical concerns due to the denial of potentially beneficial treatment to qualified individuals, and are infeasible for universal entitlements or ongoing programmes". For these reasons the use of non-experimental methods is common in the field of education research.

For example, a group of students who have received the treatment is compared to a group of students who have not received the treatment. The students, however, are not randomly allocated to the two groups. Schoenecker et al. (1998), Etter et al. (2001), and Lagerlöf and Seltzer (2009) compared the academic performance of students who are required to do a remedial course with the academic performance of students who are not required to do such a course. The research design problem is that students are placed into a remedial course on the basis of a certain set of characteristics, which they do not necessarily share with the students who do not do the remedial course. This gives rise to the sample-selection problem, which is discussed in some detail later in this chapter.

In the course of the past 30 years there has been the growing use of a variety of experimental designs and statistical methods aimed at enabling researchers to identify the relationship

between changes in the independent variable and changes in the dependent variable (Blundell and Dias 2009).

There is no single methodology that informs research practice in the social sciences. For example, Jawitz and Case (2009) outline three methodologies; positivism, constructivism and critical inquiry. Given the emphasis on the evidence-based approach to policy and practice, this thesis sits comfortably in the postpositivist paradigm (Phillips and Burbules 2000). The theory of postpositivism developed out of positivism, which is an epistemology that is based on the assumption that knowledge is derived from objective observations, and that it is possible to determine the one true explanation for any particular relationship that exists between two variables.

Positivists rely heavily on the experimental method, which is designed to tease out the effect of the relationship between a single independent variable and the dependent variable. As previously noted, the experimental method is characterised by the random allocation of subjects to the experimental (treatment) and control groups. The assumption is that the only difference between the two groups is that the treatment group has been subjected to the independent variable under investigation. Any difference in the performance of the two groups in terms of the dependent variable is assumed to be due to the effect of the independent variable.

Postpositivists, in contrast, believe that knowledge is conjectural. Researchers have grounds or warrants for accepting an explanation for a given set of relationships. But the warrants do not have the same status as statements of fact (Black and Wiliam 2003). It is possible that a warrant is falsifiable. This does not mean that it is false; rather that, if it is false, then it can be shown to be so by observation or experiment. Therefore, it is possible that a better-supported (warranted) conjecture (hypothesis) may be put forward at a later date and that the old, previously accepted, explanation is superseded by one that has greater credibility in the light of the new evidence that has become available.

Postpositivists are more eclectic in their choice of research techniques. They recognise that well-warranted conjectures can be supported by the findings derived from both quantitative and qualitative research. Indeed, it is generally accepted that both types of research have their place in educational research (Tashakkori and Teddlie 2003, Ercikan and Roth 2006).

In short, it is important, in the postpositivist view, that evidence from as many sources as possible should be marshalled in support of any hypothesis. The better warranted a conjecture, the more likely it is to be a sound explanation of the relationship seen to exist between the independent and dependent variables.

That said, there are a number of threats to the internal validity of the case studies described in this thesis. Meyer (1995, p. 152) defines internal validity as "whether one can validly draw the inference that within the context of the study the differences in the dependent variables were caused by the differences in the relevant explanatory variables". Cohen et al. (2011, p. 183) state that "internal validity seeks to demonstrate that the explanation of a particular event, issue or set of data which a piece of research provides can actually be sustained by the data". Meyer (1995) lists several threats to internal validity. As regards the studies included in this thesis the key threats to internal validity are omitted variable bias, trends in outcomes (matriculation grade inflation), incorrect measurement of the dependent and independent variables, and the sample-selection problem.

This thesis focuses on the use of a variety of statistical techniques to establish whether the educational interventions included in AD courses and programmes do enable AD students to improve their academic performance. In so doing it seeks to secure internal validity and in so doing establish well-warranted conjectures that can be used as a base for further investigations of both a quantitative and qualitative nature.

3.1.1 Threats to internal validity

There are several sources of bias that need to be taken into account when efforts are made to determine whether an educational intervention has a positive effect on academic performance.

Specification problems

The first source of specification bias is the omitted variable. The purpose of the specification is to identify the extent to which the treatment variable (the AD course or programme) affects the dependent variable. In an ideal world all the independent variables that affect the

dependent variable, including the treatment variable, are specified. In such a model the variation in the dependent variable is fully explained by the variation in the independent variables and the R^2 is equal to one.

In the social sciences it is not possible to specify all the independent variables. Therefore, it is not possible to account for all the variation in the dependent variable and the R^2 is less than one. Indeed, it is not unusual to find reported R^2s of less than 0.2.

If an independent variable is correlated with the treatment variable, in its effect on the dependent variable, then its omission leads to bias (omitted variable bias). For example, students with low matriculation points scores are more likely to be offered places on AD programmes. Therefore, to identify the precise effect of the treatment variable (membership of an AD programme) it is necessary to include students' matriculation points scores as an independent variable. The inclusion of such a variable reduces omitted variable bias; the coefficient of the treatment variable is now a better estimate of the effect of the treatment on the value of the dependent variable.

If an independent variable is not correlated with the treatment variable, in its effect on the dependent variable, then its omission has no effect on the reliability of the estimate of the coefficient of the treatment variable. The omission of such an independent variable does, however, result in a decrease in the reported R^2.

In general, a variable should always be included if it is thought that it may be correlated, either directly or indirectly, with the treatment variable in its effect on the dependent variable. If it offers no additional explanatory power (superfluous variable) then it reduces the efficiency of the estimation for no additional benefit. However, if the variable is a potential source of omitted variable bias then its inclusion improves the level of confidence that can be placed in the estimate of the coefficient of the treatment variable.

The purpose of this thesis is to determine whether AD courses and programmes are effective in improving AD students' academic performance through to graduation. As a first step it is important to minimise the possibility of omitted variable bias. This implies that all the independent variables that are thought to affect the dependent variable in tandem with the treatment variable should be included in the specification. The inclusion of additional

independent variables, which are not directly or indirectly related to the treatment variable, improves the reported R^2 but has no influence on the possible bias of the coefficient of the treatment variable. Also, the inclusion of additional variables, *ceteris paribus*, results in a loss of power.

In practice it is very difficult to identify and to measure reliably all the independent variables that may, in tandem with the treatment variable, affect the value of the dependent variable (Anderson et al. 1994). For example, Ashwin (2009, p. 9) argues that there is evidence of "complex social processes impacting on students' experience of higher education in different countries" and "that there is strong evidence that the higher education systems are shaped by the societies in which they operate".

For example, AD students may have a higher level of motivation and a more positive attitude towards their studies than do mainstream students. Insofar as students' level of motivation and positive attitude towards their studies is correlated with the treatment variable (AD programme), the omission of these variables leads to omitted variable bias. The positive effect of the AD course or programme on academic performance may be due to these two psychological states and not to the educational interventions included in the first-year courses. That said, the variables motivation and attitude are omitted, as they can take different forms, and there is sufficient evidence to suggest that these traits are not stable over time (Bong 1996, Entwistle 1998).

It may be, however, that the omitted variable that is correlated with the treatment variable (AD programme) has a negative effect on students' academic performance relative to mainstream students. For example, it maybe that AD students' academic performance is negatively affected by the fact that they come from socioeconomically and educationally disadvantaged backgrounds, and that the variables included in the specifications do not capture these negative effects. In this instance, the negative effect of the AD course or programme on academic performance may be due to the effect of the students' disadvantaged backgrounds and not related to the educational interventions included in the first-year courses.

A second source of specification bias relates to the matriculation points and subject grades achieved by students over the period of the study. It has been suggested that grade inflation

("upward grade creep") has occurred over this period of time (Foxcroft 2006); students in the latter part of the period under investigation may have been awarded higher grades than were previously awarded for work of the same standard. To circumvent this problem, interaction dummies are used in the first-year microeconomics and mathematics estimations. The adjusted matriculation points score and each of the subject grades is interacted with a dummy for each of the years under investigation. This makes it possible to control for any variation in grades and the adjusted matriculation points score for each of the years under investigation. If there is no evidence of grade inflation, the dummies can be discarded in the knowledge that a formal test of their statistical significance has been executed. In conducting this analysis it is assumed that the standard of the assessment used by the three faculties has remained constant over the period as has the course content and course delivery. It is also assumed that the mapping from academic ability to the matriculation points score is stable over time. Insofar that these assumptions do not hold true, the use of dummies for each year make it possible to control for any differences that may exist between the years in combination.

Sample-selection problems

There are two additional sources of bias that generally arise in studies that focus on measuring the effectiveness of AD courses and programmes.

The first source of bias is the sample-selection problem that arises in the absence of the random allocation of subjects to the treatment and control groups (Bifulco 2002, Collins and Pascarella 2003). Given the ethical constraints noted previously, it is not possible to conduct such an experiment. Students are allocated to AD and mainstream programmes on the basis of their performance in the school-leaving examination and on their perceived educational and socioeconomic disadvantage relative to their peers. Therefore, it is necessary to use a variety of methods, so as to mimic the experimental method, in comparing the academic performance of AD and mainstream students.

The focus of this thesis is estimating the efficacy of AD programmes in improving the academic performance of AD students relative to mainstream students. In doing so, unlike much of the literature on the subject, this thesis explicitly addresses the sample-selection problem that arises as AD and mainstream students are not drawn from the same

population.[15] Mainstream students can act as a comparison group only if they are drawn from the same population as the AD cohorts across a broad range of characteristics. If they are not, the difference in the performance of the AD and mainstream cohorts might be due to their differing set of characteristics rather than to the effectiveness of the AD programme or course. In short, the better/worse academic performance of AD students may be a function of their method of selection and not a function of the educational interventions that are part of the AD programme and its courses.

In general, researchers estimating the efficacy of AD courses and programmes have tended to ignore the sample-selection issues that arise when the academic performance of students on AD programmes is compared to that of students on mainstream programmes. There are relatively few studies that have made an explicit attempt to account for the sample-selection problem (Bettinger and Long 2005, Hotchkiss et al. 2006, Lesik 2007). The great majority of studies ignore the sample-selection problem. Examples from the United States include Schoenecker et al. (1998), Zeegers and Martin (2001), Bowen and Bok (1998), Etter et al. (2001), Berkner et al. (2002), Jenkins and Boswell (2002) and Bahr (2008), and from Spain, Mora and Escardíbul (2008). Examples drawn from the South African literature include Grayson (1997), Hay and Marais (2004), Downs (2005), Wood and Lithauer (2005), Onsongo (2006) and Downs (2010).

Two methods are used in an attempt to finesse the sample-selection problem that arises in the absence of the random allocation of subjects to the treatment and control groups: identifying a mainstream control group and MVA. Two options are explored in identifying a comparable mainstream group.

The first option involves the identification of a mainstream cohort which has similar characteristics to that of the AD cohort across a range of variables. The academic performance of the treatment group (AD students) is then compared to that of the control group (identified body of mainstream students).

The second option used to construct a mainstream control group is the statistical technique known as propensity score matching (PSM) (D'Agostino 1998, Dehejia and Wahba 2002,

[15] There is an extensive literature on sample-selection problems; examples are Park and Kerr (1990) and Raimondo et al. (1990).

Luellen et al. 2005, Sianesi 2010). PSM is a relatively recent statistical innovation that is used in the analysis of data drawn from non-experimental and quasi-experimental studies. It is a statistical technique designed to construct a control group, drawn from the untreated group, which is as similar as possible to the treatment group across a range of identified independent variables.[16] Statistical analysis is used to determine the probability that each member of the mainstream (control) group would qualify as a member of the treatment group on the basis of the values of the independent variables. To quote Luellen et al. (2005, p. 530), "The goal of propensity score analysis is to balance two non-equivalent groups on observed covariates to get more accurate estimates of the effects of a treatment on which the two groups differ." D'Agostino (1998, p. 2265) defines the propensity score "as the conditional probability of being treated given the covariates (and it) can be used to balance the covariates in the two groups, and therefore reduce (self-selection) bias". It is noted, however, that the two groups are only matched on the identified independent variables for which there are observations. It is not possible to assume that the two groups are matched on the unobserved independent variables for which there are no observations. The academic performance of the treatment group (AD students) is then compared to that of the control group (mainstream students) constructed using PSM.

An alternative approach to countering the sample-selection problem is to use MVA, which is designed to control for the impact of the independent variables included in the specification. MVA makes it possible to account for those variables that in tandem with the treatment variable contribute to the variation in the dependent variable, on average. The more comprehensive the specification, the less is the omitted variable bias, and the less biased an estimate is the coefficient of the treatment variable.

In short, the chief purpose of this approach is to isolate the effect of the treatment variable (for example doing an AD course) on the dependent variable (for example academic performance), taking into account the variety of other factors (independent or control variables) also reckoned to influence academic performance.

MVA makes it possible to identify some of the determinants of academic performance of AD and mainstream students in addition to the AD programme under investigation. Insofar as the

[16] This is also known, colloquially, as finding the "statistical twin".

determinants of academic performance for the two groups are the same, it suggests that the two groups share a similar set of characteristics. Such a similarity, if it exists, can be used as additional evidence supporting the claim that the treatment and control groups come from the same population.

The second source of bias is the sample-selection problem that arises in the type of investigation undertaken in this series of case studies, namely that not all the students who start a course necessarily complete it. For example, they may withdraw, fail to meet the minimum requirements, or be medically unfit to write the final examination and therefore not complete the course. The Heckman two-step estimator (Heckman 1979) is designed to take account of the characteristics of those students who did not write the final examination in explaining the variations in the final examination or course mark. As a first step an estimation is specified to identify the importance of selected independent variables that are thought to explain whether a student writes the final examination, or not. The result of this estimation is the inverse Mills ratio (IMR), which is then included in a second ordinary least squares (OLS) estimation (second step), which identifies the relative importance of the range of independent variables in determining students' academic performance as measured by their examination or course mark.[17] In this way the characteristics of those students who did not write the final examination or complete the course are included as determinants of course or examination success. Omitting the students who did not write the final examination may bias the results. For example, Douglas and Sulock (1995) used Heckman's (1979) two-step estimation to correct for sample-selection bias caused by omitting those students who do not complete the course and write the final examination (12.0% of the total in their study). They found that the selection bias caused the effect of students' effort and ability to be underestimated, and the effect of gender to be overestimated.[18]

There is another source of bias, which is unrelated to the sample-selection problem, namely, the measurement error associated with determining the value of the dependent variable. The student's course or examination mark may not be an accurate measure of his or her knowledge as it is subject to variation. The following are examples of possible causes of variation: variation in marking between examiners, and for each examiner over time, the

[17] The IMR is also known as lambda.
[18] See Parker (2007) for the use of the Heckman two-step estimator in a study using data on South African students.

student's emotional state at the time of writing, the relative success of the student's "spotting" strategy etc.

Finally, there is the small-sample problem. The great majority of studies measuring the effectiveness of AD programmes and courses use relatively small sample sizes as there are usually few students who are on these programmes. In general, standard errors are larger for small samples, thus making it difficult to identify statistically significant variables in explaining academic performance (Goldacre 2009). The larger the size of the sample, the smaller the standard errors, *ceteris paribus*, and the more likely it is to isolate those variables that are statistically significant at, at least, the 5% level. In this thesis the AD programmes in the faculties of Commerce (CADP), Engineering and the Built Environment (ASPECT), and Science (GEPS) are investigated as each accepts an average of 60 to 70 students each year.[19] In addition, the data for the different years is pooled so as to increase the sample size. These two advances, namely the use of the Heckman two-step estimator and the pooling of the data, make it possible to generate a more robust set of results than was previously the case.

It is fair to say that the use of the methods described above do not fully secure internal validity, that is, resolve the specification and sample-selection problems. Until 2001 the National Senior Certificate (NSC) examinations differed, and the papers were graded by teams of examiners, across provinces.[20] For this period, as noted by Edwards (2000), the extent of the sample-selection problem may not be particularly large. Substantial measurement error may be associated with the main variable (matriculation grades) used to select students for each of the three AD programmes. Therefore, it is not unlikely that school leavers of similar academic ability (preparedness), as measured by their performance in the matriculation examination, were awarded different marks by the examining bodies. Thus, some AD students might have been placed on a mainstream programme if they had written the matriculation examination in another province. Conversely, some mainstream students might have been placed on an AD programme if they had written the matriculation

[19] The faculties of Law and Humanities have only recently introduced AD programmes, and the model followed by Health Sciences is fundamentally different to that used in the other faculties.
[20] All the students included in this study wrote the National Senior Certificate examination. Therefore, students who wrote school-leaving examinations set by other examining bodies in South Africa or abroad are excluded from the data sets.

examination in another province.[21] From 2001, however, national papers were set in five subjects including mathematics, English second language and physical science. In 2003 a national paper was also set in history (DOE 2003). The overall pass rate and the pass rates for selected provinces, and for mathematics, physical science and English first language for each of the years 1998 to 2004 are shown in table 3.1.

Table 3.1 National Senior Certificate past rates (1998–2004)

Year	National	Western Cape	Eastern Cape	English first language	Mathematics	Mathematics (HG)	Physical Science	Physical Science (HG)
	Percentage	Percentage	Percentage	Percentage	Percentage	Percentage	Percentage	Percentage
1998	49	79	45	89	42	7	65	17
1999	49			90	43	7	64	15
2000	58	81	50	93	45	7	69	14
2001	62			94	47	7	69	16
2002	69	87	52	97	56	8	76	16
2003	73	87	60	97	59	9	80	17
2004	71	85	54	94	57	9	74	17
			52					
Mean	62	84	52	93	50	8	71	16

South Africa Survey (2002), (2003) and (2008)

It can be seen that the pass rates improved throughout the period. The same observation applies to the percentage of students who passed mathematics and physical science on the higher grade. The pass rates for these two subjects are very low, and were a great cause for concern as students intending to study any of commerce, science or engineering are generally expected to have passed these two subjects on the higher grade. Also of concern is the relatively low number of black students who passed mathematics (HG) in the year 2000 (3000) (DOE 2001), and in 2006 (9000) (Cronje 2007).

The steady improvement in the pass rates may suggest that there has been some grade inflation as was previously discussed. For the period under investigation (1999–2005), however, there does seem to have been any marked change in pass rates between any two consecutive years.

[21] The effect of measurement error in the "Xs" is to bias the coefficient of each "X" to zero. This implies that the greater the measurement error, the smaller the effect of the independent variable on the value of the dependent variable.

3.2 Research design

The chief purpose of this thesis is to determine whether first-year AD courses are effective in improving AD students' academic performance through to graduation.

3.2.1 Course performance

The purpose of these case studies is to determine the effect of the AD courses on students' academic performance relative to the performance of mainstream students in selected first- and second-year courses, as it important to establish the impact educational interventions have on students' academic performance in particular courses.

In general, the dependent variable is either the student's mark in the final examination or the final course mark; therefore, the variable is continuous. The chief independent variable is dichotomous: whether the student undertakes an AD course, or not. A number of other independent (control) variables that are considered to play a role in determining whether the student is successful in the course are also included. These include a number of student characteristics, performance in the matriculation examination, and the type of school attended. Some are continuous (for example age and matriculation points score), while others are dichotomous (for example gender and type of school attended). Some of the key determinants of course performance for AD and mainstream students are identified. In addition, the effect of the educational interventions on the pass rates achieved by the AD cohorts, relative to the mainstream cohorts, over the period covered by the study, is determined.

The course taken by the greatest proportion of students in each of the three faculties is chosen for investigation.

Faculty of Commerce

Of the AD courses in commerce, economics is the subject chosen for this analysis, for three reasons. Firstly, nearly all commerce students must take economics in their first and second years of study. This makes it possible to estimate the effect of the educational interventions included in the first-year AD course (ECO1010H) on all AD students' academic performance

in the first-year course relative to the academic performance of all mainstream students. It also makes possible the estimation of the effect of the educational interventions included in ECO1010H on AD students' academic performance in the second-year microeconomics course (ECO2003F).

Secondly, voluntary workshops were offered to AD students doing second-year microeconomics (ECO2003F), starting in 2003. This makes it possible to investigate the effects of this educational intervention on the academic performance of the ECO1010H cohorts in ECO2003F relative to the mainstream cohorts.

Thirdly, ECO1010H is open to students on the Extended Curriculum Programme for Business Science (ECP), and to some humanities students in addition to the CADP cohorts. Humanities students registered on the four-year "Gateway to Commerce" programme took ECO1010H for the years 1999–2002. The "Gateway" cohorts included white students, which is unusual for an extended programme.[22] Thus the composition of the ECO1010H cohorts is more diverse than is usually the case for an AD course and more closely mimics that of the comparable mainstream cohorts.

Faculty of Engineering and the Built Environment

All students in EBE must take the first-year whole-year course in mathematics (MAM1003W). ASPECT students take a parallel course, END1007W, and they write the same tests and examination as do the mainstream students and at the same sittings. Therefore, it is possible to compare the final course marks achieved by the ASPECT and mainstream cohorts in the first-year mathematics course. Students who are successful in completing either of the first-year courses in mathematics go on to the second-year whole-year course in mathematics (MAM2080W). Therefore, it is possible to compare the academic performance of mainstream and ASPECT students in MAM2080W, with the aim of determining whether the educational interventions included in the first-year AD course (END1007W) enabled ASPECT students to achieve a higher course mark, on average, relative to mainstream students.

[22] The "Gateway to Commerce" programme was discontinued in 2003.

Faculty of Science

Science students are not required to take any single first-year course. A number of GEPS students major in chemistry however, and the first-year chemistry course is the one with the greatest take-up rate among AD and mainstream students. GEPS students take a first-year whole-year half-course in chemistry, CEM1009H. If they are successful, and they choose to do so, they go on to CEM1010F in the first semester of their second year. These two courses are the equivalent of the first-year whole-year mainstream course CEM1000W. Students doing the two GEPS courses write different tests and final examinations to those written by mainstream students, although they are of a comparable standard.

It is also possible to compare the academic performance of the GEPS and mainstream cohorts in the two second-year chemistry courses CEM2007F and CEM2008S. CEM2007F is a mathematics-based course, which includes physical chemistry and spectroscopy, and the focus of CEM2008S is organic and inorganic chemistry. Therefore, it is possible to determine whether the educational interventions included in CEM1009W and CEM1010F had any effect on the academic performance of the GEPS cohorts relative to the mainstream cohorts in the second-year chemistry courses.

In general, GEPS students struggle to cope with CEM2008S, which focuses on organic chemistry. Therefore, in 2003 workshops were introduced specifically to enable GEPS students to gain a better understanding of this topic. No records, however, are available as to who attended the workshops and therefore it is not possible to test whether the educational interventions included in the workshops improved the academic performance of the GEPS cohorts relative to the mainstream cohorts.

3.2.2 Graduation performance

The purpose of these studies is to determine the effect of the first-year courses offered by each of the three AD programmes on AD students' graduation performance relative to mainstream students.

The graduation rates of the AD cohorts are compared to that of the mainstream cohorts for each of the three programmes. The dependent variable in each case is dichotomous (binary):

whether the student graduated or not. The chief independent variable is also dichotomous: whether the student is a member of the AD programme or not. A set of independent (control) variables, similar to those described in the section above, is also included. In addition, some of the key determinants of graduation performance for AD and mainstream students are also identified.

Chapter 4

Literature review

Education research is informed by a variety of psychological and sociological theories that seek to identify the environments that are most appropriate in enabling the acquisition of knowledge. Also, a wide variety of methodologies, in addition to postpositivism discussed above, are employed in an effort to understand the education process. Case and Light (2011) identify seven such methodologies: case study, grounded theory, ethnography, action research, phenomenography, discourse analysis, and narrative analysis. Furthermore, there are a variety of research designs of both a qualitative and quantitative nature that cover a broad spectrum from the single-subject case study to studies including many thousands of observations (Cohen et al. 2011).

A common approach used in empirical work in economics (Edwards 2000, Van Walbeek 2004, Parker 2006, Smith and Edwards 2007), chemistry in chemistry (Spencer 1996, Wagner et al. 2002, Tai et al. 2005, Sadler and Tai 2007, Mills et al. 2009) and engineering (Levin and Wyckoff 1991, Flier et al. 2003, Zhang et al. 2004, French et al. 2005, Veenstra et al. 2007, 2008, De Winter and Dodou 2011) education, for example, is to view academic performance as a production process involving a variety of inputs and outputs, and to use econometric analysis to identify the variables that may explain some aspect of students' academic performance in the academic environment. However this is not always the case. For example, Shanahan et al. (1997) and Meyer and Shanahan (1999), used cluster analysis to assess the determinants of students' performance in university economics.[23]

Typical education production functions are described by Becker (1964), Davisson and Bonello (1976), Hanushek (1979), Edwards (2000) and Hanushek and Welch (2006). An example is illustrated in figure 4.1. Key inputs include the student's academic performance in selected school subjects, socioeconomic background, university environment, and a variety of affective and cognitive attributes. Outputs of the education production process include

[23] Cluster analysis is a collection of statistical methods, which identifies groups of samples that behave similarly or show similar characteristics. The simplest mechanism is to partition the samples using measurements that capture similarity or distance between samples (http://www.crmportals.com/hierarchical_cluster_analysis.pdf: Accessed 20 July, 2012).

cognitive performance, attitudes and values, and generic skills. The purpose of the analysis is to identify the inputs (determinants, independent variables, explanatory variables) which help to explain students' academic performance, on average.

The education production function used in this thesis is designed to identify the importance of the input (AD course or programme) in explaining the academic performance of AD students relative to mainstream students, controlling for the effect of a range of inputs identified in the literature.

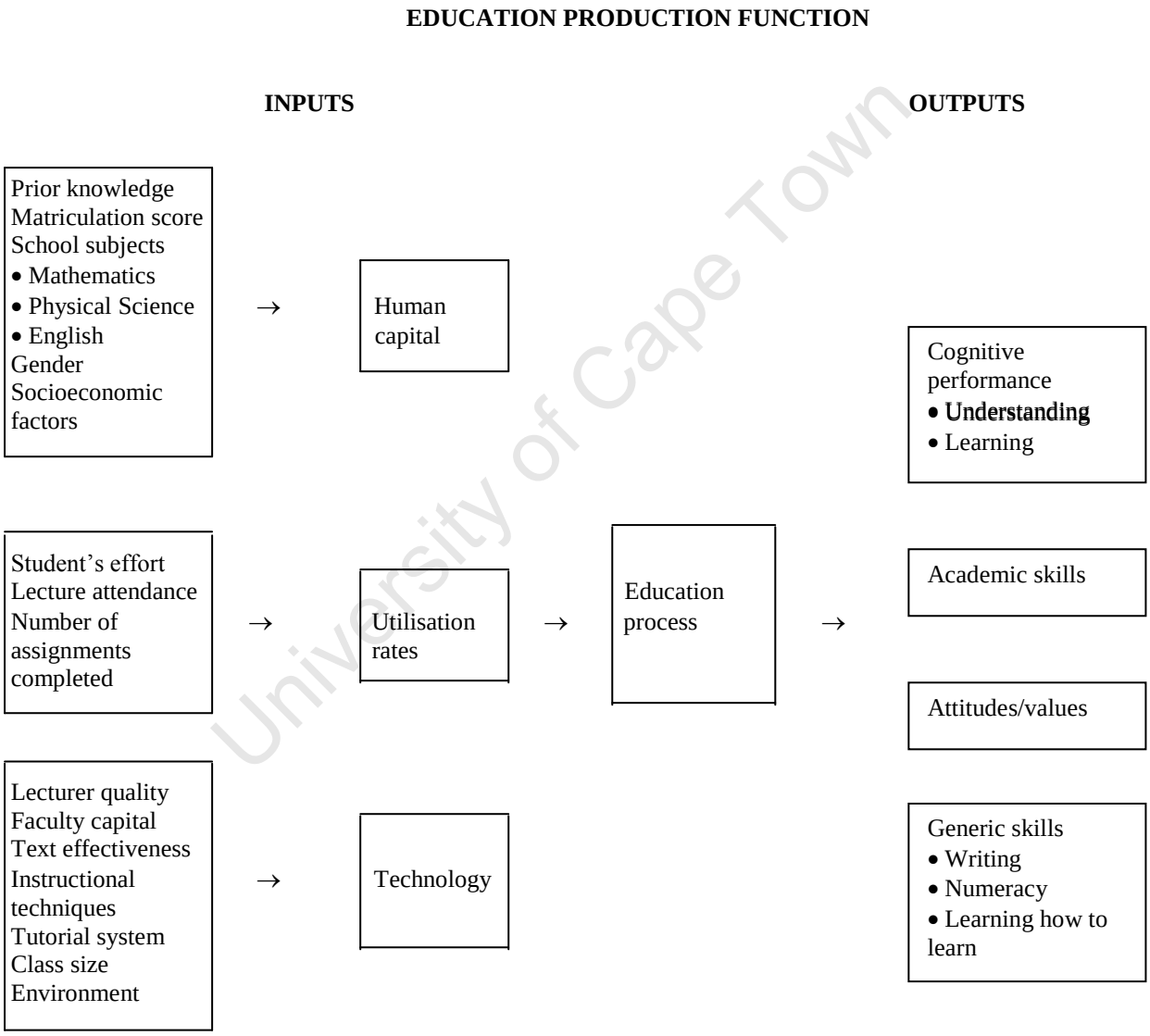

Figure 4.1 Education production function[24]

[24] Figure 4.1 is from Edwards (2000).

Some of the key outputs and inputs of the education production function are discussed in the following sections.

4.1 Education production function – outputs

The education process results in a variety of outputs. These include *knowledge* and *learning*, changes in attitudes and values, social development, and generic skills including writing, numeracy, and learning how to learn.

The type of output to be measured, and the means of measurement, has been the cause of considerable debate (Polachek et al. 1978, Hanushek 1979, Chizmar and Zak 1983). In their agenda for research on economics education, Becker et al. (1991) argue that the multiple outputs from learning economics need to be defined, measured and investigated.

Most of the research to date has focused on the cognitive outputs of knowledge and learning – the remainder having received little attention as they are difficult to quantify (Becker 1983a, 1983b, 1983c, Becker et al. 1991). It is important to distinguish between models that measure knowledge and those that purport to measure learning. Following Walstad (1990), a stock model is used in this thesis to identify the relative importance of a variety of explanatory variables in explaining the student's level of knowledge (stock of knowledge or absolute level of achievement), which is usually measured by a set of examination results (post-course score). In the usual approach, the final examination or course mark is regressed on a set of explanatory variables that excludes the results of a test taken at the beginning of the course (pre-course test score), designed to measure the student's existing stock of knowledge.

However, a flow model is used to identify the relative importance of a variety of explanatory variables in explaining the student's amount of learning (absolute improvement), over the duration of a course, usually as measured by a set of examination results. In this instance the set of students' pre-course test scores is included in the set of explanatory variables. Here the amount of learning that has taken place is shown by the change in the post-course test scores

relative to the pre-course test scores. The focus of the case studies reported in this thesis, however, is the cognitive output, knowledge.

Siegfried and Fels (1979) make the important point that many of the problems in the interpretation of the ordinary least squares (OLS) regression coefficients are the result of the failure to distinguish between stock (level of knowledge) and flow (amount of learning or attainment) models. Thus it is not made clear what is explained by the multivariate analysis.[25]

There has been much debate on the means of measuring the cognitive output of the education production process. More often than not, researchers have preferred to use multiple-choice, as opposed to structured/essay-type, questions. This is particularly true of research in economics education in the United States, where a standardised test, Test of Understanding of College Economics (TUCE), is available.

The "value of fixed-response (multiple-choice) versus constructed-response (essay or short answer) measures is a hotly debated topic" (Becker et al. 1991, p. 244) in economics education. Research suggests that multiple-choice and structured questions measure different dimensions of knowledge and cognition (Brelland et al. 1987, Lumsden and Scott 1987, Walstad and Robson 1997). Correlation coefficients ranging between 0.60 and 0.75 have been found between the scores on a good multiple-choice test and other measures of comprehension (Fels 1970). Subsequent studies, however, report much lower coefficients ranging between 0.12 and 0.39 (Lumsden and Scott 1983, 1987). The implication of relatively low correlation coefficients is that the two tests are not measuring the same types of cognitive output.

Structured and essay questions measure important outputs of the education production process, including writing and critical thinking skills. In addition these questions test students in an open-ended manner. A particular advantage of the multiple-choice format is, however, that it allows for objective marking.

[25] Walstad (1990) observes that many gender studies show significant differences in economics understanding, but fewer show gender differences in learning. In race studies in the United States, stock results (knowledge) are statistically significant but the flow results (learning) are not.

That said, there is an argument against the use of multiple-choice questions to measure economics knowledge and learning. Females have been shown to perform relatively poorly when examined using multiple-choice questions in high school (Harris and Kerby 1997) and first-year principles courses in economics (Anderson et al. 1994, Van Walbeek 2004, Parker 2006, Smith and Edwards 2007). The grading of essays is, however, less precise than the grading of multiple-choice questions and this may result in measurement error (Van Walbeek 2004).

Insofar as multiple-choice and structured/essay questions do not measure the same aspects of cognitive performance, and multiple-choice questions, in economics at least, seem to be biased against females, a case can be made to identify the determinants of academic performance for each of the two types of questions. Also, the use of structured/essay questions has particular relevance for the investigation of the outcome of an AD course, as the goals of such a course are broader than those of mainstream courses. These goals include the students' acquisition of skills in the areas of English language and communication, which can only be measured by structured/essay questions, and which are designed to enable AD students to cope successfully with subsequent, more demanding courses, in economics and other subjects (Edwards 2000).

Whatever the components of the examination (multiple-choice, structured or essay questions), the examination result can act only as an imperfect proxy for the students' overall level of achievement; they are too narrow a measure of learning (Siegfried and Fels 1979). This is particularly true of an AD course. The direct implication is that other measures must be used. One such method is to analyse the students' academic performance in subsequent courses. Ultimately, the impact of AD courses and programmes must be measured in terms of their effect on graduation rates relative to those achieved by mainstream students (Edwards 2000).

4.2 Education process – epistemological access and learning

Before considering the inputs into the education production function, factors affecting the education process are first considered.

There is an increasing recognition of the importance of the academic, social and cultural factors involved in students' adjustment to tertiary education. Morrow (1994) and Boughey (2002, 2005) stress the importance of AD students' epistemological access to the tertiary institution. It is important that students learn how to become participants in academic practice, and that they are socialised into the culture of the institution that is new to them (Astin 1993, Mphahlele 1994, Bowen and Bok 1998, Woolsey 2003). Lave and Wenger (1991), Lemke (2001), Haggis (2003) and Gee (2005) argue that students must be enabled to become part of the institution's and subject's community of practice. Moje (1995) and Lemke (1990) stress that students must learn to talk the language of science, and Lea and Street (1998) focus on the importance of students gaining mastery of a secondary discourse.

4.2.1 Learning, language, reading, writing and study skills

The literature on how students learn is vast: this section presents a very brief introduction to the topic as it applies to South African students.

It is generally accepted that very few students suffer any significant cognitive deficit and that AD programmes based on the premises of cognitive deficit are inappropriate. However, some students do find it difficult to mobilise the cognitive skills required to deal with abstract problems (Moll and Slonimsky 1989).[26] Students' difficulties stem from the fact that they have never been taught to use their *cognitive* and *language* skills to analyse complex material in an abstract manner. Insofar as the South African primary and secondary educational system has encouraged learners to rely on rote learning (atomistic or surface processing) it has not encouraged the deep processing of information (Feltham and Downs 2002, Pretorious and Mampuru 2007), and in Grayson's (1997) view is the chief cause of AD students' poor academic performance, a point echoed by Meyer and Shanahan (1999). An additional problem faces students who have English as a second language; they are able to think formally in their first language but not in English (Paxton 1998).

The topic of meta-learning (meta-cognition, deep learning, holistic processing, or learning to learn) has also attracted considerable attention (Flavell 1979). Meta-learning is defined as an activity of a learner who is aware of the learning process, and who can evaluate and monitor

[26] McConnell (1980) claims, in respect of first-year students in the United States, that nearly half have not achieved the level of intellectual development necessary for mastering abstract processes.

this process. It is the deep level restructuring of material in order to understand it, and as such it involves more than the acquisition of study skills (De Villiers 1990). Ramsden (1992) concludes that deep learning occurs when knowledge is "actively constituted" by the learner. Some scholars see it as important that students construct their own meaning by a process of discovery, rather than receiving a meaning constructed by a teacher by means of an explanation (Slabbert 1994); and that new knowledge is related to concepts that the student already knows (Gerrans 1988).

There is an extensive literature on meta-learning in the South African context. This literature includes research involving students taking first-year physics (Leonard-McIntyre et al. 1996, Holtman et al. 2004) and courses in chemical engineering (Case et al. 2001, Case and Gunstone 2002, 2006). Another area of research has been the importance of independent learning[27] and its contribution to the development of meta-learning. In one study, students who used independent learning were shown to achieve significantly better results in economics than those who relied solely on lectures (Fransman 1995). Another study showed that the use of workshops in a pre-university chemistry course encouraged students to take more responsibility for their own learning (Gerrans et al. 1991), and it has also been found that students' academic performance is enhanced when they are actively engaged in the learning process in or out of class (Langer and Applebee 1987, Greene 1994, Benzing and Christ 1997).

Therefore, theory and empirical work suggests that learning is best achieved if students develop their meta-learning skills (Moll and Slonimsky 1989, Gerrans 1988, De Villiers 1990, Ramsden 1992, Slabbert 1994, Paxton 1998), and their cognitive and language skills (Moll and Slonimsky 1989). This process is facilitated if new concepts are related to concepts that the student already knows. Cooperative learning is considered to be important in achieving this aim (Slabbert 1994, Nyamapfene and Letsaka 1995, Mather 1997), as are clearly defined tasks (Mather 1997). Gerrans et al. (1991), Greene (1994), Fransman (1995), and Benzing and Christ (1997) show that encouraging students to work independently pays dividends in the form of better results, and Slabbert (1994) discusses the contribution group learning can make to written and spoken English.

[27] Completing tutorials, essays, assignments, and textbook readings and researching journal articles.

Turning to learning and reading it is clear that second-language students often have problems in understanding the material they are required to read. This problem is particularly acute for AD students (Terenzini et al. 1994). Block and Rollnick (2003) report that students were unable to meaningfully paraphrase sentences from a geography manual, that 80% of students produced sentences with incorrect language and science, and 20% made superficial changes thus exposing a possible cause of plagiarism. De Beer (2006) suggests that poor reading skills are an important cause of students dropping out of higher education.

It is also recognised that poor writing skills are a major factor in explaining the weak academic performance of university students in general and AD students in particular (Lemke 1990, Paxton 1995, Moore 1998, Dawidowitz 2004). Poor written assignments may be evidence of either poor language proficiency or poor conceptual understanding (Rollnick et al. 1992, Inglis 1993). Also, poor writing skills compromise students' performance in tests and examinations (Rollnick et al. 2001). Jacobson (1994), Fransman (1995), Nyamapfene and Letsaka (1995), and Paxton (1995, 1998) stress the importance of developing students' essay writing skills as a means of learning and of introducing students to the subject specific discourse. Dawidowitz (2004) used a chemistry writing project at UCT to encourage students to use writing as a means of creating meaning. This approach was also followed by Allie et al. (1997) and Campbell et al. (2000) who required first-year physics students to submit writing-intensive laboratory reports, and Hand et al. (1999) and Parkinson (2000) who used writing to enhance students' science literacy. Students taking the first-year AD course in microeconomics at UCT are required to write three essays in the first semester.

Finally, it is generally acknowledged that many students arrive at university without the requisite study skills (Schiavone 2002, Hahn and Polik 2004), and that students with poor study habits are more likely to withdraw from university (Pantages and Creedon 1978, Abbott-Chapman et al. 1992).

4.3 Education production function – inputs

The typical inputs of an education production function are shown in figure 4.1 (p. 40). These include (1) human capital, (2) utilisation rates (degree to which the student uses the resources available) and (3) technology.

Students' human capital includes the prior knowledge they have about the subject being studied, their academic performance in the matriculation examination (particularly mathematics, physical science and English), their gender, and a variety of socioeconomic factors.

The utilisation rate includes three variables: student effort, lecture attendance and the number of assignments completed. Effort is usually measured by lecture and tutorial participation rates. However, there is some doubt as to whether these two variables capture the degree of an individual student's effort and motivation (Durden and Ellis 2003). Technology includes lecturer effectiveness, faculty's human capital (years of teaching experience) and physical capital, textbook effectiveness, length of course, instructional techniques, tutorial system, class size and general environmental conditions. Morgan and Vasche (1978) identified socioeconomic factors, school environment, economics knowledge, analytical understanding, and instructor characteristics as important inputs into the education production process.

In their wide-ranging review of the state of economics education, Siegfried and Fels (1979) identified a range of inputs into the education production process. These include general academic performance measures (high-school examination scores and verbal and mathematical abilities), student maturity and age, gender, family income and parents' education and socioeconomic status, prior knowledge of economics, and level of motivation and effort.

Some of the inputs can be measured with a fair degree of precision, for example a student's age or matriculation points score. Such variables are termed observables. There are, however, variables which are difficult to measure, for example motivation and effort, or variables for which data is not readily available, for example parents' income. These variables are termed un-observables. In such instances it might be possible to identify variables for which measures do exist, which can be used as proxies for the un-observables.

It is clear that there are a number of inputs that are used to explain the acquisition of knowledge and learning. The purpose of this section is to identify the most important inputs mentioned in the literature for first- and second-year economics, mathematics and chemistry

education, and also to identify those that have been found to be important in determining graduation success.

For the purposes of this series of case studies the selected inputs, or explanatory (independent) variables, are categorised into four groups: student characteristics, school-leaving subjects, school characteristics and course characteristics. Each of these is discussed in turn with the aim of identifying their broad effects in determining academic performance.[28]

4.3.1 Student characteristics

Student characteristics include academic ability (preparedness), non-cognitive factors (effort, motivation and attitude), English as a second language, ethnicity, whether the student is in receipt of financial aid, gender, maturity and age, socioeconomic status, and area of residence.

Academic ability (preparedness)

Several international studies have found that academic ability, or preparedness, as measured by the student's performance in the school-leaving examination, or by grade point average (GPA), is the key variable in explaining the level of economics knowledge (Clauretie and Johnson 1975 (USA), Morgan and Vasche 1978 (USA), Reid 1983 (Canada), Lumsden and Scott 1987 (UK), Walstad and Soper 1989 (USA), Park and Kerr 1990 (USA), Raimondo et al. 1990 (USA), Anderson et al. 1994 (USA), Robb and Robb 1999 (USA), Durden and Ellis 2003 (USA), Ballard and Johnson 2004 (USA), Cohn and Johnson 2006 (USA), Kherfi 2008 (United Arab Emirates), Kinney and Yakolev 2008 (USA)), and academic performance in first-year psychology (Diseth et al. 2010 (USA)), engineering (Levin and Wyckoff 1991 (USA), Ting 2001 (USA), French et al. 2005 (USA), Mendez et al. 2008 (USA), Veenstra et al. 2008 (USA)), medicine (Arularnpalam et al. 2004, 2007 (UK)), courses in first- and second-year chemistry (Ozsogomonyan and Loftus 1979 (USA), Craney and Armstrong 1985 (USA), Noble and Sawyer 1987 (USA), Bunce and Hutchinson 1993 (USA), Wagner et al.

[28] All reported findings are statistically significant at, at least, the 5% level. Variables reported as being statistically insignificant are insignificant at the 5% level.

2002 (USA), Tai et al. 2007 (USA), Easter 2010 (USA)), and science (Astin and Astin 1992 (USA), Mendez et al. 2008 (USA)).

Furthermore, a number of studies identify the student's performance in the school-leaving examination as the key determinant of first-year academic performance (Devadoss and Foltz 1996 (USA), Hagedorn et al. 2000 (USA), McKenzie and Schweitzer 2001 (Australia), McKenzie et al. 2004 (Australia), Win and Miller 2005 (Australia), Shulruf et al. 2008 (New Zealand), Mora and Escardíbul 2008 (Spain)).[29] There are also several studies that report on the chief determinants of graduation success and which identify school-leaving academic performance as a key variable in explaining whether a student is likely to graduate (Adelman 1999, 2006 (USA), Smith and Naylor 2005 (UK), Mendez et al. 2008 (USA) (engineering), Tumen et al. 2008 (New Zealand)).

Similar findings have been reported for South African studies: Bokhorst et al. (1990) (psychology), Curtis and De Villiers (1992) (commerce AD course), Jawitz (1992) (engineering), Sawyer (1994) (commerce), Jawitz (1995) (engineering), De Villiers and Rwigema (1998) (commerce), Zaaiman (1998) (AD engineering and science), Edwards (2000) (first-year economics), Van Rooyen (2001) (bridging programme), Eiselen and Geyser (2003) (first-year courses), Lourens and Smit (2003) (first-year courses), Van der Flier et al. (2003) (mathematics and science foundation programme), Van Walbeek (2004) (first-year microeconomics), Smith and Edwards (2007) (first-year microeconomics and macroeconomics, and second-year microeconomics), Horn and Jansen (2009) (first-year economics), and Dlomo et al. (2011) (first-year economics).

There have been far fewer studies on the determinants of learning, and to the author's knowledge, only on the determinants of economics learning. Becker et al. (1990), in their survey of research on high-school education, found that the higher the aptitude or intelligence of the student as measured by their GPA, the greater the learning in economics, again as measured by student performance on a multiple-choice post-course test. Van Scyoc and Gleason (1993) found both students' GPA and their pre-course TUCE score to be positive and statistically significant in explaining economics learning.

[29] An exception to this general rule is Tay's (1994) finding that grade point average is statistically insignificant in determining student grade symbols in an essay examination at the University of Singapore.

Non-cognitive factors

There is a rich literature that seeks to identify the importance of non-cognitive (affective) factors in explaining students' achievement and persistence in tertiary courses (Messick 1979, Snow 1989, Schiefele et al. 1992, Corno 1993, Johnston 1997, Clark and Riley 2001, Hahn and Polik 2004, Robbins et al. 2004, Burtner 2005, Lubinski and Benbow 2006, Clifton et al. 2008, Easter 2010). Some researchers have suggested that non-cognitive factors may be stronger predictors of academic success than are measures of academic ability and preparedness (Tracey and Sedlacek 1987, Furnham 1992, House 1995).

The non-cognitive factors include self-efficacy, alienation, stereotype threat, stress and anxiety, effort, attitude and motivation.

There is an extensive literature on the importance of self-efficacy. Bandura (1982, 1997) argues that the more students perceive their actions as effective, the more likely they are to persist in a task they are doing. Several studies have identified self-efficacy as an important factor in students' academic achievement (Schunk 1989, Multon et al. 1991, McKenzie and Schweitzer 2001), engineering students' academic achievement (Wilhite 1990, Hackett et al. 1992, Schaefers et al. 1997, Seymour and Hewitt 1997, Yousuf 2000, Lent et al. 2003), and mathematics students' achievement (Brown and Burnham 2012). The failure of students to perceive their actions as effective leads them to experience anxiety and to exhibit relatively poor performances in tests and examinations.

Alienation is defined as a "state or experience of being isolated from a group or activity to which one should belong or in which one should be involved" (Mann 2001, p. 8). Loo and Rolison (1986) report that first-generation students become disconnected from their family and culture giving rise to feelings of alienation. In the same vein Lemke (2001) and Gee (2005) note the cost to the student of becoming part of a community of practice: students feel that they have changed and that they no longer connect with their families or feel at home. Case (2007) argues that the university and its faculty should engage students so as to enable them to overcome their feelings of alienation, and Sennet et al. (2003) stress the importance of addressing AD students' social and emotional issues so as to facilitate their adjustment to a historically white South African tertiary institution.

In the US context, Steele and Aronson (1998) argue that the difference between the test scores achieved by African-Americans and their peers is due in part to the stereotype threat. African-Americans experience anxiety in test situations because they feel that they are expected to underperform their peers. Rising anxiety levels lead to lower levels of academic performance, and the development of a self-fulfilling prophecy. Interestingly, Zaaiman (1998) argues that if there is a critical mass of disadvantaged students at former white universities in South Africa then the stereotype threat disappears.

Ramsden (2001) describes the negative effect that stress may have on students' academic performance. Swart (2008) established a direct correlation between stress (anxiety) and the throughput rate achieved by students taking an engineering module at a South African university, as did Tchen et al. (2001) for students taking a course in first-year chemistry at a university in Victoria, Australia. De Beer (2006) reports that high levels of stress in conjunction with a lack of motivation contribute to students dropping out at South Africa's Central University of Technology (CUT). Finally, Bédard et al. (2010) report that support in the form of tutorials reduced students' levels of stress.

Effort refers to the amount of work a student puts into a course. Usually, it is measured by the number of hours the student spends studying the subject. This measure is imperfect as the degree of effort can vary between students, some students use their time more efficiently than others, or they learn at different rates.

Morgan and Vasche (1978) used lecture and tutorial attendance as proxies for effort, and found this variable to be positive and statistically significant in affecting students' grades. In similar studies, Schmidt (1983), Lumsden and Scott (1987), and Park and Kerr (1990) confirmed these results. Wetzel (1977) used time devoted to the economics course as a measure of effort. He found that students who achieved an A grade, and students who expected to get an A grade, put in more effort. However, Schmidt (1983) found that the total time allocated to an economics course does not have an impact on student learning. This finding was echoed by Gleason and Walstad (1988), as reported in Van Scyoc and Gleason (1993), Park and Kerr (1990), and Siegfried and Walstad (1990), in their survey of economics education. However, Siegfried and Fels (1979), in their review of economics education, noted that study effort does not influence academic performance very much. Finally, Diseth et al.

(2010) used factor analysis and structural equation modelling to show that student effort (time spent studying) directly affects academic performance.

Attitude and motivation represent complex psychological states and it is not surprising that researchers have experienced difficulty in measuring these variables or identifying proxies that are both reliable and valid. As a result, the evidence is often ambiguous. Siegfried and Walstad (1990), in a survey of economics education, concluded that attitude has an insignificant effect on students' performance in a first-year economics course, as did Wetzel (1997).[30] In contrast, House (1995) reports that students' initial attitudes are significant predictors of their subsequent academic performance in college chemistry.

Karstensson and Vedder (1974) used the *Questionnaire on Student Attitude Toward Economics* as a pre- and post-test to measure the change in students' attitude over the duration of the course. They found that a 10 point increase in attitude, out of a maximum possible change of 32, increased grade level performance by approximately one third, from, say, a C+ to a B-. Myatt and Waddell (1990), in a Canadian study, measured attitude in terms of whether the economics course is compulsory or not. They found the coefficient of the compulsory variable in explaining examination results to be -2.2 and statistically significant. This implies that students for whom economics was compulsory scored, on average, 2.2 percentage points less in the examination than students who had chosen to do the course. The authors used this finding to suggest that students who choose to study economics tend to do better than those for whom it is compulsory, because they have a more positive attitude towards the subject.

Moore et al. (2002) used remedial students' mandatory versus voluntary attendance at a summer orientation programme to predict their success in subsequent courses at a college in the United States. They report that students who were required to attend the orientation programme achieved marks that were 33% lower than those achieved by their peers who had chosen to attend the programme. They also report that lecture and tutorial attendance are the strongest predictors of students' success though they question the use of attendance as a dummy variable for the psychological state motivation.

[30] Wetzel (1997) adopted the same approach as Karstensson and Vedder (1974) to measure attitude.

As regards South African studies, Fraser and Killen (2005) analysed the perceptions of students and lecturers at two South African universities as regards the factors that influence academic performance. They report (p. 33) that "the 'success' items that both lecturers and students ranked highly paint a picture of a self-motivated, hard-working student who can learn independently, prepare well for examinations and who has made a wise choice of course of study". Feltham and Downs (2002) report that although AD students at UKZN lacked discipline when it came to their studies they were not unmotivated.

This brief review highlights the ambiguous nature of the results, which is due in some part to the relative crudeness of the proxies chosen to measure the selected non-cognitive constructs. A further problem in interpreting the results is, however, related to the issue of causality. The direction of causality may be from academic performance to a positive student attitude towards the subject, rather than the reverse (Becker et al. 1990). Similarly the relationship between effort and academic performance is equally difficult to disentangle.

English as a second language

Generally, students who have English as a second language are expected to experience difficulty in mastering any subject when it is studied through the medium of English. Furthermore, Rollnick (2000) asserts that educationally disadvantaged students find it more difficult to learn a second language than do their peers from more privileged backgrounds.

Webb (2002) argues that the academic development of second-language students is compromised as language is a key instrument of learning, and that it is more difficult to assess the progress of students when the assessment is conducted in their second language. He also states that the development of high-level cognitive and social skills is dependent on language. An additional complication for second-language students is that they must also acquire, in addition to the language of instruction, the language of science.

There are strong grounds for expecting English (home language) to have a positive impact on academic performance in economics at universities where English is the medium of instruction (North 1985, Edwards 2000, Van Rooyen 2001, Kherfi 2008). However, for South African studies at universities where English is the medium of instruction the results are mixed. These studies are discussed below.

As regards economics, Lumsden and Scott (1987) found that students whose home language is not English underperformed their peers in first-year economics. Similarly, Harris and Kerby (1997), in a study of high-school economics, found that English second-language students did significantly worse, in multiple-choice questions, but not in essays, than students who had English as their first language. The negative impact of English as a second language can also extend into subsequent years. For example, Meyer and Shanahan (1999) showed that English as a second language has a negative impact on students' acquisition of economics knowledge into their third year.

As regards South African studies, Edwards (2000) reports a positive, and Smith and Edwards (2007) report a negative, coefficient for this variable (both statistically significant). Van Walbeek (2004), however, reports that the coefficient of the variable English (home language) is statistically insignificant, and Banach et al. (1992) conclude, on the basis of "close scrutiny" of students' papers, that the main explanation for the high failure rate among African students is their poor grasp of English and their lack of analytical skills.

Dawidowitz (2004) reports that the communication problems experienced by chemistry students whose home language is not English are closely linked to the difficulty they have in utilizing abstract thinking. A similar finding is reported by Nordstrom (1990).

There is an extensive international literature, which explores the relationship between language and mathematics performance. In general, the findings are that the learning of mathematics requires a variety of linguistic skills, which second-language learners might not have mastered (Cuevas 1984, Lepik 1990, Noonan 1990, Abedi et al. 1995, 1998, Abedi and Lord 2001). Howie (2003) reports in a study of South African secondary school pupils that their proficiency in English is a strong predictor of their success in mathematics.

Rollnick (2010) identifies the models of language support offered to AD students in South Africa. She describes three types of English-language courses offered by 35 science access courses. In the first type, which theory suggests is best, language and study skills are integrated into study of discipline (Gee 1996, Rollnick et al. 2004). The second type of course, described by Parkinson (2000), is taught by language specialists and is a separate content-based language course, which may or may not be credit bearing, and the third type is

a separate generic course. According to Rollnick (2010) 24/35 science access courses offered by South African tertiary institutions were of the second type, three of the first type, four of the third type, and four offered no English-language course at all.

The first type of English-language course, as described by Rollnick (2010) is offered as part of the first-year AD courses in microeconomics and physics at the UCT, and was also offered by the College of Science at the University of the Witwatersrand (Osberg 1998). An example of the second type is the theme-based course offered to science students at UKZN (Parkinson 2000).

Ethnicity

Several studies in the USA report that ethnicity is a significant determinant of students' academic performance in economics. Buckles and Freeman (1983) and Walstad and Soper (1989) found that "non-white" and black students perform relatively poorly, respectively, although the latter study found that black students had a greater predisposition to learn the subject. Black/African-American and Hispanic students have also been shown to perform relatively poorly on multiple-choice questions (Harris and Kerby 1997). Zhang et al. (2004) report that white engineering students are more likely to graduate than their peers across a range of educational institutions in the United States. Sadler and Tai (2007) found that African-American students achieved lower grades than their peers for college chemistry courses, and that the difference was statistically significant, and Tai et al. (2005) report a similar finding for students' performance in an introductory chemistry course. Finally, Cabrera et al. (1999) report that African-American students are less likely to be committed to their studies if they are exposed to a campus culture of prejudice and intolerance.

Parker (2007, 2010) reports that white South African students exhibit a higher level of academic performance in first-year economics than do black, Indian and coloured students, and Horn et al. (2011) report the same finding for students taking second-year economics. Van Walbeek (2004) and Dlomo et al. (2011) found, however, that white South African students did no better than their peers, conditional on the independent variables.

Many advantages accrued to members of South Africa's white population under the apartheid system (Terreblanche 2002). These advantages make it likely that white children in South

Africa have access to material resources that are unavailable to other children. They are more likely than other children to have parents who themselves have a tertiary qualification. Also, they are more likely than other children to come from family backgrounds where it is expected that they will go to university (Taylor et al. 2002).

Financial aid

Students receiving financial aid (bursaries, loans, grants) may achieve higher levels of academic performance as they do not have to cope with the psychological stress associated with insufficient means, nor do they have to seek part-time employment (Astin 1993, Taylor et al. 2002). Hatt et al. (2005), in their study using quantitative and qualitative data, report that bursary students are more likely to continue with their studies than their peers from low-income backgrounds who do not receive financial support. In a similar vein, Thomas (2002), Alon (2005), De Beer (2006) and Stater (2009) report that financial aid has a positive impact on students' academic performance through to graduation. Wilson (2000), in a study of ten developed countries reports that the absence of financial support is one of the most cited reasons for the non-participation by non-traditional students in higher education, and Schuetze and Slowey (2002) state that financial support is a critical variable in improving student retention in higher education. As regards the USA, Nora (2001) reports that some 50% of minority students receive financial aid. In South Africa the most successful AD programmes are associated with full financial support and accommodation for students (Grayson 1996, Rutherford 1997, De Villiers and Rwigema 1998, Zaaiman 1998, Van Rooyen 2001, Woollacott and Henning 2004).

Gender

The effect of gender on learning and knowledge acquisition is one that has been explored at great length. There are a number of psychological, cultural and sociological theories that seek to explain why males differ from females in learning and in the acquisition of knowledge (Ferber et al. 1983, Becker et al. 1990, Childs 1990, Anderson et al. 1994, Tay 1994, Hirschfeld et al. 1995, Walstad and Robson 1997). A discussion of these theories, however, lies outside the scope of this thesis.

The summary finding is that females tend to do better in essays and males in multiple-choice questions, and the differences are statistically significant (Lumsden and Scott 1983, 1987, Walstad and Soper 1989, Siegfried and Walstad 1990, Harris and Kerby 1997, Bachan and Reilly 2003, Kherfi 2008). Clauretie and Johnson (1975), Myatt and Waddell (1990), Breland (1991), Anderson et al. (1994), and Robb and Robb (1999) reported females scoring between 2.7 and 3.3 percentage points less than males in a multiple-choice economics examination.

A number of studies have focused on students' performance in essay questions. For example, Breland (1991) and Greene (1997) showed that females have an advantage in essay questions. However, Lumsden and Scott (1987) found that the female advantage in essay writing decreases, and that the female disadvantage in multiple-choice questions increases, over the course of their degree. That said, there are a number of studies that report results to the contrary: that the difference between male and female test scores for multiple-choice and essay questions is statistically insignificant (Reid 1983, Park and Kerr 1990, Williams et al. 1992, Tay 1994).

In a study of first-year engineering students, De Winter and Dodou (2011) report that gender was not predictive for first-year GPA, but it was a weak predictor for women of degree (science) completion, and in a study of first-year chemistry students Tai et al. (2005) report that gender is a statistically insignificant variable in predicting students' academic performance.

As regards South African studies investigating the determinants of academic success in first-year economics, Edwards (2000), Van Walbeek (2004), Parker (2006, 2007), and Horn and Jansen (2009) all report that male students outperform female students on multiple-choice questions in first-year economics, and that the difference is statistically significant. Smith and Edwards (2007) found that males also outperform females in multiple-choice questions in first-year macroeconomics and second-year microeconomics, but females outperform males on the structured/essay questions in second-year microeconomics. Van der Merwe (2006) reports, however, that a student's gender has a statistically insignificant effect on academic performance.

Maturity and age

Maturity refers to the *number of years* a student has been attending university. It is generally assumed that mature students acquire a variety of skills that enable them to make a greater success of any course that they take. Several studies report that more mature students tend to outperform first-year students in first-year economics examinations (Clauretie and Johnson 1975, Bonello et al. 1984, Anderson et al. 1994, Kherfi 2008).

It is also assumed that there is a positive relationship between students' *age* and economics performance; older students are more likely to have achieved the level of intellectual development necessary for mastering abstract processes (Herron 1975, Albanese et al. 1976, McConnell 1980, Bunce and Hutchinson 1993, Lewis and Lewis 2007). The evidence regarding students' ages is, however, is inconclusive. A number of studies show that the student's age has a positive, and statistically significant, effect on the student's academic performance in economics courses (Park and Kerr 1990, Myatt and Waddell 1990, Siegfried and Walstad 1990, Tay 1994), two studies found the effect of age to be statistically insignificant (Morgan and Vasche 1978, Lumsden and Scott 1987), and Wagner et al. (2002) report that students' age is negatively correlated with students' performance in a general chemistry course in the United States.

As regards South African studies, Van Walbeek (2004), Parker (2006), and Horn and Jansen (2009) found the effect of age to be positive and statistically significant in determining the academic performance of economics students.

Socioeconomic status and area of residence

Several studies have investigated the impact of socioeconomic variables on academic performance. The environment in which a student lives can impact significantly on the student's academic performance (Reid 1983, Hagedorn et al. 1999, Abedi and Lord 2001, Smith and Naylor 2001, Tinto 2006). Students who come from poor socioeconomic backgrounds, who live in crowded households, far from their place of study, without access to electricity and running water, cannot be expected to perform as well as their more privileged peers. Key socioeconomic variables include parents' income, area of residence, amount of infrastructure (hospitals, libraries, water, electricity and sanitation), and the type of

school attended. The latter variable may act as a proxy for socioeconomic status in the absence of data about the other variables.

In a Canadian study, Reid (1983) reported that students living in an adverse environment (selected university residences) have a lower stock of knowledge at the end of an introductory economics course. In contrast, in the United States, Park and Kerr (1990) found that the students' environment has no effect on their economics performance.[31]

Win and Miller (2005), in an Australian study, report that the academic performance of students from well-resourced homes exceeded that achieved by their peers from poorer families. Similarly, Adelman (2006) found that students from poorer socioeconomic backgrounds in the United States achieved lower graduation rates than their peers who were better off, and Kalender and Berberoglu (2009) report a negative and statistically significant relationship between socioeconomic status and academic performance for students at a Turkish university.

Van Walbeek (2004) reports that students from the Western and Eastern Cape Provinces outperformed students from the rest of South Africa in their first-year microeconomics course at the UCT. The former finding was also reported for a first-year economics course at the University of Stellenbosch (Horn and Jansen 2009). It is possible that students from the Western and Eastern Cape Provinces experience less dislocation in their transition to university when they have family and friends living relatively close to the university. Indeed, many students may continue to live with a family member or friend whilst pursuing their studies at university. It is also possible, however, that the schools in the Western and Eastern Cape Provinces offer education of a higher quality than schools elsewhere in South Africa, conditional on the independent variables.[32] Another explanation for this finding is that the matriculation examination was more demanding (or more rigorously marked) in the Western and Eastern Cape Provinces than elsewhere in South Africa in the period 1999–2001. This would imply that the effect of the students' matriculation points on academic performance at university is not fully reflected in the coefficient of the matriculation points score.

[31] Unfortunately, the authors do not comment on the socioeconomic diversity of the student body.
[32] This seems unlikely as the average pass rate for students schooled in the Eastern Cape Province for the years 1998 to 2004 is 52%. The figures for the Western Cape Province and South Africa as a whole are 84% and 62%, respectively (Table 3.1).

Finally, Van der Flier et al. (2003) found that the effect of AD students' socioeconomic status on their academic performance at UNIN is statistically insignificant. Similar findings are reported for UK students as regards the effect of social class and previous school background on students' academic performance at medical school (Arularnpalam et al. 2004).[33]

4.3.2 School-leaving subjects

In this section the research findings regarding the school-leaving subjects English, mathematics, physical science and economics are discussed.

Most international and South African studies designed to isolate the key determinants of students' academic performance at university include the grades the students achieved in the school-leaving subjects English, mathematics and physical science as independent variables. These subjects are chosen because they have been shown to be particularly important in explaining students' academic performance at university where English is the medium of instruction, and where many subjects require a good understanding of mathematics and, to a lesser extent, physical science. The school-leaving subject economics is also selected for case study of students' academic performance in first-year microeconomics.

English

There are strong grounds for expecting this variable to have a positive impact on students' academic performance at universities where English is the medium of instruction. Students' ability to understand multiple-choice questions, and to express themselves clearly in answering structured/essay type questions, is thought to be closely allied to their command of English, the language in which they are taught and in which tests and examinations are set.

The results of the international studies are mixed. For example, Myatt and Waddell (1990) found school-leaving English grades to be positively correlated with examination results, and that good English results had slightly more explanatory power than good mathematics results, in a first-year economics course. However, Anderson et al. (1994) found that English grades are not a statistically significant explanatory variable, although students who had above-

[33] In Smith et al. (forthcoming) none of the socioeconomic variables were found to be statistically significant in explaining the academic performance of AD students.

average results outperformed those who did not by 4.9 percentage points. Bunce and Hutchinson (1993) report a positive relationship between the results achieved by USA students in their school-leaving examination and their subsequent performance in college chemistry courses.

The results for South African studies of first-year microeconomics are also mixed. Van Walbeek (2004), Parker (2006, 2007, 2010), Smith and Edwards (2007) and Dlomo et al. (2011) report that this variable is statistically significant in explaining academic performance, but Edwards (2000), Van der Merwe (2006), and Horn and Jansen (2009) report that this variable is statistically insignificant in explaining students' academic performance.

Mathematics

There is a large body of evidence from international studies reporting that competence in mathematics is strongly associated with success in first- and second-year courses (Levin and Wyckoff 1988, Astin and Astin 1992, Adelman 1995, Hagedorn et al. 2000, McKenzie and Schweitzer 2001, Veenstra et al. 2007, 2008, De Winter and Dodou 2011, Min et al. 2011). Several international studies report that competence in mathematics is strongly associated with academic performance in economics[34] (Reid 1983, Raimondo et al. 1990, Robb and Robb 1999, Bachan and Reilly 2003, Durden and Ellis 2003, Ballard and Johnson 2004, Kherfi 2008, Kinney and Yakolev 2008, Lagerlöf and Seltzer 2009), engineering (Ohland et al. 2004, Zhang et al. 2004, French et al. 2005, Gardner et al. 2007), chemistry (Ozsogomonyan and Loftus 1979, Nordstrom 1990, Bunce and Hutchinson 1993, Russell 1994, Spencer 1996, McFate and Olmsted 1999, Evans 2000, Wagner et al. 2002, Pienta 2003, Bentley and Gellene 2005, Tai et al. 2005, Sadler and Tai 2007, Leopold and Edgar 2008), and mathematics (House 1993).

As regards economics, Lumsden and Scott (1987) and Myatt and Waddell (1990) reported statistically significant slope coefficients of 0.61 and 0.26 respectively. This means that a one percentage point increase in the mathematics mark results in a 0.61 and 0.26 percentage point increase in the economics mark, respectively. Reid (1983) found the intercept coefficient for

[34] It is argued that the ability to understand and interpret graphs, and to use algebra and calculus, facilitates a student's ability to understand microeconomics in particular and economics in general (Myatt and Waddell 1990).

mathematics to be 4.23 and statistically significant. This means that students who have taken mathematics achieve on average 4.23 percentage points more in the economics course than those who have not. Bonello et al. (1984) found the coefficient of the mathematics section of the Student Admissions Test (MSAT) to be positive and statistically significant. In contrast, Robb and Robb (1999) found courses in calculus and algebra to be statistically insignificant in their effect on students' academic performance in first-year economics.

As regards South African studies, Hesketh et al. (1994), Van Walbeek (2004), Parker (2006, 2007, 2010), Smith and Edwards (2007), Horn and Jansen (2009) and Dlomo et al. (2011) report a positive relationship between students' level of achievement in matriculation mathematics and academic performance in first- or second-year economics courses, and Potgieter et al. (2010) report that students' prior performance in mathematics acted as a determinant of students' success in a first-year chemistry course. Van der Flier et al. (2003) found a positive relationship between students' results in the matriculation examination and their success in a mathematics and science foundation programme at UNIN, and De Beer (2006) reports that a low level of mathematical skills is associated with students dropping out at CUT, South Africa.

Physical Science (Physics and Chemistry)

Tai et al. (2005) report a positive relationship between the results achieved by USA students in the science school-leaving examination and their subsequent performance in an introductory college chemistry course. De Winter and Dodou (2011) found that students' high-school chemistry performance is a strong predictor of their first-year academic performance.

The nature of the relationship between the level of achievement in the school-leaving examination in the physical sciences (physics and chemistry) and the subsequent level of academic performance in economics has not been reported in the international literature. Edwards (2000), Van Walbeek (2004), Smith and Edwards (2007), and Horn and Jansen (2009), however, all report a positive and statistically significant relationship between these two variables for South African students in first- and second-year economics courses, and Potgieter et al. (2010) report that students' prior performance in physical science acted as a determinant of students' success in a first-year chemistry course.

High-school or prior economics courses

There appears to be a strong argument for a positive relationship between students' grades in high-school or prior economics courses and their academic performance in the first-year economics examination. A range of findings has emerged regarding the effect of high-school or prior economics courses on the acquisition of knowledge of the subject at the tertiary level. In summary, it appears that much depends on the content of the high-school course attended by the student (Reid 1983, Lopus 1997). For example, for the relationship between A-level economics and academic performance in a first-year economics course, Lumsden and Scott (1987) reported an intercept coefficient of 3.5. This result implies that students who took A-level economics achieve, on average, 3.5 percentage points more in the first-year economics course than those students who did not. Tay (1994) reports a slope coefficient of 0.37 for the same relationship. This means that for every one percentage point increase in their A-level economics mark, students achieve a 0.37 percentage point increase in their first-year economics course mark, on average. This finding was replicated in Canada by Myatt and Waddell (1990), who showed that students with previous exposure to economics gain 3.5 percentage points[35], and in the United States by Brasfield et al. (1993).

A number of studies, however, have shown that prior economics courses have little or no effect on academic performance at the tertiary level (Siegfried and Fels 1979, Becker et al. 1990, Siegfried and Walstad 1990). Indeed, Reid (1983), Anderson et al. (1994) and Robb and Robb (1999) found statistically significant negative effects.

As regards the South African studies of the determinants of academic performance in economics the evidence is mixed. Edwards (2000) reports that students with who took economics as a school-leaving subject outperformed their peers conditional on the selected control variables. Van Walbeek (2004), Parker (2006), Smith and Edwards (2007) and Dlomo et al. (2011) report, however, that students with prior knowledge of economics do no better than their peers, conditional on the selected independent variables.

[35] They reported that the effect of high-school economics on academic performance decays over time.

Apart from variations in content between high-school economics courses in different countries, and the extent of the match between the content of the high-school economics course and the content of the first-year university course, there is a another difficulty in assessing the impact of high-school economics on the acquisition of knowledge and learning: academically strong students tend not to take economics at school (Peterson 1992, Anderson et al. 1994). This gives rise to an important selection issue. In some countries, academically weaker students may be offered a subject such as economics as an alternative to mathematics, physical science or history, for example. This is certainly the case in South Africa, where many students opt for business economics and economics as alternatives to the sciences and mathematics on the higher grade. In short, a negative relationship may reflect selection bias rather than the negative impact of school economics on the acquisition economics knowledge and learning.

4.3.3 School characteristics

It is generally accepted that students who attended schools that, in the apartheid era, fell under the Department of Education and Training (DET) and Houses of Representatives and of Delegates (HRD) are less well prepared for academic demands placed on them at university.[36] It is expected that students from former DET and HRD schools will continue to suffer an educational disadvantage (Case and Deaton 1998) and that this disadvantage will have a negative impact on their academic performance at university. As regards the study of economics, however, the type of school attended does not seem to be an important factor in determining academic performance, conditional on the other explanatory variables. The relatively poor quality of the DET and HRD schools is largely reflected in the relatively poor academic performance of those students who attended these two types of school (Edwards 2000, Van Walbeek 2004, Smith and Edwards 2007).

That said, DET and HRD schools may act as proxies for relatively disadvantaged socioeconomic backgrounds. These schools are usually located in areas that were set aside for those people classified as "black", "Indian" and "coloured" by the apartheid government

[36] DET and HRD schools were established by the apartheid state to serve the "black", and "coloured" and "Indian" groups, respectively. Other secondary institutions include Model C and private schools, and technical, "cram" and correspondence colleges.

prior to 1994. These areas received far less investment than those areas of South Africa reserved for people who were classified "white".

However, Van Walbeek (2004) reports that students from the Western Cape outperformed students from the rest of South Africa in their first-year microeconomics course at the UCT irrespective of the type of school they attended. Students from the Western Cape might outperform students from other parts of South Africa as schools in the Western Cape might offer education of higher quality than schools elsewhere in South Africa offer. An alternative explanation might be that students from the Western Cape felt more at ease at the UCT, which is located on their doorstep, so to speak.

4.3.4 Course characteristics

Class size

The evidence regarding the importance of class size in explaining students' knowledge and learning is mixed. According to Siegfried and Fels (1979), class size does not matter very much in explaining knowledge and learning in the principles of economics course. In contrast, Lopus (1990), Raimondo et al. (1990) and Arias and Walker (2004) found that smaller class sizes, in the United States, had a positive and statistically significant effect on students' academic performance in economics.

As regards South African AD students, Feltham and Downs (2002) report that the majority of students on foundation programmes come from schools characterised by over-crowded classrooms.

Lecture and tutorial attendance

Morgan and Vasche (1978), Schmidt (1983), Lumsden and Scott (1987), Park and Kerr (1990), Romer (1993), Devadoss and Foltz (1996), Marburger (2001, 2006), and Kinney and Yakovlev (2008) found lecture and/or tutorial attendance to be positive and statistically significant in affecting students' grades in economics courses. These findings are echoed by Hammen and Kelland (1994) (physiology class), Newman-Ford et al. (2008) (22 undergraduate classes in a variety of disciplines), Bédard et al. (2010) (engineering classes),

and Fitzpatrick et al. (2011) (engineering classes). Lodish and Rodriguez (2002) (first-year biology) reported that a combination of lectures, problem sets and tutorials is an excellent way to teach undergraduate cell biology. Finally, Moore et al. (2002) found that lecture and tutorial attendance are the strongest predictors of students' academic success at a college in the United States.

Van Walbeek (2004), Horn and Jansen (2009) and Dlomo et al. (2011) report similar findings for South African students studying first-year economics, and Horn et al. (2011) for South African students studying second-year economics.

Teacher/tutor characteristics

It is generally assumed that the teacher/tutor's ability and knowledge of economics is positively related to students' learning and knowledge of economics (Morgan and Vasche 1978, Weaver et al. 1987, Walstad and Soper 1989, Becker et al. 1990). There are, however, a number of dissenting voices. Siegfried and Walstad (1990) and Tay (1994), however, report that the instructor plays an insignificant role in determining students' academic performance.

Other studies have investigated the importance of the relationship between the teacher and the student. Morgan and Vasche (1978) found that the ability of the teacher to communicate and relate to students' problems and questions plays an important role in promoting academic performance. In a similar vein, Becker et al. (1990) reported that the teacher's attitude has a positive effect on the student's approach to subject. Case (2007) notes the importance of the teacher's personality in engaging the student, and Rizwani et al. (2008) report that the teacher's pedagogic skills are a critical factor affecting the level of satisfaction experienced by engineering students. In contrast, Lumsden and Scott (1987) found that the students' opinion of their teacher is unimportant in explaining economics students' academic performance.

4.4 Academic development programmes

This section considers the international and South African research designed to estimate the success of AD courses and programmes. The research design employed is also described when it is considered appropriate to do so.

4.4.1 International research

In this section the effect of educational interventions on students' academic performance in individual courses and through to graduation are considered.

As regards USA studies, Congos and Schoeps (1999) used MVA to show that students who volunteered to take a programme of supplementary instruction scored higher GPAs than those who did not. These authors did not, however, compare graduation rates, nor did they account for the sample-selection problem. Etter et al. (2001) describe the effect of a supplementary instruction model. They provide descriptive data on students' academic performance, failure, and withdrawal rates for 132 introductory accounting classes from 21 four-year colleges and universities that used supplementary instruction. Students taking supplementary instruction courses had higher average course grades, and lower failure and withdrawal rates than mainstream students.

Zeegers and Martin (2001) evaluated the use of a student-focused learning-to-learn program, which focused on developing students' understanding of the learning process and of their own learning, both in general and in chemistry in particular. They found that the 1997 class as a whole showed an overall increase in pass rate compared to that achieved by the 1996 cohort. Ayaya (1996) used ordinary least squares to investigate the effect of 29 explanatory variables, including students' first-year weighted mean marks[37], on the academic performance of students in a Bachelor of Commerce programme at the National University of Lesotho for the period 1982/83 to 1991/92. He concluded that the transition programme was successful. This conclusion, however, does not seem warranted as there was no control group and it seems more likely that the transition-year weighted mean mark was primarily a measure of academic ability.

In contrast, Lagerlöf and Seltzer (2009) used a natural experiment and report that a remedial mathematics course is not effective in raising the academic performance of remedial students relative to mainstream students.

[37] At the University of Lesotho, first-year courses are transitional courses, which do not count towards the final degree. These marks, however, determine whether the student is accepted onto the degree programme.

The results of a number of graduation studies conducted by researchers based in the USA are mixed.

Adelman (1998, 1999), reporting on a comprehensive study that followed the national high-school class of 1982, found that it is poor high-school preparation, rather than taking remedial coursework, that reduces students' chances of graduating from college, whilst the Little Hoover Commission (2000) reports that remedial course placement is associated with a low probability of completing a degree programme. Berkner et al. (2002) found that after six years, students who attended remediation courses are much less likely to transfer to four-year institutions.

Jenkins and Boswell (2002) report that 45.0% of students who earned more than 10 credits at a two- and/or four-year institution, and who took two remedial courses, earned either an associate or bachelor's degree by the time they were 30. This compares to 60.0% of students who took no remedial courses. Adelman (2006), in a large-scale USA study, claims there is a relatively narrow academic path that maximises the likelihood that a student will earn a degree. This path includes a rigorous high-school curriculum, immediate full-time attendance (preferably at a four-year college), continuous study through to completion, and vacation class attendance, if necessary. Particularly important is the academic intensity of the high-school curriculum.

Attewell et al. (2006) report that 28.0% of remedial students of the high-school class of 1992 in two-year colleges graduated within 8.5 years compared to 43.0% of students who did not take remediation classes, and that 52.0% of remediation students in four-year colleges completed bachelor's degrees compared to 78.0% of students who did not take remediation classes. They go on to report that 50.0% of African-American bachelor's programme graduates and 34.0% of Hispanic bachelor's programme graduates graduated after taking remediation courses. If these students had been denied entry to four-year institutions, a large proportion of the minority graduates in the high-school class of 1992 would never have received degrees. Importantly, Attewell et al. (2006) go on to say that they were able to distinguish the effects of a poor high-school academic preparation from the effects of taking remedial coursework in college, on the students' graduation rates. They found, like Adelman (1999, 2006), that most of the difference in graduation rates is a function of pre-existing skill differences carried over from high school.

Viadero (2009) reports on a study by Martorell and McFarlin (2007). They analysed the academic performance and future earnings of 454 000 Texan students who entered two- and four-year colleges in the 1990s, and who took the Texas Academic Skills Program (TASP) tests. They found that students who were required to take remediation courses, as they had failed the TASP tests, were only marginally more likely than students who just passed the TASP tests to complete a college degree, to transfer to a four-year college if they started out in a two-year school, or to be earning a higher income seven years after starting college. All the reported differences are, however, statistically insignificant.

In contrast, Bettinger and Long (2005), as discussed above, endeavoured to control for the sample-selection problem by means of a natural experiment. They found that students who took mathematics remediation classes achieved higher graduation rates than those who did not.

A number of studies report that students who attend remediation classes tend to exhibit higher persistence rates than mainstream students, though these studies do not mention graduation rates.

Kulik et al. (1983), in a meta-analysis, report that high-risk students who enrolled in remediation programmes stayed in college somewhat longer than mainstream students and they received better grades. Kulik et al. (1983) did not, however, compare the graduation rates achieved by the two groups of students, nor did they attempt to minimise omitted variable bias. Schoenecker et al. (1998) report that community college students who were recommended for remedial non-degree courses, but did not take them, had lower GPAs and persistence rates than students who had completed remediation courses. They also report that students who voluntarily took classes outperformed their peers who did not. This study did not include the usual control variables and is subject to sample-selection bias.

Lesik (2007) reports that students who participate in remedial mathematics programmes exhibit a lower risk of leaving college than comparable students who did not participate in such programmes. Finally, Bailey (2009) concludes that remediation is not particularly effective in overcoming students' academic weaknesses, as the majority of students do not complete the classes to which they are referred.

4.4.2 South African research

Rollnick (2010) argues that some AD programmes are at universities with high research output. Therefore, there is great deal of research on AD students at these universities at the micro and macro level.

A good example of such micro-level research, in addition to the research already cited in this chapter, is the model developed by Rollnick et al. (1998) to study gaps in education, and which identifies issues related to teaching and learning in a particular subject or programme. This model has inspired a number of research projects at South African tertiary institutions. Cox (2000) identifies the chief cause of the mathematics gap between high school and university as the differences between students in their learning approaches. Mumba et al. (2002) identify the chief causes of the gap between high school and first-year chemistry as content knowledge and the difference in teaching styles employed in high-school and university, and Green (2002) and Dawidowitz and Rollnick (2005) identify the impediments to students' adjustment to the second-year chemistry courses at the Universities of the Witwatersrand and Cape Town, respectively. Meyer et al. (1994) undertook a similar investigation for mainstream and AD engineering students at the UCT. Finally, Rollnick (2010) makes the point that the gap between first- and second-year courses puts AD students at risk in their second year when they join mainstream courses, which is a point echoed by Pinto (2001).

There has been a steady growth in the literature to do with AD programmes and courses since the early 1980s. However, as noted by Kloot (2011), much of it is of a descriptive nature, discussing aims, pedagogy and structure of the various courses and programmes. For example, Bradley (1984) examined issues of assessment in the slow-stream Chemistry I course at Wits; Allie (1987) reports on the foundation course in physics at UCT; Kotecha and Rutherford (1987) describe the first year of the Wits Integrated Study Programme for Engineering (WISPE), which was started at the University of the Witwatersrand in 1987; Volmink (1987) describes a science foundation "package" offered in mathematics, physics and chemistry; Sharwood (1992) discusses the pre-technician course for science and engineering at the Port Elizabeth Technikon; Zaaiman (1998) describes the foundation year (UNIFY) at the UNIN, which was introduced in 1993 to address the low numbers and high

failure rates in the UNIN science-based faculties; Parkinson (2000) describes the augmented model in engineering at the University of Natal (now UKZN); Hay and Marias (2004) describe the Career Preparation Programme (CPP) at the University of the Free State (UFS); Holtman and Marshall (2008) describe the foundational provision in the UWC science faculty, which focuses on providing epistemological access to educationally disadvantaged students; and Grayson (2010) describes the engineering foundation programme at the University of Pretoria, recently re-designed to meet the Department of Education's (DOE) criteria as an extended curriculum programme (ECP).

From the beginning of the 1990s there was an increased interest in assessing whether the aims of AD programmes and courses were being met. A typical example of the genre (Kloot 2011) is the paper by Grayson (1997). Grayson (1997, p. 107) describes the year-long pre-degree Science Foundation Programme (SFP) at UKZN, which took some 30 students in each of the years 1994–1996 and is designed

> to identify academically talented but underprepared black students who wish to pursue tertiary studies in science or applied science, and help them develop their potential in order to achieve this aim. In the model of the foundation programme adopted, we attempted to identify underlying skills, attitudes and resources that would help students succeed in their studies, and then tried to help the students acquire these in as efficient and lasting a way as possible. Thus the focus of the resulting curriculum is on issues such as cognitive skills, practical skills, effective study attitudes and strategies, peer learning, articulation and communication of understandings, positive coping skills, self-reliance, confidence-building and awareness of how each individual student learns best.

The positive responses of 99 students who completed the first three years of the programme are used to show that the aims of the programme have been met. As such the study is of a qualitative nature, no data is supplied on students' subsequent academic performance and no statistical analysis is conducted.

Other papers in this genre include Hay and Marais (2004), Downs (2005), Wood and Lithauer (2005), De Klerk et al. (2006), Downs (2006, 2010) and Lubben et al. (2010).

As was previously noted Hay and Marias (2004) described the CPP at UFS. They state that 610 black students obtained degrees through the CPP. However, the total number of CPP students is not given, and neither is any comparison made with the performance of mainstream students. As regards an evaluation of the programme, the final section in the paper contains three quotations of positive feedback from "numerous experts" about the programme.

Downs (2005) reports on the SFP established at UKZN in 1991 as there was a particular concern about the small numbers of black students majoring in life sciences. The number of students in the SFP has increased from 35 in 1991, to 140 in 2000 and to 280 from 2001 onwards. Downs (2005) finds that passing the SFP biology course is a poor indicator of students' subsequent academic performance in the first-year mainstream biology course. The author claims that this is a consequence of a many academic and non-academic factors. There is, however, no analysis of the importance of the various factors, nor is there statistical analysis of the relative performance of the SFP and mainstream students in the first-year mainstream biology course.

Wood and Lithauer (2005) describe and evaluate the foundation programme (UFP) at the Nelson Mandela Metropolitan University (NNMU). At this time (2005) the UFP was a non-credit bearing bridging programme by which students could gain access to the first year in business, science and the humanities. The authors discussed the findings from the analysis of three focus group interviews held with a total 53 former UFP students, and they use the students' responses to claim that the programme not only has academic benefits but also assists in the development of self-knowledge and self-management skills, and gives students an improved sense of self-worth. As such the study is of a qualitative nature, no data is supplied on students' subsequent academic performance and no statistical analysis is conducted.

Downs (2006) develops her analysis of the academic performance of SFP students at UKZN, who did not meet mainstream entrance requirements to the university, and who came from educationally disadvantaged backgrounds. The academic performance of mainstream and SFP students was compared in the first-year mainstream biology course for the years 1995–2000 using repeated measures ANOVA. The key findings were that SFP students showed the poorest performance. In particular, the SFP students performed poorly in the theory

examinations, which were examined using short questions and essays that require higher-order cognitive skills. In this study, Downs (2006) compares the academic performance of SFP and mainstream students of the same ethnic group. A more rigorous approach would have been to use MVA to control for several of the variables that impact on students' academic performance.

De Klerk et al. (2006) describe the Extended Degree Programme (EDP), which was introduced at the University of Stellenbosch in 1995, with a focus on broadening access and improving the success rates of under-prepared first-year students. In the ten years since it was started the programme has catered for some 1 000 students across six faculties. The study reports on quantitative (cohort analysis) and qualitative (personal interviews) data, which highlighted the strengths and weaknesses of the programme. Unfortunately, no comparison of the academic performance of EDP and mainstream students is reported.

Downs (2010) reports on the SFP at UKZN for the period 1991–2003. In this descriptive study including 1533 students, 1101 (71.8%) went on to register for first-year mainstream courses at UKZN. Of the original intake of 1533 students, 479 (31.2%) graduated and 24.6% were still in the system. Therefore, the final graduation rate is likely to increase. Downs (2010) also reports that women are more likely to graduate than men (53.6% to 38.3%). Unfortunately, no data is provided for mainstream students so it is not possible to draw a comparison between the academic performance of mainstream and SFP students through to graduation.

Lubben et al. (2010) used data from semi-structured interviews with 20 third-year GEPS students to analyse their decision-making processes as they progress through their degree. They found that some students are motivated initially by an interest in a science subject and, later, by the possibilities of the study programme. They go on to report that career-oriented students are motivated, initially, by role models and extra-curricular science activities, and subsequently by the career they see themselves pursuing after graduation. They report that there is some evidence to suggest that students who are motivated by the possibility of pursuing a particular career are more likely to persist at university. Apart from the problems of sample-selection bias posed by the use of a small sample, no mention is made of the effect of the identified variables on students' graduation rates.

The AD programmes in science at the University of the Witwatersrand are now considered at some length as they have been the source of some of the more rigorous research in the field to date. Woollacott and Henning (2004) give a brief history of these programmes, a summary of which follows:

> Privately funded programmes began in 1980 with the Anglo-American Cadet Scheme. In 1986 this evolved into the very effective Pre-University Bursary Scheme (PBS) that is still running in 2003. Students were carefully selected, given bursaries and were accommodated on campus. The students did not earn any university credits but were guaranteed acceptance into first year engineering if they passed the programme. The effectiveness of the PBS programme has been demonstrated consistently in that the graduation statistics for successful students are better than those for first time entrants to engineering programmes at Wits (Hillman, 1992).
>
> The programmes at Wits have evolved through three stages – WISPE, ESCOS (Engineering Scheme in the College of Science) and the Special Programmes. WISPE – the 'Wits Integrated Studies Programme for Engineers' ran from 1987 to 1991 and was essentially a selective rescue programme for mainstream students who were heading for almost certain failure. The format of the programme was very similar to the Special Programme described shortly.
>
> In 1992, the Faculty of Science at Wits introduced the College of Science – an access programme for selected students who did not qualify for entry into a BSc programme. The approach was to spread the first two years of the BSc degree over three years and to embed in the course any communication or remediation that was required to deal with under-preparedness.
>
> For various reasons the faculty of engineering decided to drop the WISPE programme in favour of an 'Engineering Stream in the College of Science' – ESCOS. The programme was very effective in getting a significant proportion of its entrants through first year. However, the performance of these students once they joined the engineering main stream was disappointing and the programme was dropped in 1999 in favour of a revised version of WISPE – now called the Special Programme.
>
> The philosophy behind this programme (Special Programme) is that all students who enter the main stream and, within seven weeks, are found to have the potential to pass but are 'at risk'

> because of under-preparedness are given the opportunity to enter an extended programme. The programme involves completing the first two years of the degree programme in three years. In the remaining two years of the special programme, no further 'remediation' or extra help is provided and the students join the main stream and do only main stream courses.

Curtis and De Villiers (1992) compared the examination results achieved by 70 PBS students at the University of the Witwatersrand who matriculated from DET schools with the results of a comparable group of 107 ex-DET students. This study is important in the context of this thesis at it represents the first attempt to identify whether an AD course improves the academic performance of AD students relative to their peers on the mainstream.

The authors used OLS to control for students' academic ability as measured by their admission rating.[38] The findings indicate that the academic achievement of the PBS group during the bridging year was superior to that achieved by the control group. Furthermore, the students achieved 7.7 percentage points more, on average, than did the control group in the first-year mainstream course, Business Economics I, and the difference is statistically significant. Unfortunately, the regression estimation is extremely parsimonious; the OLS analysis would have benefitted from the inclusion of several additional variables that may also explain students' academic performance.

Onsongo (2006) in a detailed data analysis reports, among other things, on the first seven years of the Special Programme described above, which started in 1999. An average of 46 students was admitted to the programme for each of the seven years covered in the study. Of the 1999 cohort (58 students), 16 students continued with their first-year degree studies in 2000, and eight graduated, although there was still one student in the system. Of the 2000 cohort (57 students), 24 students continued with their first-year studies in 2001, and six graduated in the minimum time of five years at the end of 2004. 13 members of this cohort remained in the system at the time of writing.

Rollnick (2010, p. 51) describes the College of Science at the University of the Witwatersrand, which is a two-year access programme that admitted candidates who took mathematics (SG) and physical science (SG) with the aim of turning them into science

[38] Admission rating was calculated on the basis of points awarded for each grade achieved in the matriculation examination on either the higher or standard grade for each subject.

graduates. She reports that 10 cohorts produced 420 BSc graduates, but the total number of students initially admitted to the programme is not given, neither is any comparison made with the academic performance of mainstream students. She goes on to say that the College of Science has received favourable external reviews and evaluations.

In a follow-up study to Curtis and De Villiers (1992), De Villiers and Rwigema (1998) investigated the effect of the PBS bridging year on the graduation success of the same 70 PBS students relative to the same group of 107 comparable mainstream students. This is also an important study in the context of this thesis as it represents the first time that statistical analysis is used to compare the graduation performance of AD and mainstream students. Of the 70 PBS students 56% graduated compared to 29% of the non-PBS students. The PBS students took 4.92 years to graduate (including the bridging year), on average, whilst the control group 5.20 years, on average. De Villiers and Rwigema (1998) show, controlling for admission rating, that bridging-programme attendance had a positive and statistically significant effect for each of the four periods to graduation.

As in respect of Curtis and De Villiers' (1992) study, the regression estimation is extremely parsimonious, and as a result the study is likely to suffer from omitted variable bias. There is also the sample-selection problem as it is unlikely that the PBS and mainstream students are drawn from the same population across a broad range of characteristics. Another defect of the study was the use of OLS analysis with a binary dependent variable, which can result in heteroskedastic non-normal error terms. In this instance logit or probit models should be used.

There are three other studies that have analysed the academic performance of AD students and the academic effectiveness of AD courses and programmes.

Edwards (2000) used MVA to estimate the success of an introductory first-semester economics course for 79 academically disadvantaged students at the UCT. Unlike Curtis and De Villiers (1992) he found that the AD cohort of ex-DET students did not outperform a comparable mainstream cohort of 317 students in a subsequent mainstream course in first-year microeconomics.

Van der Flier et al. (2003) analysed the academic performance of 294 UNIFY students at UNIN. They report that the 294 students outperformed first-time and repeat students for the years 1994 and 1996. They go on to postulate that access programmes at a disadvantaged institution have the effect of making the disadvantaged student advantaged with respect to their peers on the mainstream. Van der Flier et al. (2003) also used regression analysis to identify the key determinants of each cohort's academic performance, as was previously reported.

As was previously noted, Smith and Edwards (2007) found that a first-year AD course in microeconomics at the UCT had a positive and statistically significant effect on the academic performance of 194 AD students relative to 230 mainstream students in both the first- and second-year mainstream microeconomics courses. They showed that AD students achieved some 15.0 and 12.0 percentage points more than mainstream students for the structured/essay questions in the first-year and second-year microeconomics examination, conditional on the control variables, respectively, and both results are statistically significant.

Notwithstanding the development of a substantial research literature it remains true that there is little research of a statistical nature aimed at identifying whether AD courses and programmes are successful in improving the academic performance of AD relative to mainstream students. Nor is there much statistical research aimed at identifying the key determinants of academic performance for mainstream and AD students.

4.5 Summary discussion

Numerous studies have been undertaken over the past 35 to 40 years, and these have generated a diverse range of results. There are many factors that contribute to the mixed nature of the results regarding the relationship, and statistical significance, of the inputs (explanatory variables) to learning and knowledge.

Firstly, these studies have been conducted in a number of different countries, each with its own culture, or cultures, and educational system. For example, the impact of high-school economics on economics performance at the tertiary level has been shown to vary

considerably between the USA, the UK and South Africa (Reid 1983, Lumsden and Scott 1987, Smith and Edwards 2007).

Secondly, in the vast majority of studies, each variable is assumed to be independent of the others; MVA has been undertaken on the basis of this assumption. However, it seems likely that there is some degree of interdependence between several of these variables. For example, the difficulty in determining the nature of the relationship between effort and attitude has already been considered. Furthermore, the effort and the attitude of the student may not be determined independently of the attitude and ability of the lecturer. It may well be that the values of these variables are simultaneously determined along with the students' examination and course results.

The precise nature of the relationship between the many variables that may explain students' academic performance is complicated. Not only must the interactions between the variables be modelled, but it is also necessary that the interaction variables be built into the procedure of estimation. Steps to elucidate the many complex relationships that determine students' knowledge and learning remain a major challenge for researchers in the years ahead.

There are relatively few studies designed to estimate the success of AD courses and programmes in improving students' graduation rates. In addition, many studies are descriptive in nature and are flawed in terms of their research design. Specifically, the steps necessary to ensure the internal validity of the studies, which compare the academic performance of AD and mainstream students, are rarely acknowledged or addressed.

Chapter 5

Empirical specification and data base construction

5.1 Empirical specification

For the purposes of the analysis adopted in this thesis, education is viewed as a production process whereby academic performance is a function of a variety of inputs, as was explained in some detail in Chapter 4 (Edwards 2000). This relationship can be represented as:

OUTPUT = F(D ADP, STUDENT, MATRICULATION PERFORMANCE, SCHOOL, COURSE, OTHER) (1)

where:
OUTPUT is a measure of academic performance;
D ADP is a dummy variable, equal to 1, for an AD course or programme;
STUDENT includes variables measuring students' characteristics;
MATRICULATION PERFORMANCE includes variables measuring students' academic performance in school-leaving subjects;
SCHOOL includes variables for different types of schools
COURSE includes variables relating to university course characteristics; and
OTHER includes other relevant variables such as faculty registration and a variable that accounts for the sample-selection problem that arises as not all students take the final examination.

Three methods are employed to determine whether the educational interventions included in AD courses and programmes improve AD students' academic performance relative to that of mainstream students. The first is to identify mainstream cohorts that have several characteristics in common with the relevant AD cohorts. To determine the extent of the similarity between the two sets of cohorts, tests for differences of means and proportions are conducted for each of the continuous and discrete variables. In addition two statistical methods are employed to determine whether the educational interventions included in AD

courses and programmes improve AD students' academic performance relative to that of mainstream students. The two statistical methods are multivariate analysis (MVA) and propensity score matching (PSM). MVA can be used when the dependent variable is continuous or dichotomous. The same is true for PSM.

MVA makes it possible to identify the effects of each of the independent variables on the dependent variable. The independent variables include the treatment variable, which in this case is whether a student was on the AD course or programme or not. This makes it possible to identify the effect of the treatment variable on the dependent variable (examination or course mark, or graduation), having controlled for the effects of each of the independent variables included in the specification. As was noted previously, there may be explanatory variables thought to influence the value of the dependent variable that are excluded from the estimation because the data is not available (un-observables). Insofar as the unobservable variable is correlated with the treatment variable (AD course or programme) the estimation is subject to omitted variable bias.

In essence PSM does the same thing. The treatment (AD) cohorts and mainstream cohorts are matched on the observed independent variables, which are usually the same as those used in the MVA estimation. In the studies reported below, this is always the case by construction unless stated otherwise. It does not follow, however, that the two groups are matched on the un-observables.

In using PSM, two tests are conducted to determine whether the two groups come from the same population, that is, that the mainstream cohorts can act as a control group against which the academic performance of the AD cohorts can be compared.

The first test is a t-test which is used to determine whether the difference between the values of each of the independent variables for the two groups after the "matching" process is statistically significant at, at least, the 5% level. Insofar as the differences are not statistically significant, the two groups can be said to be matched on the independent variables; that is, the treatment and control groups are balanced on the "Xs". The second test is designed to identify whether there is "common support". This refers to the regions of the propensity score values, from 0 to 1, where there are observations from both the treated and control groups. Therefore, a priori, there is some chance that a student with that particular propensity score value could

fall into the treatment group or the control group. If a sufficiently large range of propensity scores does not have observations from the treatment and control groups then PSM fails due to the lack of "common support".

To accept the hypothesis that the mainstream and AD cohorts come from the same underlying population, after applying PSM, it is necessary that the conditions prescribed by both tests are satisfied.

5.1.1 Output or dependent variables

For each of the course estimations the dependent variable is a measure of the students' stock of knowledge. This variable is measured using AD and mainstream students' final examination or course marks before the writing of any supplementary examination. Therefore, the variable is continuous.

For each of the graduation rate estimations the dependent variable is dichotomous (binary), which takes the value of one if the student graduated and zero if not.

5.1.2 Input or independent variables

The first independent (explanatory, control) variable is a dummy variable that represents the AD course or programme, and is used to assess the effectiveness of the educational interventions on students' academic performance in the first- and second-year courses in economics, mathematics and chemistry, and through to graduation. A positive sign for the coefficient of the dummy variable suggests that the AD course or programme exerts a positive influence on students' academic performance relative to that of the mainstream cohorts, conditional on the selected control variables.

To obtain the conditional impact of the AD course or programme on academic performance, a number of additional variables that are thought to affect students' academic performance are included as independent variables.

Ideally, all the variables thought to determine the value of the dependent variable should be included in the estimation. This applies, in particular, to any variable that is thought to act in

tandem with the treatment variable (AD course or programme) in its effect on the dependent variable. As was previously noted, it is difficult to identify and reliably measure all the potential independent variables (un-observables) that may affect the value of the dependent variable together with the treatment variable. Thus there is the problem of omitted variable bias.

A selection of the variables, discussed in Chapter 4, is included in all the specifications. These variables include students' characteristics, academic performance in school-leaving subjects, school, and course characteristics. The variables discussed below are included in all the specifications. Any additional variable included in any individual specification is discussed when that estimation is considered.

Proxies for academic ability (preparedness) are important in explaining students' academic performance at university. In the case studies included in this thesis, the school-leaving subjects English first language higher grade (HG), mathematics (HG) and physical science (HG) (physics and chemistry) are treated as independent variables.[39] Following Edwards (2000) and Smith and Edwards (2007), a modified version of the matriculation points score (the adjusted matriculation points score) is used as a measure of academic ability.[40]

Mainstream students' matriculation points scores range from 21 to 48 points, with a mean of 40.8 points. For AD students the matriculation points range from 21 to 41 points, with a mean of 33.4 points. Mainstream students' adjusted matriculation points range from 12 to 36 points (11 to 34 points for AD students), with a mean of 26.3 points (21.5 points for AD students). The reason for using the adjusted matriculation points score rather than the total matriculation points score is to ensure that the effect of English first language (HG), mathematics (HG) and physical science (HG) is not estimated twice.

To determine the adjusted matriculation points score (*Adjmatpt*), the points allocated to English first and second language (HG) and to mathematics (HG) and standard grade (SG) are deducted from the matriculation points score. Therefore, the adjusted matriculation points

[39] During the period 1999–2005 students sat one of two school-leaving examinations in each subject: Higher Grade (HG) and Standard Grade (SG). Starting in 2008 students sat a single examination in each subject.
[40] The University of Cape Town allocates points to matriculation subjects as follows: Higher Grade (HG): A=8, B=7, C=6, D=5, E=4, F=3. Standard Grade (SG): Two points less for each grade. The maximum matriculation points score that a student can achieve is 48 points (eight points for each of the six subjects).

score includes the matriculation points that the students earned for the four subjects taken in the matriculation examination, net of the points earned for mathematics and English.[41] Two points are also deducted in respect of physical science (HG). Students who took physical science (HG) retain the remaining matriculation points that they earned for this subject as part of their adjusted matriculation points score. It is then possible to treat each of English first language (HG) (*D Eng FL HG*), mathematics (HG) (*D Math HG*), and physical science (HG) (*D PS HG*) as independent variables in the estimations. For English and mathematics, progressively higher positive coefficients are expected as the grade improves.

The quadratic variable $Adjmatpt^2$ is included to test for non-linearity: whether there are increasing or decreasing returns to academic ability as measured by the adjusted matriculation points score. For example, if the coefficient of the variable $Adjmatpt^2$ is positive and statistically significant ($p<0.05$) it implies that this variable is subject to increasing returns; the student's course or examination mark increases at a faster rate than the increase in the adjusted matriculation points score. Similarly, if the coefficient is negative and statistically significant ($p<0.05$) the implication is that the student's course or examination mark increases at a slower rate than the increase in the adjusted matriculation points score.

The following dummy variables are also included in the each of the specifications; English home language (*D Enghome*), male (*D Male*), and financial aid (*D Finaid*). The latter variable refers to students in need who have received loans from the government. Therefore, the variable might act as a proxy for socioeconomic disadvantage. To test that students have reported their home language correctly an additional dummy variable is created for those students who have reported English as their home language and who took English first language (HG).[42] In addition there are dummy variables for those schools that previously fell under the authority of the Department of Education and Training (*D DET*) and the Houses of Representatives and Delegates (*D HRD*), for those students who wrote their matriculation examination under the auspices of the Western Cape Province's education department (*D WC*), and for white students (*D White*). The variable *Age* is included as a continuous variable measured in years to the first decimal place, and to allow for non-linearity the square of this variable is also included in the specification.

[41] All students have taken English first language (HG) or English second language (HG) and mathematics (HG) or mathematics (SG).
[42] Another equation is estimated, which includes this dummy variable rather than the variable *D Enghome*. The result of this estimation is reported when appropriate.

Dummy variables are also included for each of the years to control for the following: the effect of differences in the assessment practices undertaken in each year with respect to the base year; the differences in the lecturers' marginal productivity from year to year; and the variety of unobservable year-specific factors that may be correlated with student achievement.

There is a second specification problem in addition to omitted variable bias. This relates to the matriculation points and subject grades achieved by students over the period of the study. It is suspected that grade inflation (upward grade creep) has occurred over this period of time, as was discussed in Chapter 3. The grade achieved for each of the school-leaving subject, English first language (HG), mathematics (HG), physical science (HG), and the adjusted matriculation points score, is interacted with each year. It is expected that if there is grade inflation, the coefficients of these interaction terms will decrease with each passing year relative to the base year, as the impact of each level of academic performance on university academic performance decreases with the passage of time, *ceteris paribus*. The coefficient of the interaction dummy is influenced by any changes in grading, the rigour and content of the course material, and the assessment practices.

The Heckman two-step estimator is used to account for the fact that not all students who started the course write the final examination. The main reason for their not writing the examination is that they do not meet the requirements to do so. For example, students are generally required to write all the tests, hand in a certain number of tutorial assignments, and attend a certain number of tutorials. The exclusion of these students in the estimations may lead to sample-selection bias (Douglas and Sulock 1995, Parker 2006); the size of the coefficients and the t-scores of each of the independent variables are biased as no account has been taken of the variables associated with the students who dropped out of the course and did not write the final examination. In general, a relatively small proportion of students did not write the final examination across the studies reported in this thesis. These relatively small proportions suggest that the sample-selection bias arising from this source may not be large, but nevertheless, it is important to determine the effect of the omitted students on the size of the coefficient, and statistical significance, of the AD course variable.

The first step of the Heckman two-step estimator is to construct a probit estimation with a binary dependent variable which takes the value of one if the student wrote the final examination. There is no set method for choosing the independent variables, nor does theory offer any guidance except the demand for an exclusion variable. The choice of variables is as much an art as a science. That said, the choice of the selected independent variables must be justified.

The independent variables included in this estimation are *Age*, *D DET*, *D HRD*, *D Enghome* and *D White*. All these variables are included in the estimations discussed above. Also included as an independent variable is the matriculation points score (*Matpt*) as a proxy for students' level of academic ability (preparedness). In addition, there is another variable, usually a test or previous examination score, which is not included in the OLS estimation. This is known as the exclusion variable. Older students who declared themselves as "white", who have a relatively high matriculation points score, and who have English as their home language are expected to experience less difficulty in adapting to the academic demands made of them at university, and are therefore more likely to write the final examination. Students who achieve relatively high test or examination marks are also deemed to be more likely to go on and complete the course and so qualify for the final examination. However, students who come from schools that formerly fell under the Department of Education and Training and the Houses of Representatives and Delegates are expected to be less likely to write the final examination.

The result of the probit estimation is used to calculate the inverse Mills ratio (IMR), which is included as an independent variable in the OLS estimations in each of the case studies of the first- and second-year courses. The IMR accounts for the sample-selection bias that arises as not all students who start a course go on to write the final examination. It does this by including the effect of the independent variables of those students who did not write the final examination on the final examination or course mark.

A key requirement in the specification of the probit estimation is that the value of the exclusion variable is determined independently of the value of the dependent variable of the OLS estimation. Ideally, there should be more than one exclusion variable but this is not possible given the data available. The requirement regarding the independence of the

exclusion and dependent variables will be addressed as each of the case studies using the Heckman two-step estimator is described.

5.2 Data base construction

Demographic and school-leaving data for some 9000 students was obtained from the university's data base. Data on students' examination and course performance was obtained from the university's data base or from the department responsible for administering the relevant course.

Only students who wrote the South African matriculation examination were included in the data base as some 96.0% of the AD students wrote this examination. The corresponding figure for mainstream students is approximately 85.0%. Students who wrote school-leaving examinations other than the South African matriculation examination were excluded whether they wrote the examination in South Africa, or not. Thus South African students who wrote examinations set by independent examining bodies at home or abroad, and foreign students who sat the equivalent school-leaving examination in their own countries were excluded from the studies. This decision was taken to ensure that the AD and mainstream cohorts shared a common background as regards their academic experience at school, and so to improve the comparability of the two groups.

Furthermore, only AD students who attended the AD courses from the beginning of the semester, or year, are included in the data base. Students, who transferred from the mainstream to an AD course during the course of the semester, or year, are either excluded from the data base or are identified as a separate group in the estimations.

Chapter 6

Analysis of first-year data

This chapter consists of three case studies: these contain the analysis of the effectiveness of the AD courses in economics, mathematics and chemistry in improving the academic performance of AD students relative to mainstream students. The analysis follows the same trajectory in each case study as it also does for the second-year case studies presented in Chapter 7. Firstly, the data for the chief characteristics of the AD and mainstream cohorts are presented and compared. Secondly, a summary of the academic performance of the AD and mainstream students in each of the courses is presented. This is followed by the results of the statistical analysis (MVA and PSM). Finally, the premiums, if any, earned by students taking the AD courses are used to establish the effect of the educational interventions on the pass rates achieved by the AD students in each of the three courses.

6.1 Microeconomics (Commerce)[43]

In this case study the examination performance of AD students taking the first-year whole-year course in microeconomics (ECO1010H) is compared to that of mainstream students who are taking the second-semester first-year course in microeconomics (ECO1010S), which is a repeat of the first-semester mainstream course in microeconomics (ECO1010F).

The chief reasons for choosing the ECO1010S cohorts as a comparison (control) group is that some 80.0% of the students registered for ECO1010S are repeating the first-year microeconomics course, having failed the first-semester mainstream course in microeconomics, ECO1010F, the previous semester. Therefore, they spend the same amount of time studying the subject as the ECO1010H cohorts and the allocation of teaching resources to the two courses is comparable. The second reason is that they tend, on average, to have a lower level of academic preparedness as measured by their matriculation points score; therefore, the difference between the average matriculation points score for the ECO1010H cohorts and the ECO1010S cohorts is smaller than the difference between the

[43] In Smith (2009a) an earlier version of this analysis is reported.

average matriculation points score for the ECO1010H cohorts and the ECO1010F cohorts. To test for the extent of the similarity between the two sets of cohorts, tests for differences of means and proportions are conducted for each of the continuous and discrete variables.

However, it is possible that the ECO1010S students are adversely selected as they are the ones who failed the first-semester first-year microeconomics course. They may have failed the course because they are less academically capable and/or prepared. As a result of failing the first-semester course the ECO1010S students may be less motivated (a negative unobservable) and more likely to underperform in the ECO1010S final examination, *ceteris paribus*.

The data for the five years 2001–2005 is pooled as AD and mainstream students did not write the same examination in 2000. The matriculation examinations are standardised across provinces and very few changes have been made to the content of the first-year microeconomics course during the period, or to the content, structure and standard of the final examination paper. Also, the same person acted as course convener and chief lecturer for ECO1010H throughout the period, which was not the case for the ECO1010S course. Also, the AD and mainstream (ECO1010S) cohorts wrote the same final examination in each of the five years at the same sitting.

6.1.1 Characteristics of the academic development and mainstream cohorts

It is clear from the data presented in table 6.1 that the two groups differ markedly from one another; with the exception of the variables *Indian*, *Male* and *Zulu FL HG* the null hypothesis of equal means and proportions can be rejected.[44] For example, the mean matriculation points score for the ECO1010S students is greater than the mean score for the ECO1010H students ($p<0.01$). The proportion of students taking economics at school is greater for the ECO1010H cohorts, and white students make up a larger proportion of the ECO1010S cohorts. Importantly, the ECO1010S cohorts show a strong bias towards mathematics (HG), English first language (HG) and physical science (HG). All these differences are statistically significant ($p<0.01$). These findings suggest that the AD and mainstream students do not come from the same population.

[44] This finding is unsurprising; a different set of criteria is used to admit students to the AD and mainstream programmes.

Table 6.1 Control variables first-year microeconomics

	ECO1010H	ECO1010S	Tests
Personal characteristics	**% share**	**% share**	**z-stat**
Black	56.1	34.9	**9.1
Indian	7.9	10.1	1.6
Coloured	25.7	17.0	**4.7
White	10.4	38.0	**13.7
English home language (Enghome)	43.4	62.9	**8.7
Male	49.5	52.3	1.2
Financial Aid (Finaid)	43.0	17.4	**12.6
	Mean	**Mean**	**t-stat**
Age	18.4	18.9	**6.5
School attended	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	17.8	10.5	**4.3
Department of Education and Training (DET)	21.7	12.3	**5.9
Matriculation points	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	33.9	37.3	**17.9
Mean adjusted matriculation points score (Adjmatpt)	23.5	24.9	**7.3
Matriculation subjects	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	68.7	82.7	**7.8
Afrikaans first language (HG) (Afrik FL HG)	4.5	5.2	0.7
Xhosa first language (HG) (Xhosa FL HG)	15.7	3.3	**18.0
Zulu first language (HG) (Zulu FL HG)	4.0	3.2	0.9
Mathematics (HG) (Math HG)	51.7	72.5	**9.5
Physical Science (HG) (PS HG)	37.4	65.3	**12.1
Economics (HG)	21.6	10.3	**6.8
Province			
Western Cape (WC)	51.7	46.3	**2.6
Other			
Commerce Faculty (Commerce)	66.6	55.4	**4.9
ECO1010S students first registration for ECO1010 (First time)	0.0	21.2	**13.6
Year			
2001	27.6	20.7	**3.5
2002	23.8	19.3	**2.6
2003	11.3	21.9	**6.1
2004	20.9	16.6	*2.2
2005	16.4	21.4	**2.8
Observations	751	1215	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ECO1010H and ECO1010S students
** and * statistically significant at the 1% and 5% levels, respectively

6.1.2 Data and results

Analysis of data

This section compares the final examination and course results of the AD (ECO1010H) and mainstream (ECO1010S) cohorts, which are presented in table 6.2.

Of the ECO1010H students, 95.1% qualified to write the final examination. The corresponding figure for the ECO1010S students is 92.5%. This suggests that the bias that may arise from excluding the students who did not write the final examination is unlikely to be large.

The ECO1010H students outperform the ECO1010S students by 4.7 percentage points in the structured/essay questions ($p<0.01$). However, the ECO1010S students had the greater success in the multiple-choice component of the final examination ($p<0.01$). The examination mark achieved by the ECO1010H cohorts in the final examination is 2.4 percentage points greater than that achieved by the ECO1010S cohorts ($p<0.01$), despite the fact that they exhibit a lower level of academic ability as measured by their performance in the matriculation examination (table 6.1). The ECO1010H cohorts also achieved a higher course mark ($p<0.01$) and pass rate ($p<0.05$) than did the ECO1010S cohorts.

Table 6.2 Examination and final results for ECO1010H and ECO1010S cohorts

	ECO1010H	ECO1010S	z-stat[2]
Examination results			
Number writing the final examination	714	1124	
Percentage	95.1	92.5	
Structured/essay questions (SQ) %	49.9	45.2	**7.0
Multiple-choice questions (MCQ) %	56.6	59.1	**3.4
Examination (exam) %	52.2	49.8	**3.8
Pass rate	56.1	51.4	*2.0
Final results			
Pass rate	67.5	62.0	*2.5
Mean course mark %[1]	53.7	51.2	**3.4
Observations	751	1215	

[1] For students who wrote the final examination only
[2] For the large number of observations the t-stat collapses into the z-stat. Therefore, only the latter is shown.
** and * statistically significant at the 1% and 5% levels, respectively

Estimation results[45]

Three variables are included in these estimations in addition to those identified in Chapter 5; whether or not the student is in the Commerce Faculty (*D Commerce*), did Economics HG as a school-leaving subject (*D Economics*), and is doing the first-year microeconomics course for the first time (*D First time*).

The majority of students doing ECO1010H and ECO1010S are registered in the Commerce Faculty. However, there are also students from the Humanities, Engineering and the Built Environment, and Science faculties. The variable *D Economics* is included to test whether students have an advantage if they took economics as a school-leaving subject. The majority

[45] The statistical programme STATA is used for all the estimations in this thesis.

of the ECO1010S cohorts are repeating the first-year microeconomics course; therefore, they have been exposed to the course material for a whole year, as have the ECO1010H cohorts.

(a) MVA estimations

To identify the impact of the AD course (ECO1010H) on academic performance in first-year microeconomics the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using OLS.

Table 6.3 shows the results of the Heckman two-step estimations for the combined ECO1010H and ECO1010S cohorts for the years 2001–2005. These cohorts include 1966 students of whom 1838 wrote the same final examination at the same sitting. The determinants of academic performance for the multiple-choice and structured/essay sections of the examination, and for the combined examination mark, are identified.

The purpose of the Heckman two-step estimator is to include the effect of the independent variables associated with those students who started the course, but who did not go on to write the final examination, on the examination mark.

The probit estimation is designed to identify the importance of the selected variables in explaining whether students wrote the final examination or not. This estimation includes the variables *Matpt*, *Age*, *D Enghome*, *D HRD*, *D DET*, *D White* and *Test 1mark* for the reasons outlined in Chapter 5. In addition the variable *D Economics* is included as it is expected that students who took economics as a school-leaving subject are more likely to write the examination. The examination mark is determined independently of the first test mark, which increases the suitability of the latter as the exclusion variable. The students' age, whether they have English as their home language, and the mark they achieved in test 1 are statistically significant in explaining whether the student wrote the final examination or not ($p<0.05$). Older students, and students who have English as their home language are less likely to write the final examination, and students with a higher first test mark are more likely to write the final examination, on average.[46]

[46] Six students are aged 30 or more.

Table 6.3 Results of the multiple-choice question, structured/essay question and examination Heckman two-step OLS estimations

	Base cases	OLS MCQ[1] (1)	t-stat	OLS SQ[2]/ Essay (2)	t-stat	OLS Exam (3)	t-stat
Dependent variable						E	
Examination mark							
Independent variables							
Probit estimation							
Matpt		-0.01	-0.43	-0.01	-0.43	-0.01	-0.43
Age		-0.11	**-4.68	-0.11	**-4.68	-0.11	**-4.68
D Enghome		-0.25	*-2.00	-0.25	*-2.00	-0.25	*-2.00
D Economics		0.13	0.89	0.13	0.89	0.13	0.89
D HRD	Model C Private	-0.01	-0.07	-0.01	-0.07	-0.01	-0.07
D DET	Model C Private	-0.03	-0.17	-0.03	-0.17	-0.03	-0.17
D White		0.03	0.23	0.03	0.23	0.03	0.23
Test1 mark		0.02	**8.39	0.02	**8.39	0.02	**8.39
Constant		2.62	**4.15	2.62	**4.15	2.62	**4.15
IMR		-42.90	**-3.66	-34.80	**-3.66	-37.50	**-3.66
OLS estimation							
D 1010H		1.50	0.67	7.92	**4.33	5.78	**2.94
Adjmatpt		0.65	*2.13	0.64	*2.58	0.65	*2.41
D Eng FL HG ABC	Eng SL HG	-1.28	-0.34	-0.50	-0.16	-0.76	-0.23
D Eng FL HG DEF	Eng SL HG	-1.05	-0.25	-0.69	-0.21	-0.81	-0.22
D Math HG ABC	Math SG	5.98	*2.17	5.15	*2.30	5.43	*2.25
D Math HG D	Math SG	3.38	1.22	3.57	1.58	3.51	1.44
D Math HG EF	Math SG	3.19	1.03	2.53	1.01	2.75	1.02
D PS HG	PS SG	2.68	1.20	1.72	0.94	2.04	1.04
D Economics		-2.11	-0.67	-1.99	-0.78	-2.03	-0.74
Age		1.22	1.63	1.12	1.85	1.16	1.77
D Enghome		-0.60	-0.20	-0.50	-0.21	-0.54	-0.21
D Male		3.38	1.70	-0.13	-0.08	1.04	0.60
D White		4.21	1.49	3.14	1.37	3.50	1.42
D Finaid		0.50	0.20	0.98	0.49	0.82	0.38
D HRD	Model C Private	1.19	0.36	1.54	0.54	1.36	0.47
D DET	Model C Private	-1.72	-0.43	0.66	0.20	-0.13	-0.04
D WC		-0.18	-0.09	-0.97	-0.57	-0.71	-0.39
D Commerce	Humanities Engineering Science	1.29	0.59	1.22	0.69	1.25	0.65
D First time		0.80	0.24	0.29	0.11	0.46	0.16
D 2002	2001	-2.07	-0.75	4.71	*2.10	2.45	1.01
D 2003	2001	-7.15	*-2.28	2.06	0.81	-1.01	-0.37
D 2004	2001	-6.69	*-2.18	6.76	**2.71	2.28	0.85
D 2005	2001	-1.21	-0.37	3.57	1.34	1.97	0.69
Constant		20.07	1.22	3.86	0.28	9.46	0.64
Wald Chi-squared (23)	35.7*		*35.20	45.4*		**46.60	29.0	29.20
Observations		1966		1966		1966	

[1] Multiple-choice questions
[2] Structured/essay questions
** and * statistically significant at the 1% and 5% levels, respectively

The result of this specification is then used to calculate the IMR, which is used as an additional explanatory variable in each of the multiple-choice, structured/essay and examination estimations. The coefficient of the IMR is negative and statistically significant ($p<0.01$) for each of the multiple-choice, structured/essay and examination estimations. Excluding those students who did not write the final examination from the estimations might lead to a biased set of estimates.

The coefficient of the ECO1010H variable *D 1010H* is 1.50 in the multiple-choice estimation, but it is statistically insignificant ($p>0.10$). The coefficient for the structured/essay question estimation is 7.92 ($p<0.01$). AD students outperform their peers taking the comparable mainstream course, ECO1010S, by 7.92 percentage points, on average, conditional on the independent variables. This finding mirrors that of Smith and Edwards (2007), who reported that ECO1010H students achieved an average of 15.0 percentage points more than the ECO1010S cohorts, conditional on the selected control variables in the structured/essay section of the first-year microeconomics examination. This robust result is consistent with the emphasis placed on language and writing skills in the AD course. The coefficient for the examination estimation is 5.78 ($p<0.01$).

As regards the three OLS estimations, only a few variables are statistically significant ($p<0.05$). These include *Adjmatpt*, *D Math HG ABC*, *D 2003* and *D 2004* (multiple-choice estimation), *D 1010H*, *Adjmatpt*, *D Math HG ABC*, *D 2002* and *D 2004* (structured/essay estimation), and *D 1010H*, *Adjmatpt* and *D Math HG ABC* (examination estimation). The chief reason for this is that the standard errors are much greater when using the Heckman two-step estimator compared to the standard OLS estimation.

The coefficient of the variable *Adjmatpt* is 0.65 for the multiple-choice estimation. Students' examination marks increase by 0.65 percentage points for each one unit increase in the adjusted matriculation points score, on average, controlling for the independent variables that are included in the estimation.[47]

The coefficient of the variable *D Math HG ABC* is 5.98 and 5.15 for the multiple-choice and structured/essay estimations, respectively. For example, students who achieve an A, B or C grade in mathematics (HG) score 5.98 percentage points more, on average, than students who took mathematics (SG) in the multiple-choice component of the final examination, conditional on the control variables.

The sign of the coefficient of the variables *D 2003* and *D 2004* is negative for the multiple-choice estimation. For example, the 2003 cohort scored 7.15 percentage points less than the

[47] The adjusted matriculation points score ranges from 11 to 36 points.

2001 cohort, on average, conditional on the independent (control) variables. The coefficient of the variable *D 2004* is 6.76 for the structured/essay estimation. This suggests that students achieved an average of 6.76 percentage points more in the structured/essay section of the examination in 2004, relative to the base year, 2001, conditional on the independent variables. The latter finding implies that either the standard of the examination varied over time, or there were changes in the supply-side factors, for example quality of teaching, assessment of coursework and examinations, and textbook in these years relative to the base year, 2001.

Table 6.4 shows the results of a second set of multiple-choice, structured/essay and examination OLS estimations for the combined ECO1010H and ECO1010S cohorts for the years 2001–2005. These results are for the 1838 students who wrote the same final examination at the same sitting. The rationale for running these estimations is that relatively few students did not write the final examination (128 students, or 6.5% of the cohorts), few studies make use of the Heckman two-step estimator, and that the standard OLS estimation generates a more robust set of results than does the Heckman two-step estimator.

Table 6.4 Results of the multiple-choice question, structured/essay question and examination OLS estimations

	Base cases	OLS MCQ[1] (1)	t-stat	OLS SQ[2]/ Essay (2)	t-stat	OLS Exam (3)	t-stat
Dependent variable							
Examination mark							
Independent variables							
D 1010H		1.75	*2.12	8.12	**10.70	6.00	**8.69
Adjmatpt		0.81	**7.42	0.77	**7.66	0.78	**8.61
D Eng FL HG ABC	Eng SL HG	-0.75	-0.55	-0.07	-0.05	-0.29	-0.26
D Eng FL HG DEF	Eng SL HG	-0.90	-0.60	-0.57	-0.41	-0.68	-0.54
D Math HG ABC	Math SG	6.93	**6.88	5.92	**6.38	6.26	**7.44
D Math HG D	Math SG	4.17	**4.08	4.22	**4.48	4.20	**4.93
D Math HG EF	Math SG	4.42	**4.36	3.53	**3.38	3.82	**4.05
D PS HG	PS SG	3.33	**4.04	2.25	**2.96	2.61	**3.80
D Economics		-1.04	-0.96	-1.12	-1.13	-1.09	-1.21
Age		0.09	0.37	0.21	0.92	0.17	0.82
D Enghome		-3.37	**-3.46	-2.76	**-3.07	-2.96	**-3.64
D Male		3.43	**4.68	-0.09	-0.13	1.08	1.78
D White		4.91	**5.08	3.71	**4.18	4.11	**5.11
D Finaid		0.37	0.41	0.87	1.04	0.71	0.93
D HRD	Model C Private	1.12	0.98	1.39	1.33	1.30	1.37
D DET	Model C Private	-2.50	-1.78	0.03	0.02	-0.81	-0.69
D WC		0.32	0.42	-0.56	-0.78	-0.26	-0.41
D Commerce	Humanities Engineering Science	1.77	*2.18	1.61	*2.17	1.66	*2.47
D First time		1.69	1.37	1.02	0.90	1.24	1.21
D 2002	2001	-1.67	-1.63	5.03	**5.33	2.80	**3.27
D 2003	2001	-7.48	**-6.43	1.79	1.68	-1.30	-1.34
D 2004	2001	-5.26	**-4.71	7.92	**7.70	3.53	**3.78
D 2005	2001	0.22	0.18	4.72	**4.26	3.22	**3.21
Constant		31.04	**5.31	12.60	*2.31	18.70	**3.82
R^2		0.137		0.167		0.152	
F-stat.			**12.50		**15.80		**14.10
Observations		1838		1838		1838	

[1] Multiple-choice questions
[2] Structured questions
** and * statistically significant at the 1% and 5% levels, respectively

Turning to the multiple-choice question results, ECO1010H students outperform the ECO1010S students by 1.75 percentage points, on average, conditional on the other explanatory variables ($p<0.05$).[48] For the Heckman two-step estimation the coefficient is 1.50 ($p>0.10$). Similarly, Smith and Edwards (2007) reported that the advantage enjoyed by the ECO1010H cohort is statistically insignificant ($p>0.10$). The finding of this case study implies that the educational interventions designed primarily to improve the academic performance of ECO1010H students in the structured/essay questions also improved their performance in the multiple-choice component of the final examination, relative to the control group.

[48] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles to check the magnitude of the educational interventions on the weakest, average and strongest students. In all cases, the coefficient of the ECO1010H variable is positive and statistically insignificant ($p>0.10$) with reference to 1.75.

For the structured/essay questions, the ECO1010H cohorts outperform the ECO1010S cohorts by 8.12 percentage points on average ($p<0.01$).[49] This finding mirrors the results of the Heckman two-step estimation (7.92) and the study by Smith and Edwards (2007), which found that the ECO1010H students achieved an average of 15.0 percentage points more than the ECO1010S students, conditional on the selected control variables. This robust result is consistent with the emphasis placed on language and writing skills in the AD course. The examination mark achieved by the ECO1010H cohorts is 6.0 percentage points higher than that achieved by the ECO1010S cohorts ($p<0.01$), on average, conditional on the independent variables.[50] For the Heckman two-step estimation the coefficient of this variable is 5.78 ($p<0.01$)

Looking at the other variables, the results are generally consistent with other studies in the field as discussed in Chapter 4.

The coefficient of the adjusted matriculation points score, *Adjmatpt*, is positive and statistically significant for the multiple-choice and structured/essay questions estimations ($p<0.01$). For example, a one unit increase in the adjusted matriculation points score increases the multiple-choice mark by 0.81 percentage points, on average, conditional on the selected explanatory variables. Academic ability as measured by the student's performance in the school-leaving examination is an important determinant of success in first-year microeconomics, and finds plenty of support in the international literature on economics education (Clauretie and Johnson 1975, Morgan and Vasche 1978, Reid 1983, Lumsden and Scott 1987, Walstad and Soper 1989, Park and Kerr 1990, Raimondo et al. 1990, Anderson et al. 1994, Robb and Robb 1999, Durden and Ellis 2003, Ballard and Johnson 2004, Cohn and Johnson 2006, Kherfi 2008, Kinney and Yakolev 2008), as well as in the South African economics education literature (Edwards 2000, Van Walbeek 2004, Smith and Edwards 2007, Horn and Jansen 2009).

[49] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficient of the ECO1010H variable is positive, and with the exception of the 80th percentile estimation, statistically insignificant ($p>0.05$) with reference to 8.12.

[50] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficient of the ECO1010H variable is positive, and with the exception of the 40th and 80th percentile estimation, statistically insignificant ($p>0.05$) with reference to 6.00.

A background in mathematics (HG) improves academic performance in multiple-choice and structured/essay questions. For example, for multiple-choice questions the average grade of students who achieved an A, B or C in mathematics (HG) (*D Math HG ABC*) is 6.93 percentage points higher than that achieved by students who took mathematics (SG) ($p<0.01$), and 5.92 percentage points higher for the structured/essay questions ($p<0.01$). The coefficients for the variables *D Math HG D* and *D Math HG EF* are also positive and statistically significant ($p<0.01$), and the difference between them is statistically insignificant ($p>0.10$).

These findings are in line with those reported in the international literature (Reid 1983, Lumsden and Scott 1987, Myatt and Waddell 1990, Raimondo et al. 1990, Robb and Robb 1999, Bachan and Reilly 2003, Durden and Ellis 2003, Ballard and Johnson 2004, Kinney and Yakolev 2008, Kherfi 2008, Lagerlöf and Seltzer 2009), and by South African researchers into the determinants of success in first-year economics (Hesketh et al. 1994, Van Walbeek 2004, Parker 2006, 2010, Smith and Edwards 2007, Horn and Jansen 2009, Dlomo et al. 2011).

These results indicate that mathematics (HG) contributes positively towards academic achievement in first-year microeconomics relative to mathematics (SG). That said, 48.3% of the ECO1010H cohorts, and 27.5% of the ECO1010S cohorts, did mathematics (SG). Given that a relatively large proportion of the two cohorts did not take mathematics (HG), they may well have benefitted from additional support when studying those sections of the microeconomics syllabus that require a good understanding of mathematics at the higher level. Implementing such changes may yield positive returns in terms of improved student academic performance.

The coefficients for English first language (HG) grades A, B and C (*D Eng FL HG ABC*) are statistically insignificant ($p>0.10$). This finding is supported by three South African studies: Edwards (2000), Van der Merwe (2006) and Horn and Jansen (2009). In contrast, Van Walbeek (2004), Parker (2006, 2007, 2010), Smith and Edwards (2007), and Dlomo et al. (2011), report that the coefficient of this variable is positive and statistically significant ($p<0.05$).

The coefficients for physical science (HG) are positive and statistically significant ($p<0.01$). Edwards (2000), Van Walbeek (2004), Smith and Edwards (2007), and Horn and Jansen (2009) report a positive and statistically significant relationship between these two variables for South African students taking first-year economics courses.

The coefficients for economics HG are negative but statistically insignificant ($p>0.10$). This result, supported by the findings of Van Walbeek (2004), Parker (2006), and Smith and Edwards (2007), implies that high-school courses in economics do not contribute towards improved performance in first-year university-level microeconomics.[51]

The results for the performance of male students relative to female students are consistent with international and South African studies for the multiple-choice component of the examination (Walstad 1990, Harris and Kerby 1997, Edwards 2000, Bachan and Reilly 2003, Van Walbeek 2004, Parker 2006, 2007, Smith and Edwards 2007, Kherfi 2008, Horn and Jansen 2009). Male students achieved an average of 3.43 percentage points more than female students, conditional on the control variables.

The coefficient for English home language (*D Enghome*) is negative and statistically significant ($p<0.01$), which is in agreement with the finding reported by Smith and Edwards (2007). To test for the possibility that students declare their home language to be English when this is not the case, a dummy variable was created, in another equation not shown here, for students who declared English as their home language and who did English first language (HG) as a school-leaving subject.[52] The coefficient for this variable is negative and statistically significant for both the multiple-choice and structured question estimations ($p<0.01$). This surprising result implies that students who declare English as their home language and who take English first language (HG) underperform their peers, conditional on the control variables.

[51] Of the ECO1010H cohorts 21.6% did economics at school. The figure for the mainstream (ECO1010S) cohorts is 10.3%.
[52] Ten students declared English as their home language and did not take English first language (HG) as a matriculation subject; 441 students who did not have English as their home language took English first language (HG) as a matriculation subject.

White students enjoy a premium of 3.71 to 4.91 percentage points. This finding is supported by Parker (2007, 2010). As noted above, this finding may be a function of the many advantages accruing to white people under the system of apartheid.

The type of school attended does not seem to be an important factor in determining subsequent academic performance; the relatively poor quality of the DET and HRD schools, and the poor socioeconomic backgrounds they represent, may well be reflected in the relatively poor academic performance of students who attended these two types of school in the matriculation examination.

The coefficient of the variable *D Commerce* is positive and statistically significant ($p<0.05$) and is in line with the finding of Smith and Edwards (2007). The coefficient for the variable *D First time* is statistically insignificant ($p>0.10$), implying that students repeating the microeconomics course enjoyed no advantage over their peers who were doing it for the first time, despite having had a whole year's exposure to the subject.

There is considerable variation in students' examination results from year to year, relative to the base year (2001). For example, the 2003 cohort underperformed the 2001 cohort by 7.48 percentage points, on average, conditional on the control variables. In the absence of more research it is not possible to say whether this difference is due to changes in the standard of the final examination or to the supply-side factors mentioned above.

Finally, the R^2 varies between 0.137 (multiple-choice estimation) and 0.167 (structured/essay question estimation); 15.2% of the variation in the examination mark is explained by the independent variables included in the estimation. This suggests that there are omitted variables that may have a significant role in explaining most of the variation in the final examination mark. However, as noted above, if an independent variable is not correlated with the treatment variable in its effect on the dependent variable, then its omission has no effect on the reliability of the coefficient of the treatment variable (*D 1010H).*

The estimation including the interaction terms (appendix A, table A1) is now considered.

There are increasing returns to academic ability (number 3) as measured by the adjusted matriculation points score and decreasing returns to age (number 5). An F-test was used to

test the joint significance of the terms *Adjmatpt* and $Adjmatpt^2$, and *Age* and Age^2. The former two variables are jointly statistically significant ($p<0.01$) and the latter two are not ($p>0.10$).

The coefficients of the interaction terms *D 1010H*D Commerce* (number 10) and *D 1010H*D DET* (number 12) are positive and statistically significant ($p<0.05$). This suggests, for example, that commerce students who are in the ECO1010H cohorts score a higher mark in the final examination, on average, than do commerce students who are in the ECO1010S cohorts, conditional on the independent variables.

The coefficients for *D 1010H*D 2003* (number 14) and *D 1010H*D 2004* (number 15) are negative and statistically significant ($p<0.05$). These two results suggest that in the years 2003 and 2004 the ECO1010H cohorts underperformed the ECO1010S cohorts in the final examination, conditional on the control variables.[53]

Each of the grade groups for each of the subjects English first language (HG), mathematics (HG) and physical science (HG), and the adjusted matriculation points score, are interacted with each of the years to test whether there has been grade inflation over the five-year period. If there has been grade inflation it is expected that the coefficient of the interaction term will be smaller for each succeeding year relative to the base year (2001); for example, the effect of a given adjusted matriculation points score on academic performance as measured by the examination mark would be expected to fall over time.

A summary of the results for these interaction variables (appendix A, table A1) is presented in table 6.5. The coefficients of only three of the interaction terms are statistically significant ($p<0.05$). Importantly, no consistent pattern emerges. For example the coefficient for the adjusted matriculation points score, interacted with the current year, relative to the base year (2001) is 0.22 in 2002, -0.43 in 2003, -0.14 in 2004, and 0.04 in 2005. The coefficient for mathematics (HG) ABC interacted with the current year, relative to the base year, rises, then falls, and then rises again. It is larger in 2005 than it was in 2002, relative to 2001, conditional on the independent variables. This inconsistent pattern is repeated for the other variables and implies that there has been no persistent grade inflation in the period 2001 to

[53] The examination means for the two cohorts for each of the five years are as follows:

	2001	2002	2003	2004	2005
ECO1010H	53.0	52.1	53.1	55.2	60.0
ECO1010S	48.8	46.4	52.1	55.2	56.7

2005 insofar as it is relevant to the cohorts that are the subject of this case study, *ceteris paribus*.[54]

Table 6.5 Selected coefficients from the first-year microeconomics interaction OLS estimation

Variables	2002	2003	2004	2005
Adjusted matriculation points score	0.22	-0.43	-0.14	0.04
Statistical significance (t-stat)	0.69	-1.35	-0.43	0.13
English first language (HG) ABC	-1.42	-2.61	-3.88	-2.72
Statistical significance (t-stat)	-0.66	-1.10	-1.77	-1.26
English first language (HG) DEF	-3.16	-0.88	-8.41	0.27
Statistical significance (t-stat)	-1.11	-0.27	**-3.05	0.09
Mathematics (HG) ABC	2.17	4.29	3.23	7.47
Statistical significance (t-stat)	0.81	1.59	1.20	**2.90
Mathematics (HG) D	0.50	3.88	2.13	3.54
Statistical significance (t-stat)	0.21	1.41	0.78	1.33
Mathematics (HG) EF	-5.76	-0.86	-4.17	2.14
Statistical significance (t-stat)	*-2.20	-0.27	-1.31	0.72
Physical Science (HG)	-1.52	0.02	0.41	1.72
Statistical significance (t-stat)	-0.72	0.01	0.19	0.81

** and * statistically significant at the 1% and 5% levels, respectively
The base year is 2001

Determinants of academic performance for each of the ECO1010H and ECO1010S cohorts

One of the objectives of this thesis is to identify the variables that may explain the academic performance of each of the AD and mainstream cohorts for each of the different courses and through to graduation. The identification of some of the key determinants of academic performance enables educators to improve their practice and achieve improved throughput rates. For example, mathematics (HG) may be shown to be an important determinant of academic performance in first-year microeconomics for AD students. If so, an additional course in the relevant mathematical concepts and techniques could be made available to those students who did not have the prerequisite grade in mathematics.

Table 6.6 shows the determinants of academic performance for each of the AD and mainstream cohorts for both the multiple-choice and structured/essay sections of the examination. Insofar as the determinants of the multiple-choice and structured/essay marks are the same for the two groups of students, it may be said that the two groups are more alike

[54] The chief assumption is that there has been no change in the standard of the final first-year microeconomics examination for the period 2001–2005. This assumption is not supported by the data given in footnote 53, which shows some evidence of grade inflation between 2001 and 2005. The other assumptions have been considered previously in Section 3.1.1.

for the purposes of the comparison of their academic performance in first-year microeconomics.

Table 6.6 Results of the multiple-choice question and structured/essay question OLS estimations for each of the ECO1010H and ECO1010S cohorts

	Base cases	OLS MCQ[1] (1)		OLS SQ[2]/ Essay (2)	
		ECO1010H	ECO1010S	ECO1010H	ECO1010S
Dependent variable					
Examination mark					
Independent variables					
Adjmatpt		**0.75	**0.80	**0.95	**0.71
D Eng FL HG ABC	Eng SL HG	-2.54	0.87	-1.60	0.56
D Eng FL HG DEF	Eng SL HG	0.05	-1.21	-0.60	-0.86
D Math HG ABC	Math SG	**6.64	**6.45	**7.13	**5.36
D Math HG D	Math SG	**5.13	*3.08	**6.13	**3.43
D Math HG EF	Math SG	**5.95	2.85	**5.86	*2.90
D PS HG	PS SG	**3.13	**3.45	*3.18	1.65
D Economics		-1.99	0.12	-1.98	-0.97
Age		-0.98	0.19	0.54	0.14
D Enghome		**-5.28	-1.93	**-6.23	-0.45
D Male		**4.08	**2.57	-0.58	-0.20
D White		**10.40	**3.63	*4.52	**2.62
D Finaid		1.47	-0.69	-0.28	0.83
D HRD	Model C Private	0.39	2.20	3.24	1.68
D DET	Model C Private	-3.40	-1.17	1.55	-1.43
D WC		0.97	0.19	-2.00	0.30
D Commerce		**5.75	0.21	*3.51	1.23
D First time			1.14		1.43
D 2002	2001	-0.62	-2.28	**4.04	**6.18
D 2003	2001	**-12.50	**-5.76	-4.06	**4.48
D 2004	2001	**-7.67	**-4.00	1.14	**12.20
D 2005	2001	0.96	-0.23	-2.84	**8.40
Constant		**35.80	**29.60	14.60	12.40
R^2		0.185	0.130	0.169	0.197
F-stat.		**7.49	**7.45	**6.71	**12.30
Observations		714	1124	714	1124

[1] Multiple-choice questions
[2] Structured questions
** and * statistically significant at the 1% and 5% levels, respectively

In general, the determinants of academic performance for both types of question are broadly similar for the two sets of cohorts. The coefficients of the variables *Adjmatpt*, *D Math HG ABC*, *D Math HG D*, and *D White* are positive and statistically significant ($p<0.05$).[55] The finding for *D White* is particularly marked for the multiple-choice section of the examination. In addition, AD and mainstream male students outperform female students in the multiple-choice component of the examination and the difference is statistically significant ($p<0.01$). Therefore, these results provide some evidence for the similarity of the two cohorts for the purpose of comparing their academic performance.

[55] Of the ECO1010H cohorts, 10.4% declared that they were white. The figure for the ECO1010S cohorts is 38.0%.

The coefficient for the variable *D Enghome* is negative and statistically significant ($p<0.01$) for the AD students for the multiple-choice and structured/essay estimations. It seems that it is the AD students who are driving the results reported for English home language presented in table 6.4.[56] The same method was used as described above with the same results. AD students who have English as their home language and who take English first language (HG) underperform their peers, conditional on the control variables. This unexpected result warrants further research.

That the coefficients for the variables *D Eng FL HG ABC* and *D Eng FL HG DEF* are statistically insignificant ($p>0.10$) may suggest that the educational interventions enabled AD students to overcome some the disadvantages associated with having a relatively poor mark for English first language (HG) or with having taken English second language (HG) in the matriculation examination.

Mathematics (HG) and physical science (HG) are important determinants of academic performance for AD students. This suggests that particular attention should be given to improving the mathematical skills of AD students who took mathematics on the standard grade.

(b) PSM estimations

The purpose of PSM is to construct a control group from the ECO1010S cohorts that shows a greater similarity to the treated group (ECO1010H cohorts) across the range of independent variables. The result of the estimation is presented in table 6.7.[57]

[56] Six students declared their home language English but did not do English first language (HG) and 196 students did English first language (HG) although they declared their home language to be other than English.
[57] Epanechnikov kernel density estimations are used throughout the thesis unless stated otherwise.

Table 6.7 Result of the PSM probit and matching estimations for first-year microeconomics

Independent variables	Probit estimation	% bias before matching "Xs"	% bias after matching "Xs"
Adjmatpt	**-0.13	**-33.8	6.2
D Eng FL HG ABC	-0.72	**-45.8	-0.5
D Eng FL HG DEF	0.20	**22.3	-6.3
D Math HG ABC	**-0.98	**-67.4	4.8
D Math HG D	**-0.40	3.3	5.8
D Math HG EF	-0.13	**18.6	-7.5
D PS HG	**-0.65	**-58.2	-4.5
D Economics	0.13	**31.2	4.6
Age	**-0.21	**-31.0	-6.9
D Enghome	-0.26	**-39.8	-5.6
D Male	**0.25	-5.3	3.4
D White	**-0.81	**-68.1	1.0
D Finaid	**0.35	**58.1	9.2
D HRD	**0.03	**21.3	-8.1
D DET	-0.12	**25.1	5.9
D WC	**0.35	*10.7	-6.2
D Commerce	**0.51	**23.1	-8.1
D 2002	0.03	*10.9	-7.0
D 2003	0.02	**-28.7	2.9
D 2004	**0.35	*11.0	8.4
D 2005	**0.51	**-12.8	7.3
Constant	**6.92		
Pseudo R^2	0.294		
LR chi^2 (21)	**721.30		
Observations	1838		

** and * statistically significant at the 1% and 5% levels, respectively

The sign of the coefficients of the variables in the probit estimation (table 6.7) and whether they are statistically significant or not indicate the probability that students in the ECO1010H cohorts would qualify for membership of the control group (ECO1010S). For example, the coefficient for the adjusted matriculation points score (*Adjmatpt*) is negative and statistically significant ($p<0.01$). This implies that the ECO1010H cohorts have a lower mean adjusted matriculation points score than the ECO1010S cohorts, and that there is a lower probability that ECO1010H students would achieve membership of the ECO1010S group on the basis of their adjusted matriculation points score. The same finding holds for mathematics (HG) ABC (*D Math HG ABC*), physical science (HG) (*D PS HG*) and age (*Age*), for example. These findings are consistent with the data presented in table 6.1.

On checking the balance of the independent variables after the matching process, it was found that the reduction in bias was considerable across all the independent variables. Indeed, none of the differences between the pre-and post-matching values of any of the independent variables remains statistically significant ($p>0.10$). Furthermore, the conditions for "common support", following Lechner (2000) (appendix D, figure D1), are mainly met. Most of the regions of the propensity score values, defined as the conditional probability of being treated given the selected independent variables, have observations from both treated (ECO1010H) and untreated groups (ECO1010S); there is some chance that a student with a given

propensity score could fall into either of the two groups. Therefore, it can be said that there are good grounds for believing that the two samples come from the same population, and that it is justified to use PSM in addition to MVA to identify the effect of the first-year AD course in microeconomics on AD students' academic performance.[58]

Turning to table 6.8 below, the mean multiple-choice mark for the ECO1010H cohorts (56.6%) is less than that for the ECO1010S cohorts (59.1%) before PSM, and the difference is statistically significant ($p<0.01$). However, after PSM the mean for the control group falls to 54.9%, which is 1.70 percentage points less than that achieved by the ECO1010H cohorts. This difference is statistically significant ($p<0.10$). The coefficient for multiple-choice estimation using OLS is 1.75 ($p<0.05$). Therefore, the two methods give a similar result (tables 6.4 and 6.8), which suggest that the educational interventions, designed primarily to improve the performance of ECO1010H students in the structured/essay questions, also improved their academic performance in the multiple-choice component of the final examination, conditional on the selected independent variables.

The mean structured/essay question mark for the ECO1010H cohorts (49.9%) is greater than that achieved by the ECO1010S cohorts (45.2%) before PSM and the difference is statistically significant ($p<0.01$). After PSM the mean for the control group falls to 41.2%, which is 8.7 percentage points less than that achieved by the ECO1010H cohorts, on average. This difference is also statistically significant ($p<0.01$).

Table 6.8 Results of the PSM estimations for first-year microeconomics

Dependent Variable	Sample	Treated ECO1010H	Controls ECO1010S	Difference	Std Error	t-stat
MCQ mark	Unmatched	56.6	59.1	-2.5	0.73	-3.38*
Estimation 1	ATT	56.6	54.9	1.7	1.01	1.74
SQ mark	Unmatched	49.9	45.2	4.7	0.67	6.98*
Estimation 2	ATT	49.9	41.2	8.7	0.94	9.31*
Exam mark	Unmatched	52.2	49.8	2.4	0.61	3.80*
Estimation 3	ATT	52.2	45.9	6.3	0.83	7.55*
Observations	1838					

ATT (Average treatment effect on the treated)
* statistically significant at the 1% level

[58] Different specifications of the probits, normal and tricube kernels, and bandwidths 0.04 to 0.08 were executed for each PSM presented in this thesis. No systematic and substantive differences across the various estimations were found.

The coefficient for structured/essay estimation using OLS is 8.12 (table 6.4) ($p<0.01$). Therefore, the two methods give a very similar result. This suggests that the educational interventions designed to improve the performance of ECO1010H students in the structured/essay questions met with some success.

The mean examination mark for the ECO1010H cohorts (52.2%) is greater than that for the ECO1010S cohort (49.8%) before PSM and the difference is statistically significant ($p<0.01$). After PSM the mean for the control group falls to 45.9%, which is 6.3 percentage points less than that achieved by the ECO1010H cohorts. This difference is also statistically significant ($p<0.01$). The coefficient on ECO1010H for the examination estimation using OLS is 6.0 ($p<0.01$). Therefore, the two methods give similar results (tables 6.4 and 6.8).

Pass rates

To calculate the effect of the educational interventions included in the AD course in first-year microeconomics (ECO1010H) on the examination and course pass rates achieved by AD, relative to mainstream students, it is necessary to identify the examination premium. The examination premiums going to ECO1010H are 5.8, 6.0 and 6.3 percentage points for the Heckman two-step, standard OLS, and PSM estimators, respectively. For the reasons outlined above (relatively few students did not write the final examination, few studies make use of the Heckman two-step estimator, and that the standard OLS estimation generates a more robust set of results than does the Heckman two-step estimator), the result of the standard OLS estimation is preferred (table 6.4) to the Heckman two-step estimation. The effect of the standard OLS premium for ECO1010H on the pass rate achieved by the AD students over the five-year period is presented in table 6.9.

Table 6.9 Examination and course pass rates for the ECO1010H cohorts

	Total	Percentage
Examination performance		
Number of students	714	100.0
Pass (premium of 6.0 percentage points)	421	59.0
Pass (no premium)	317	44.4
Course performance		
Number of students	751	100.0
Pass (premium of 3.0 percentage points)	507	67.5
Pass (no premium)	440	58.6

The average examination pass rate for ECO1010H students over the five-year period is 59.0%. However, if it is assumed that these same students had attended the ECO1010S course, they would not have enjoyed the premium of 6.0 percentage points, and the pass rate for the 714 students who wrote the final examination would have fallen to 44.4%. In other words, 104 students may be said to have passed the examination they otherwise would not have passed. This represents 15.0% of the cohorts.

The final examination counts 50.0% of the student's final course mark. Therefore, the course-mark premium is 3.0 percentage points. Applying the same analysis as that used above, the effect of the educational interventions incorporated in the ECO1010H course may be said to have resulted in 67 additional passes; this represents 8.9% of the cohorts.

It is fair to say that examination premium represents a lower bound because the educational interventions included in ECO1010H would probably have increased the students' test, essay and tutorial marks, which together contribute towards the course mark. Unfortunately, it is not possible to test for the exact size of this effect.

Overall, the results provide strong evidence that ECO1010H contributes positively towards academic performance in first-year microeconomics, particularly in the structured/essay questions. The interventions incorporated in the ECO1010H course to improve students' quantitative, learning, writing and English language skills were partly successful in enabling students to overcome some of their educational disadvantages.

6.1.3 Concluding remarks

In this section the effectiveness of educational interventions in a first-year microeconomics AD course on students' understanding is investigated.

To the extent that the ECO1010H cohorts outperformed the control group, it is possible to draw the following conclusions. The ECO1010H course had a positive impact on students' academic performance in the multiple-choice and structured/essay questions, relative to a comparable mainstream group for the five-year period. The positive impact is particularly marked for the essay/structured questions. These findings imply that the educational interventions have been applied consistently and have been effective for the majority of the cohorts in the five-year period. Finally, the pass rate for the ECO1010H cohorts in the final examination is 15.0 percentage points greater than it would have been if the AD students had attended a comparable mainstream course in first-year microeconomics.

The key variables that explain the relative success of the educational interventions in the AD course include the tutorials in economics, and language and communication, essay writing, the module designed to develop students' quantitative and graphical skills, and the smaller class size. The focus on improving students' writing and English language skills might go some way in explaining their strong performance in the structured/essay questions relative to the mainstream cohorts.

The robust and positive nature of the relationship between the ECO1010H course and students' examination performance suggest that the aims of the educational interventions – to improve students' learning, English language, writing and quantitative skills – are partly met.

6.2 Mathematics (Engineering)

In this case study the course performance of AD students taking the first-year whole-year AD course in mathematics (END1007W) is compared to that of mainstream students who are taking the first-year whole-year mainstream course in mathematics (MAM1003W).

The data for the seven years 1999–2005 is pooled. It is noted that the matriculation examinations are standardised across provinces and very few changes have been made to the content of the first-year mathematics course during the period, or to the content, structure and standard of the final examination paper. Also, the same person acted as course convener and chief lecturer for the AD course in mathematics (END1007W) throughout the period, and the AD and mainstream cohorts wrote the same tests and final examination, at the same sittings, in each of the seven years.

6.2.1 Characteristics of the academic development and mainstream cohorts

To determine the extent of the similarity between the two groups, tests for differences of means and proportions are conducted for each of the continuous and discrete variables. It is clear from the data presented in table 6.10 that the two groups differ markedly from one another, as was previously described for the AD and mainstream students taking first-year microeconomics. Again, these differences are unsurprising given the different criteria used for placing students into the mainstream and AD courses.

The mainstream cohorts exclude the 37 students who were in ASPECT but attended the mainstream course in first-year mathematics (MAM1003W).[59] These students have a matriculation points score of 41.0, on average, and a similar set of academic characteristics to those exhibited by the mainstream cohorts as shown in table 6.10.

[59] Some students are required by their bursars to be on the ASPECT programme even though they are deemed to have the ability to make a success of the mainstream course (personal communication, course convener).

Table 6.10 Control variables first-year mathematics

	ASPECT	Mainstream	Tests
Personal characteristics	**% share**	**% share**	**z-stat**
Black	84.2	25.5	**21.7
Indian	4.5	10.4	**3.7
Coloured	10.4	12.2	1.0
White	1.0	51.8	**18.8
English home language (Enghome)	16.8	70.4	**19.5
Male	68.6	78.0	**3.9
Financial Aid (Finaid)	39.6	12.7	**12.5
	Mean	**Mean**	**t-stat**
Age	19.1	18.9	*2.3
School attended	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	9.4	9.8	0.2
Department of Education and Training (DET)	58.7	12.0	**20.3
Matriculation points	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	36.0	41.7	**23.8
Mean adjusted matriculation points score (Adjmatpt)	22.1	25.9	**20.8
Matriculation subjects	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	36.1	85.6	**20.6
Afrikaans first language (HG) (Afrik FL HG)	0.1	4.7	**23.1
Xhosa first language (HG) (Xhosa FL HG)	7.7	2.1	**5.7
Zulu first language (HG) (Zulu FL HG)	10.9	1.9	**8.5
Mathematics (HG) (Math HG)	96.3	99.8	**7.0
Mathematics (HG) ABC (Math HG ABC)	55.9	93.3	**19.1
Physical Science (HG) (PS HG)	98.3	99.9	**5.2
Physical Science (HG) ABC (PS HG ABC)	69.6	93.9	**13.9
Province			
Western Cape (WC)	19.8	42.7	**8.4
Year			
1999	12.9	12.0	0.5
2000	12.6	9.8	1.6
2001	10.4	9.6	0.5
2002	14.9	14.3	0.3
2003	13.4	17.5	*2.0
2004	15.8	17.4	0.8
2005	20.0	19.6	0.2
Observations	404	1547	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ASPECT and mainstream students
** and * statistically significant at the 1% and 5% levels, respectively

The ASPECT cohorts also exclude the 28 students who started MAM1003W and subsequently transferred to the ASPECT first-year mathematics course. These students have a matriculation points score of 37.5, which is 1.5 points higher than that achieved by the ASPECT cohorts, and they have a similar set of academic characteristics to those exhibited by the mainstream cohorts as shown in table 6.10.

6.2.2 Data and results

Analysis of data

This section compares the academic performances of the ASPECT and mainstream cohorts in their first-year mathematics courses, which are presented in table 6.11.

Of the ASPECT cohorts, 94.3% qualified to write the final examination. The corresponding figure for the mainstream cohorts is 91.5%. This suggests that the bias that may arise from excluding the students who did not write the final examination may not be large.

The ASPECT cohorts achieved a slightly lower course mark (57.7%), on average, than the mainstream cohorts (58.6%), and a higher pass rate (70.5% as opposed to 65.9%). Neither of the differences, however, is statistically significant ($p>0.05$). That said, these results are notable in that the ASPECT cohorts have a lower level of academic ability on entering university as measured by their performance in the matriculation examination.

Table 6.11 Course results for the ASPECT and mainstream cohorts

	ASPECT	Mainstream	z-stat
Started first-year mathematics	404	1547	
Number of the cohorts who wrote the final examination	381	1415	
Percentage	94.3	91.5	1.9
Passed first-year mathematics	285	1019	
Percentage	70.5	65.9	1.8
Mean course mark %[1]	57.5	58.6	1.2

[1] For students who wrote the final examination only

The 37 ASPECT students who attended the mainstream course achieved an average course mark of 66.8%, and a pass rate of 91.9%. The figures for the 28 mainstream students who transferred to the ASPECT course are 52.7% and 60.7%, respectively.

Estimation results

The variables included in these estimations are those identified in Chapter 5.

(a) MVA estimations

To evaluate the impact of the AD course (END1007W) on academic performance in first-year mathematics, the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using OLS.

Table 6.12 Results of the Heckman two-step and OLS estimations for first-year mathematics

	Base cases	OLS[1]	Std Err	t-stat	OLS[2]	Std Err	t-stat
Dependent variable							
Course mark							
Independent variables							
Probit							
Matpt		0.06	0.01	**4.20			
D Math HG A		0.32	0.14	*2.23			
Age		0.12	0.03	**4.32			
D Enghome		-0.41	0.14	**-3.00			
D HRD	Model C Private	-0.07	0.16	-0.44			
D DET	Model C Private	0.19	0.16	1.18			
D White		-0.22	0.12	-1.82			
Mark Test 1		0.03	0.01	**9.35			
Constant		-3.99	0.79	**-5.03			
IMR		-45.20	10.3	**-4.41			
OLS							
D ASPECT		7.39	3.29	*2.25	10.60	1.01	**10.50
D ASPECT (mainstream)		2.36	7.91	0.30	0.69	2.33	0.29
D Mainstream (transfer to ASPECT)		2.92	8.64	0.34	2.74	2.76	0.99
Adjmatpt		0.27	0.44	0.62	0.91	0.12	**7.38
D Eng FL HG	Eng SL HG	1.39	4.48	0.31	1.13	1.39	0.81
D Math HG A	Math HG DEF Math SG	9.85	4.34	*2.27	17.50	1.23	**14.30
D Math HG B	Math HG DEF Math SG	4.74	3.73	1.27	8.00	1.17	**6.81
D Math HG C	Math HG DEF Math SG	0.84	3.43	0.25	2.21	1.10	*2.00
D PS HG AB	PS HG DEF PS SG	-0.77	3.98	-0.19	1.79	1.28	1.40
D PS HG C	PS HG DEF PS SG	-2.31	3.43	-0.67	-1.29	1.12	-1.15
Age		0.16	0.89	0.18	0.99	0.26	**3.88
D Enghome		2.30	3.33	0.69	-1.51	0.93	-1.62
D Male		0.53	2.39	0.22	0.38	0.74	0.52
D White		5.84	2.93	*2.00	4.27	0.85	**5.02
D Finaid		-0.25	2.78	-0.09	-0.19	0.87	-0.22
D HRD	Model C Private	2.52	4.05	0.62	1.56	1.19	1.31
D DET	Model C Private	2.36	4.65	0.51	2.90	1.40	*2.08
D WC		-1.28	2.24	-0.57	-1.60	0.70	*-2.27
D 2000	1999	-0.63	4.16	-0.15	-0.96	1.26	-0.76
D 2001	1999	1.40	4.12	0.34	-1.84	1.27	-1.45
D 2002	1999	-3.21	3.90	-0.82	-4.94	1.19	**-4.14
D 2003	1999	-5.07	3.93	-1.29	-11.0	1.16	**-9.50
D 2004	1999	-10.1	3.72	**-2.72	-11.7	1.13	**-10.40
D 2005	1999	-2.37	3.70	-0.64	-6.21	1.10	**-5.62
Constant		46.80	23.50	*1.99	8.32	6.45	1.29
R^2					0.373		
F-stat.							**45.30
Wald Chi^2 (24)				*41.80			
Observations		2016			1854		

[1] Heckman two-step estimation includes students who did not write the final examination
[2] Standard OLS estimation excluding students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

Table 6.12 shows the results of the Heckman two-step and standard OLS estimations for the combined AD and mainstream cohorts for the years 1999–2005. These cohorts include 2016 students of whom 1854 wrote the same final examination at the same sitting. The determinants of the final course mark (sum of the test and examination marks) are identified.

Both estimations include the ASPECT students who began END1007W, the ASPECT students who took MAM1003W, the mainstream students who transferred from MAM1003W to END1007W during the first semester, and the mainstream students who took MAM1003W.

Turning to the Heckman two-step estimation (OLS[1]), the probit estimation is designed to identify the importance of the selected variables in explaining whether students wrote the final examination or not. This estimation includes the variables *Matpt*, *Age*, *D Enghome*, *D HRD*, *D DET*, *D White* and *Test 1 mark* for the reasons outlined in Chapter 5. In addition the variable *D Math HG A* is included as it is expected that students who achieved an A grade for mathematics (HG) in the matriculation examination are more likely to write the first-year mathematics examination than those students who did not. The course mark is some function of the first test mark, *Test 1 mark*, but as it accounts for only 5.0% of that mark, it is deemed to be a suitable exclusion variable. Older students, students who achieved an A grade for mathematics (HG), a relatively high matriculation points score, and who did well in test 1 are more likely to write the final examination than students who did not meet these criteria. Students who have English as their home language are less likely to write the final examination than their peers, who do not have English as their home language, on average. The coefficients of each of these variables are statistically significant ($p<0.05$).

The coefficient of the IMR is negative and statistically significant ($p<0.01$); excluding those students who did not write the final examination from the estimation leads to a biased set of estimates.

The key finding is that the ASPECT cohorts outperform the mainstream cohorts by 7.39 percentage points, on average, conditional on the explanatory variables ($p<0.05$). The other statistically significant coefficients are those for the variables *D Math HG A*, *D White* and *D 2004* ($p<0.05$).

The second estimation (OLS[2]) is for the 1854 students who wrote the final examination. The rationale for running this estimation is that relatively few students did not write the final examination (162 students, or 8.0% of the cohorts) [60], that few studies make use of the

[60] 5.7% of the ASPECT cohorts and 8.6% of the mainstream cohorts did not write the final examination.

Heckman two-step estimator, and that the standard OLS estimation generates a more robust set of results than does the Heckman two-step estimator.

The key finding is that the ASPECT students outperform the mainstream students by 10.6 percentage points, on average, conditional on the control variables ($p<0.01$).[61] This is similar to the finding using the Heckman two-step estimation and strongly suggests that the educational interventions designed to improve the academic performance of the ASPECT cohorts in first-year mathematics, relative to the mainstream cohorts, were successful. The coefficients for the 37 ASPECT students who attended the mainstream course, and the 28 mainstream students who transferred to the ASPECT course, are positive, but statistically insignificant ($p>0.10$).

Looking at the other variables, the coefficients for the variables *Adjmatpt*, *D Math HG A*, *D Math HG B* and *D Math HG C* are all positive and statistically significant ($p<0.05$). These findings have some support in the international literature (Gardner et al. 2007, Veenstra et al. 2008). While these results are unlikely to surprise, the finding that the coefficient for physical science (HG) is statistically insignificant ($p>0.10$) may do so.

The coefficients for the variables *Age*, *D White* and *D DET* are positive and statistically significant ($p<0.05$). However, the coefficient for the variable *D WC* is negative and statistically significant ($p<0.05$). Older students, white students, and students who attended former DET schools outperform younger students, black, coloured and Indian students, and students who attended other types of school, conditional on the control variables. Van Walbeek (2004), Parker (2006), and Horn and Jansen (2009) found the effect of age to be positive and statistically significant in determining South African students' academic performance in economics; and Parker (2007, 2010) reported that white South African students exhibit a higher level of academic performance in first-year economics. Students from the Western Cape, however, were less successful than students from other parts of South Africa, conditional on the control variables. Van Walbeek (2004) and Horn and Jansen (2009) report, however, that the coefficient of the variable *D WC* is positive, and statistically significant, for first-year South African microeconomics students.

[61] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficient of the ASPECT variable is positive, and with the exception of the 80th percentile estimation, statistically insignificant ($p>0.05$) with reference to 10.6.

Finally, the R^2 is 0.373, which implies that at least 37.3% of the variation in the course mark is explained by the independent variables included in the estimation. The implication is that there are omitted variables that might have a significant role in explaining some the variation in the final course mark. However, as was noted above, if an independent variable is not correlated with the treatment variable, in its effect on the dependent variable, then its omission has no effect on the reliability of the coefficient of the treatment variable (*D ASPECT)*.

The estimation including the interaction terms (appendix A, table A2) is now considered.

There are increasing returns to academic ability (number 5) as measured by the adjusted matriculation points score and decreasing returns to age (number 7). An F-test was used to test the joint significance of the terms *Adjmatpt* and $Adjmatpt^2$, and *Age* and Age^2. The former two variables are jointly statistically significant ($p<0.01$) and the latter are not ($p>0.10$).

The coefficients for *D 2004*D ASPECT* (number 17) and *D 2005*D ASPECT* (number 18) are positive and statistically significant ($p<0.01$). These two results suggest that in the years 2004 and 2005 the ASPECT cohorts outperformed the mainstream cohorts, conditional on the control variables. However, in 2005 the ASPECT cohort achieved a lower mean mark than did the mainstream cohort.[62] These findings imply that there was some change in the educational interventions (an unobservable variable) that had a positive impact on ASPECT students' academic performance, *ceteris paribus*.

Each of the grade groups for each of the subjects English first language (HG), mathematics (HG) and physical science (HG), and the adjusted matriculation points score, are interacted with each of the years to test whether there has been grade inflation over the seven-year period. If there has been grade inflation it is expected that the coefficient of the interaction term will be smaller for each succeeding year relative to the base year (1999); for example, the effect of each of the mathematics (HG) grades A, B and C on academic performance as

[62] The final mark means for the two cohorts for each of the seven years are as follows:

	1999	2000	2001	2002	2003	2004	2005
ASPECT	62.8	62.9	61.3	56.2	53.3	54.1	54.7
Mainstream	63.0	63.7	60.3	58.0	54.4	53.6	61.2

measured by the examination mark would be expected to fall over time. A summary of the results for these interaction variables (appendix A, table A2) is presented in table 6.13.

Table 6.13 Selected coefficients from the first-year mathematics interaction OLS estimation

Variables	2000	2001	2002	2003	2004	2005
Adjusted matriculation points score	0.07	0.27	-0.27	-0.61	-0.17	0.36
Statistical significance (t-stat)	0.13	0.55	-0.55	-1.30	-0.39	0.85
English FL (HG)	8.86	4.70	4.00	6.20	5.81	5.39
Statistical significance (t-stat)	*2.51	1.45	1.30	*1.96	*1.98	1.86
Mathematics (HG) A	-3.31	-6.35	-5.09	-4.65	2.67	4.26
Statistical significance (t-stat)	-0.66	-1.31	-1.09	-0.95	0.55	0.88
Mathematics (HG) B	-5.04	-3.63	-1.53	-2.66	0.97	4.87
Statistical significance (t-stat)	-1.08	-0.80	-0.36	-0.56	0.21	1.06
Mathematics (HG) C	-6.64	-3.72	-2.46	-3.43	3.39	2.20
Statistical significance (t-stat)	-1.46	-0.86	-0.63	-0.76	0.75	0.50
Physical Science (HG) AB	3.65	-2.10	2.35	7.15	0.47	8.97
Statistical significance (t-stat)	0.69	-0.43	0.46	1.44	0.10	1.72
Physical Science (HG) C	-1.02	-1.02	-5.16	0.30	-5.65	4.54
Statistical significance (t-stat)	-0.23	-0.23	-1.31	0.07	-1.43	0.99

* statistically significant at the 5% level
The base year is 1999

The coefficients of only three of the interaction terms are statistically significant ($p<0.05$). Importantly, no consistent pattern emerges. For example, the coefficient for the variable *Mathematics (HG) A*, interacted with the current year, relative the base year (1999), is -3.31 in 2000, -6.35 in 2001, -5.09 in 2002, -4.65 in 2003, 2.67 in 2004, and 4.26 in 2005. In other words the coefficient gets smaller and then *increases* from to 2001 to 2005. The coefficient for English first language (HG) interacted with the current year, relative to the base year, falls, then rises, and then falls again. It is larger in 2005 than it was in 2001, relative to 1999, conditional on the independent variables. This inconsistent pattern is repeated for the other variables. Therefore, one can conclude that there has been no grade inflation in the period 1999 to 2005 insofar as it is relevant to the cohorts that are the subject of this case study, *ceteris paribus*.[63] As noted previously there are several qualifications to the *ceteris paribus* assumption.

[63] The chief assumption is that there has been no change in the standard of the final first-year mathematics course and examination for the period 1999–2005. This assumption is not supported by the data given in footnote 62, which shows some evidence of grade deflation between 1999 and 2005. The other assumptions have been considered previously in Section 3.1.1.

Determinants of academic performance for each of the ASPECT and mainstream cohorts

The determinants of the course mark for the ASPECT and mainstream cohorts are presented in table 6.14. Apart from the variables *D Math HG A*, *D 2003*, *D 2004* and *D 2005*, the statistically significant ($p<0.05$) determinants of academic performance differ between the AD and mainstream students. There seem to be important differences between the two groups, which imply that the mainstream cohorts are not a suitable group against which to compare the academic performance of AD students.

Table 6.14 Results of the OLS estimations for each of the ASPECT and mainstream cohorts

	Base cases	ASPECT	Mainstream
Dependent variable			
Course mark			
Independent variables			
Adjmatpt		-0.08	**1.26
D Eng FL HG	Eng SL HG	0.85	1.69
D Math HG A	Math HG DEF Math SG	**15.60	**11.30
D Math HG B	Math HG DEF Math SG	**12.80	1.81
D Math HG C	Math HG DEF Math SG	**4.70	*-3.81
D PS HG AB	PS HG DEF PS SG	2.20	3.02
D PS HG C	PS HG DEF PS SG	0.59	-0.69
Age		0.30	**1.37
D Enghome		**-7.47	-0.42
D Male		1.26	0.07
D White			**4.30
D Finaid		-2.41	0.06
D HRD	Model C Private	-0.87	2.19
D DET	Model C Private	0.51	**6.04
D WC		0.81	*-1.52
D 2000	1999	-0.76	0.24
D 2001	1999	-0.15	-1.71
D 2002	1999	-0.58	**-5.67
D 2003	1999	**-8.03	**-10.80
D 2004	1999	**-6.89	**-12.80
D 2005	1999	*-5.57	**-6.01
Constant		**51.70	-4.69
R^2		0.304	0.421
F-stat.		**7.86	**48.20
Observations		381	1415

** and * statistically significant at the 1% and 5% levels, respectively.

As regards the ASPECT cohorts, the coefficients of Mathematics (HG) A, B and C are positive and statistically significant ($p<0.01$). Unsurprisingly, a good understanding of mathematics is important if AD students are to make a success of the first-year mathematics course. That said, the course results suggest that the ASPECT course is successful in enabling AD students to master the content of first-year mathematics syllabus. The coefficient for the

variables *D 2003*, *D 2004* and *D 2005* are negative and statistically significant ($p<0.05$), conditional on the control variables.

The coefficient for the variable *D Enghome* is negative and statistically significant ($p<0.01$) for the AD students, as it was for first-year microeconomics. The same method was used as described above, with the same results. AD students who have English as their home language and who take English first language (HG) underperform their peers, conditional on the control variables.[64]

For the mainstream students the variables *Adjmatpt*, *D Math HG A*, *Age*, *D DET* and *D White* are all positive and statistically significant ($p<0.01$). However, the coefficients of the variables *D Math HG C*, *D WC*, *D 2002*, *D 2003*, *D 2004* and *D 2005* are negative and statistically significant ($p<0.05$), conditional on the control variables. The findings as regards the years 2002–2005 might be the result of a change in course delivery; examples of such supply-side variables include lecturers, tutors and assessment practices.

(b) PSM estimation

The purpose of PSM is to construct a control group from the mainstream cohorts that shows a greater similarity to the treated group (ASPECT cohorts) across the range of independent variables. The ASPECT students who started MAM1003W, and the mainstream students who transferred to END1007W, are excluded from the estimation, the result of which is presented in table 6.15.

[64] One student declared their home language English but did not do English first language (HG), and 79 students did English first language (HG) although they declared their home language to be other than English.

Table 6.15 Result of the PSM probit and matching estimations for first-year mathematics

	Probit estimation	% bias before matching "Xs"	% bias after matching "Xs"
Independent variables			
Adjmatpt	**-0.09	**-115.0	8.0
D Eng FL HG	*-0.34	**-108.6	-0.07
D Math HG A	**-1.77	**-94.7	-4.8
D Math HG B	**-1.32	**-17.3	0.7
D Math HG C	**-1.11	**16.6	2.4
D PS HG AB	**-1.01	**-113.3	0.8
D PS HG C	**-0.53	**52.6	-3.2
Age	-0.03	*11.9	1.3
D Enghome	**-0.71	**-121.3	-0.2
D Male	*-0.26	**-22.0	-1.9
D Finaid	0.02	**62.5	6.4
D HRD	**0.45	-0.3	-5.9
D DET	**0.69	**103.0	-7.3
D WC	-0.07	**-48.4	0.0
D 2000	*0.38	8.5	-0.3
D 2001	0.03	1.3	-9.4
D 2002	-0.17	2.2	-13.0
D 2003	0.32	-10.3	6.5
D 2004	0.26	-3.8	7.7
D 2005	**0.49	2.5	*14.0
Constant	**3.81		
Pseudo R^2	0.499		
LR chi^2 (20)	**926.20		
Observations	1796		

** and * statistically significant at the 1% and 5% levels, respectively

The sign of the coefficients of the variables in the probit estimation (table 6.15) and whether they are statistically significant or not indicate the probability that ASPECT students would qualify for membership of the mainstream control group. The findings of the probit estimation are consistent with the data presented in table 6.10.

On checking the balance of the independent variables after the matching process it was found that the reduction in bias was considerable across all the variables. Indeed, none of the differences between the pre- and post-matching values of any of the variables remained statistically significant ($p>0.05$), with the exception of the variable *D 2005*. The conditions for "common support", however, are not met (appendix D, figure D2). Few of the regions of the propensity score values have observations from both the treated (ASPECT) and untreated (mainstream) groups; there seems to be only a small chance that a student with a given propensity score could fall into both the treated and control groups. Therefore, the results of the PSM estimations must be interpreted with caution.

Turning to table 6.16, the mean course mark for the ASPECT cohorts (57.5%) is less than that for the mainstream cohorts (58.6%) before PSM and the difference is statistically insignificant ($p>0.10$). However, after PSM the mean for the mainstream control group falls

to 50.7%, which is 6.8 percentage points less than that achieved by the ASPECT cohorts. This difference is statistically significant ($p<0.01$).

Table 6.16 Result of the PSM estimation for first-year mathematics

Dependent Variable	Sample	Treated ASPECT	Controls Mainstream	Difference	Std Error	t-stat
Course mark	Unmatched	57.5	58.6	-1.1	0.93	-1.13
Estimation 1	ATT	57.5	50.7	6.8	1.63	*4.20
Observations	1838					

ATT (Average treatment effect on the treated)
* statistically significant at the 1% level

The coefficient for course mark estimation using OLS is 10.6 (table 6.12), and is statistically significant ($p<0.01$). Therefore, the two methods give a similar result. This implies that the educational interventions designed to improve the academic performance of ASPECT students in the first-year mathematics course were successful.

Pass rates

To calculate the effect of the educational interventions included in the AD course in first-year mathematics (END1007W) on the course pass rates achieved by AD students, relative to mainstream students, it is necessary to identify the course premium. The course premiums going to the END1007W are 7.4, 10.6 and 6.8 percentage points for the Heckman two-step, standard OLS, and PSM estimations, respectively. For the reasons outlined above, the result of the standard OLS estimation is preferred (table 6.12). That said, the effect of all three premiums on the pass rate achieved by the ASPECT students for the period 1999–2005 are presented in table 6.17.

Table 6.17 Course pass rates for the ASPECT cohorts

	Total	Percentage
Course performance		
Number of students	404	100.0
Pass (no premium)	187	46.3
Pass (premium of 7.0 percentage points) PSM and Heckman	285	70.5
Pass (no premium)	148	36.6
Pass (premium of 10.6 percentage points) OLS	285	70.5

The mean examination pass rate for the seven-year period is 70.5%. If it is assumed, however, that these same students attended the mainstream course, the results imply that they would not have enjoyed the premium of 10.6 percentage points, and the pass rate for the 404

students who started the course would have fallen to 36.6%. In other words, 137 students may be said to have passed the course they otherwise would not have passed. This represents 33.9% of the cohorts. For the premium of 7.0 percentage points, 98 additional students passed who would otherwise not have passed, or 24.2% of the cohorts.

Overall, the results provide strong evidence that the ASPECT course in first-year mathematics (END1007W) contributes positively towards AD students' academic performance.

6.2.3 Concluding remarks

In this section the effectiveness of educational interventions in the first-year AD course in mathematics (END1007W) is investigated.

To the extent that the ASPECT cohorts outperformed the mainstream control group, it is possible to draw the following conclusions. The ASPECT course had a positive impact on AD students' academic performance relative to mainstream students for the seven-year period. These findings suggest that the educational interventions have been applied consistently and have been effective for the majority of the cohorts throughout the seven-year period. Finally, the pass rate for the ASPECT cohorts is at least 19.8 percentage points greater than it would have been if the AD students had attended the mainstream course in first-year mathematics.

The robust and positive nature of the relationship between the ASPECT course and students' course performance implies that the aims of the educational interventions are largely met.

6.3 Chemistry (Science)

In this case study the course performance of AD students taking the first-year whole-year (CEM1009H) and second-year first-semester AD (CEM1010F) courses in chemistry are compared to that of mainstream students taking the first-year whole-year mainstream course in chemistry (CEM1000W).

The data for the seven years 1999–2005 is pooled. Few changes have been made to the content of the first-year chemistry course during the period, or to the content, structure and standard of the final examination paper, and the same people acted as course convener and chief lecturer for each of the two AD courses in chemistry (CEM1009H and CEM1010F). AD students cover the same material in CEM1009H and CEM1010F as do the mainstream students in CEM1000W. In contrast to the first-year courses in microeconomics and mathematics, AD and mainstream students did not write the same final examination. That said, although the methods of assessment may differ, they are of a similar standard and are moderated by the same external examiner.

6.3.1 Characteristics of the academic development and mainstream cohorts

The data for the control variables are presented in table 6.18. To determine the extent of the similarity between the two groups, tests for differences of means and proportions are conducted for each of the continuous and discrete variables.

Table 6.18 Control variables first-year chemistry

	GEPS CEM1009H	Mainstream CEM1000W	Tests
Personal characteristics	**% share**	**% share**	**z-stat**
Black	64.1	12.0	*22.0
Indian	5.8	8.4	1.9
Coloured	22.8	11.0	*6.6
White	6.8	67.3	*24.6
English home language (Enghome)	34.7	80.5	*18.9
Male	54.1	39.7	*5.6
Financial Aid (Finaid)	54.5	10.3	*19.5
	Mean	**Mean**	**t-stat**
Age	19.1	19.0	1.9
School attended	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	20.4	9.0	*6.4
Department of Education and Training (DET)	38.1	5.2	*16.9
Matriculation points	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	32.8	41.1	*40.9
Mean adjusted matriculation points score (Adjmatpt)	20.5	25.8	*34.1
Matriculation subjects	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	51.1	89.9	*17.6
Afrikaans first language (HG) (Afrik FL HG)	3.1	8.6	*4.9
Xhosa first language (HG) (Xhosa FL HG)	13.4	1.2	*9.9
Zulu first language (HG) (Zulu FL HG)	8.6	2.0	*6.4
Mathematics (HG) (Math HG)	75.0	93.9	*11.0
Mathematics (HG) ABC (Math HG ABC)	15.4	71.6	*22.9
Physical Science (HG) (PS HG)	77.0	97.9	*13.4
Province			
Western Cape (WC)	39.8	57.4	*6.8
Year			
1999	11.8	9.5	1.5
2000	17.5	7.5	*6.2
2001	14.6	14.4	0.1
2002	16.7	18.0	0.7
2003	14.0	14.6	0.5
2004	12.3	19.6	*3.9
2005	13.4	16.4	1.7
Observations	701	945	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between GEPS and mainstream cohorts
* statistically significant at the 1% level

It is clear from the data presented in table 6.18 that the two groups differ markedly from one another; with the exception of the variables *Indian* and *Age*, the null hypothesis of equal means and proportions can be rejected. Again, these differences are unsurprising given the different criteria used for placing students into the mainstream and AD courses.

6.3.2 Data and results

Analysis of data

This section compares the academic performance of the GEPS and mainstream cohorts. The results for first-year AD (CEM1009H) and mainstream (CEM1000W) chemistry courses are presented in table 6.19.

Table 6.19 Course results for GEPS (CEM1009H) and mainstream cohorts

	GEPS CEM1009H	Mainstream CEM1000W	z-stat
Started first-year chemistry courses	701	945	
Number of the cohorts who wrote the final examination	675	921	
Percentage	96.3	97.5	1.4
Passed CEM1009H/CEM1000W first time	488	633	
Percentage	69.6	67.0	1.1
Mean course mark %[1]	55.5	57.3	*2.9

[1] For students who wrote the final examination only
* statistically significant at the 1% level

Of the GEPS cohorts, 96.3% qualified to write the final examination. The corresponding figure for the mainstream cohorts is 97.5%, and the difference is statistically insignificant ($p>0.10$). This suggests that the bias that may arise from excluding the students who did not write the final examination is small.

The mainstream cohorts achieved a higher course mark than did the GEPS cohorts, on average (57.3% versus 55.5%), and the difference is statistically significant ($p<0.01$). The GEPS cohorts achieved a higher pass rate (69.6% versus 67.0%), however, and the difference is statistically insignificant ($p>0.10$). That said, it must be borne in mind that CEM1009H does not cover the content of the full first-year chemistry course, and that the AD and mainstream students were not subject to the same means of assessment.

The results for the students taking CEM1010F and CEM1000W are compared in table 6.20.[65] Only 35.4% of the cohorts who took CEM1009H went on to CEM1010F in the following year because they did not pass the course, or for some other reason.[66] This relatively low proportion suggests that the academic performance of the CEM1010F cohorts is probably driven by selection. Unfortunately, it is not possible to account for the possibility of selection bias.

[65] As was previously noted, AD and mainstream students did not write the same tests and examinations, although the tests and examinations were set to the same standard, and the examination was moderated by the same external examiner.
[66] The student may have left the university, been excluded from the university, transferred to another faculty, decided not to continue with chemistry, or failed the course (private communication from the course convener of CEM1009H).

Table 6.20 Course results for GEPS (CEM1010F) and mainstream cohorts

	GEPS CEM1010F	Mainstream CEM1000W	z-stat
Started first-year chemistry courses	701	945	
Started CEM1010F	248		
Percentage	35.4		
Number of the cohorts who wrote the final examination	232	921	
Percentage	93.5	97.5	*2.5
Passed CEM1010F/CEM1000W first time	161	633	
Percentage	64.9	67.0	**3.6
Mean course mark %[1]	54.3	57.3	**2.7

[1] For students who wrote the final examination only
** and * statistically significant at the 1% and 5% levels, respectively

Of the GEPS cohorts, 93.5% qualified to write the final CEM1010F examination. The corresponding figure for the mainstream cohorts is 97.5%, and the difference is statistically significant ($p<0.05$). It follows that the bias that may arise from excluding the students who did not write the final examination is unlikely to be large. The pass rate achieved by the mainstream cohorts exceeds that achieved by the GEPS cohorts (67.0% versus 64.9%) and the difference is statistically significant ($p<0.01$). The mean course mark achieved by the mainstream cohorts exceeds that achieved by the GEPS cohorts by 3.0 percentage points, and the difference is also statistically significant ($p<0.01$).

These findings are unsurprising given that AD students have a lower level of academic ability as measured by their performance in the school-leaving examination.

Estimation results

The variables included in these estimations are those identified in Chapter 5.

(a) MVA estimations

To evaluate the impact of the first-year AD courses (CEM1009H and CEM1010F) on the academic performance of the AD students relative to the mainstream students, the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using MVA. In the following estimations the academic performance of the CEM1010F and mainstream students is compared as both groups have covered the first-year chemistry course by the time they write their respective examinations.

Given that the AD and mainstream cohorts were not subject to the same assessment regime, and given the unknown role played by selection into CEM1010F, these estimations can act only as a guide to the relative academic performance of the two groups of students and to the effectiveness of the educational interventions included in the two AD first-year courses (CEM1009H and CEM1010F).

Table 6.21 shows the results of the OLS and logit estimations. The OLS estimation has the final course mark as the dependent variable and excludes those students who did not write the final examination. The logit estimation has a dichotomous dependent variable; 1 if the student passed the first-year course and 0 if the student failed the first-year course.[67]

Table 6.21 Results of the OLS and logit estimations for first-year chemistry

	Base cases	OLS (1)	Std Err	t-stat	Logit (2)	z-stat	dF/dx
Dependent variable							
Course mark							
Independent variables							
D GEPS		15.20	1.20	**12.70	2.35	**8.78	**0.35
D GEPS (mainstream)		5.10	2.22	*2.27	1.40	*2.45	*0.21
Adjmatpt		1.96	0.13	**15.30	0.21	**7.04	**0.04
D Eng FL HG	Eng SL HG	-0.09	1.39	-0.06	0.36	1.21	0.07
D Math HG ABC	Math SG	6.19	1.23	**5.03	0.88	**3.43	**0.19
D Math HG D	Math SG	1.65	1.27	1.29	0.26	0.99	0.05
D Math HG EF	Math SG	-0.55	1.32	-0.42	-0.09	-0.32	-0.02
D PS HG ABC	PS SG	6.01	1.50	**4.00	1.11	**3.41	**0.23
D PS HG D	PS SG	3.12	1.52	*2.06	0.23	0.72	0.04
D PS HG EF	PS SG	5.48	1.78	**3.08	0.31	0.83	0.06
Age		0.56	0.27	*2.06	0.01	0.23	0.01
D Enghome		-1.40	1.10	-1.28	-0.59	*-2.38	*-0.11
D Male		-0.14	0.66	-0.22	-0.13	-0.88	-0.03
D White		4.29	0.93	**4.63	0.92	**4.57	**0.19
D Finaid		-1.29	0.97	-1.33	-0.17	-0.85	-0.04
D HRD	Model C Private	-0.14	1.16	-0.12	0.14	0.58	0.04
D DET	Model C Private	1.30	1.46	0.89	0.68	*2.24	*0.12
D WC		0.99	0.69	1.43	0.46	**2.91	**0.09
D 2000	1999	-0.32	1.42	-0.22	-0.17	-0.53	-0.03
D 2001	1999	2.36	1.31	1.80	0.34	1.13	0.07
D 2002	1999	-1.14	1.27	-0.90	-0.46	-1.60	-0.09
D 2003	1999	-0.14	1.33	-0.11	-0.35	-1.17	-0.07
D 2004	1999	-2.22	1.28	-1.73	-0.77	**-2.69	**-0.16
D 2005	1999	-1.84	1.31	-1.40	-0.99	**-3.39	**-0.21
Constant		15.30	6.69	-2.30	-6.68	**-4.54	
R^2	0.375						
F-stat.		**28.90					
LR Chi^2 (24)						**282.70	**280.10
Pseudo R^2					0.182		0.181
Observations		1183			1223		1223

OLS estimation excludes students who did not write the final examination
Logit estimation includes students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

[67] It is not possible to do the Heckman two-step estimation as no test marks are available for the two groups of students; that is, there is not a suitable exclusion variable.

As regards the OLS estimation, the key finding is that the GEPS cohorts outperform the mainstream cohorts by 15.2 percentage points, on average, conditional on the explanatory variables ($p<0.01$).[68] The coefficient for the 30 mainstream students who attended the AD courses is 5.10, and is also statistically significant ($p<0.01$).

The coefficients of the variables *Adjmatpt*, *D Math HG ABC*, *D PS HG ABC*, *D PS HG D*, *D PS HG EF*, *Age* and *D White* are all positive and statistically significant ($p<0.05$). It is not surprising that physical science (HG) contributes to academic performance in the first-year chemistry courses; physical science includes physics and chemistry, in equal measure. Finally, it is noted that the R^2 is 0.375, which implies that at least 37.5% of the variation in the course mark is explained by the independent variables included in the estimation.

As regards the logit estimation, the coefficients for the GEPS dummy variable *D GEPS* is positive and statistically significant ($p<0.01$). The coefficient for the mainstream students who did the AD courses is also positive and statistically significant ($p<0.05$).

The coefficients for the variables *Adjmatpt*, *D Math HG ABC*, *D PSHG ABC*, *D White*, *D DET* and *D WC* are all positive and statistically significant ($p<0.05$).

The coefficient for the variable *D Enghome* is negative and statistically significant ($p<0.01$) as it was for first-year microeconomics and mathematics. The same method was used as described above with the same results. Students who have English as their home language and who take English first language (HG) underperform their peers, conditional on the control variables.[69]

The marginal effects for each of the independent variables are shown in the last column of table 6.21. For example, the probability of an AD student's passing first-year chemistry increases by 35.0 percentage points, on average, relative to the average mainstream student. For each one-point increase in the adjusted matriculation points score, the probability of a

[68] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficient of the CEM1010F variable is positive, and with the exception of the 80th percentile estimation, statistically insignificant ($p>0.05$) with reference to 15.2.

[69] Three students declared their home language English but did not do English first language (HG) and 139 students did English first language (HG) although they declared their home language to be other than English.

student's passing increases by 4.0 percentage points, on average. Also, the probability of passing for students who achieved an A, B or C grade for mathematics (HG) is increased by 19.0 percentage points, on average. All three coefficients are statistically significant ($p<0.01$).[70]

These findings suggest that the educational interventions designed to improve the academic performance of the GEPS cohorts in first-year chemistry were successful, relative to the mainstream cohorts. These findings must, however, be interpreted with considerable caution given the selection problem and the fact that the AD and mainstream students were subject to similar, though not identical, means of assessment. These findings are, however, not dissimilar to those reported for the case studies of first-year microeconomics and mathematics courses and so lend additional weight to the view that the first-year AD courses are successful in improving the academic performance of AD students relative to mainstream students.

The case study also highlights the fact that academic ability, as measured by the adjusted matriculation points score and the grades achieved for mathematics (HG) and physical science (HG), plays an important role in determining whether students succeed in the first-year chemistry course. The other key variable in explaining students' academic performance is whether they declared themselves to be "white" when applying to study at the university. These results mirror those reported for South African students by Bokhorst et al. (1990) (psychology), Curtis and De Villiers (1992) (commerce AD course), Jawitz (1992) (engineering), Sawyer (1994) (commerce), De Villiers and Rwigema (1998) (commerce), Edwards (2000) (first-year economics), Van Rooyen (2001) (bridging programme), Van Walbeek (2004) (first-year microeconomics), Parker (2006, 2007, 2010) (first-year economics), Smith and Edwards (2007) (first-year microeconomics) and Horn and Jansen (2009) (first-year economics).

[70] In interpreting the dF/dx of the logits, it is for the hypothetical student with average values for all the covariates, and not for all students. This is due to the non-linear nature of the logit function.

Determinants of academic performance for each of the CEM1009H, CEM1010F and CEM1000W cohorts

The determinants of the course mark for the CEM1009H, CEM1010F and CEM1000W cohorts are presented in table 6.22. Apart from the variable *D Math HG ABC*, the statistically significant ($p<0.05$) determinants of academic performance differ between the AD and mainstream students. It seems that there are important differences between the two groups, and that the mainstream cohorts are not a suitable group against which to compare the academic performance of AD students.

Table 6.22 Results of the OLS estimations for each of the GEPS and mainstream cohorts

	Base cases	**GEPS CEM1009H**	**GEPS CEM1010F**	**Mainstream CEM1000W**
Dependent variable				
Course mark				
Independent variables				
Adjmatpt		**0.46	0.48	**2.25
D Eng FL HG	Eng SL HG	1.34	-0.66	0.47
D Math HG ABC	Math SG	**3.73	*6.27	**4.29
D Math HG D	Math SG	*2.40	2.25	0.33
D Math HG EF	Math SG	1.07	-0.32	-1.63
D PS HG ABC	PS SG	1.87	0.31	*5.91
D PS HG D	PS SG	0.33	1.87	2.75
D PS HG EF	PS SG	0.58	-0.06	3.12
Age		-0.38	-0.53	**1.01
D Enghome		*-2.64	-4.16	-1.04
D Male		-0.26	-2.19	0.31
D White		**6.50	2.42	**4.12
D Finaid		-0.56	-1.25	-0.86
D HRD	Model C Private	-0.06	0.35	-1.01
D DET	Model C Private	-1.40	-0.08	3.48
D WC		1.20	*5.51	0.66
D 2000	1999	**6.98	*-5.69	1.47
D 2001	1999	2.83	*-6.26	**5.02
D 2002	1999	2.53	*-5.89	-0.05
D 2003	1999	-1.50	-2.19	0.78
D 2004	1999	**11.70	-3.22	-1.77
D 2005	1999	**5.27	-4.72	-0.80
Constant		**47.4	**58.20	**-31.40
R^2		0.242	0.150	0.447
F-stat.		**9.43	*1.67	**33.00
Observations		674	232	921

** and * statistically significant at the 1% and 5% levels, respectively

The coefficients of the variables *D Math HG ABC* and *D 2000* are positive and statistically significant for the AD courses CEM1009H and CEM1010F ($p<0.05$). The coefficients of the variables *Adjmatpt*, *D Math HG D*, *D White*, *D 2004* and *D 2005* are positive and statistically significant for the CEM1009H cohorts ($p<0.01$). In addition, the coefficient of the variable *D WC* is positive and statistically significant ($p<0.05$), and the coefficients of the variables

D 2001 and *D 2002* are negative and statistically significant ($p<0.05$) for the CEM1010F cohorts. It seems that AD students who have not achieved a relatively good grade in mathematics would benefit from a course designed to improve their understanding of the content of the matriculation syllabus.

The coefficient for the variable *D Enghome* is negative and statistically significant ($p<0.01$) for the AD students (CEM1009H), as it was for the AD students taking first-year microeconomics and first-year mathematics. It seems that it is the AD students who are driving the result reported for English home language presented in table 6.21. The same method was used as described above but with different results. The coefficient of the dummy variable identifying students who declare English and who took English first language (HG) is negative and statistically insignificant ($p>0.05$) for both the AD cohorts, CEM1009H and CEM1010F. More research is necessary to determine the implication of this unexpected finding.

The coefficients of the variables *Adjmatpt*, *D Math HG ABC*, *D White*, *D PS HG ABC*, *Age* and *D 2002* are positive and statistically significant for the mainstream cohorts ($p<0.05$).

(b) PSM estimation

The 30 mainstream students who transferred to the AD course are excluded from the PSM estimation; the result of the estimation is presented in table 6.23.

The sign of the coefficients for the variables in the probit estimation (table 6.23) and their statistical significance are consistent with the data presented in table 6.18 and are unsurprising given the criteria for placement into the mainstream and AD courses.

Table 6.23 Result of the PSM probit and matching estimations for first-year chemistry

	Probit estimation	% bias before matching "Xs"	% bias after matching "Xs"
Independent variables			
Adjmatpt	**-0.33	**-183.4	**84.5
D Eng FL HG	0.20	**-95.7	*22.2
D Math HG ABC	**-1.27	**-154.2	**-73.9
D Math HG D	-0.30	**24.5	-4.0
D Math HG EF	0.41	**84.4	**60.8
D PS HG ABC	**-1.88	**-139.3	-17.1
D PS HG D	**-1.80	**37.4	7.9
D PS HG EF	**-1.28	**77.8	-13.6
Age	-0.04	0.5	**-38.5
D Enghome	**-0.87	**-114.5	*24.3
D Male	-0.21	12.3	*-22.6
D Finaid	0.88	**127.6	**82.8
D HRD	**0.98	**40.0	*24.5
D DET	0.55	**84.6	-20.4
D WC	0.36	**-37.0	-0.4
D 2000	**0.79	**31.9	**-40.5
D 2001	0.24	-6.9	*19.3
D 2002	-0.08	3.4	16.4
D 2003	**0.87	-3.3	7.0
D 2004	**0.96	*-17.9	-15.3
D 2005	**1.23	-6.4	**24.4
Constant	**8.71		
Pseudo R^2	0.679		
LR chi^2 (21)	**786.50		
Observations	1153		

** and * statistically significant at the 1% and 5% levels, respectively

On checking the balance of the independent variables after the matching process, it was found that the reduction in bias was considerable across most of the variables. That said, the differences between the pre- and post-matching values for many of the variables remained statistically significant ($p<0.05$): *Adjmatpt, D Eng FL HG, D Math HG ABC, D Math HG EF, Age, D Male, D Enghome, D Finaid, D HRD, D 2000, D 2001* and *D 2005*. In addition, the conditions for "common support" are not met (appendix D, figure D3). Few of the regions of the propensity score values have observations from both the treated (GEPS) and untreated (mainstream) groups; there seems to be a small chance that a student with a given propensity score could fall into the treated and control groups. Therefore, the results of the PSM estimations must be interpreted with great caution.

Turning to table 6.24, the mean course mark for the GEPS cohorts(54.3%) is less than that for the mainstream cohorts (57.3%) before PSM and the difference is statistically significant ($p<0.01$). After PSM, however, the mean for the mainstream control group falls to 41.0%, which is 13.3 percentage points less than that achieved by the GEPS (treatment group), and this difference is also statistically significant ($p<0.01$).

Table 6.24 Result of the PSM estimation for first-year chemistry

Dependent Variable	Sample	Treated GEPS	Controls Mainstream	Difference	Std Error	t-stat
Course mark	Unmatched	54.3	57.3	-3.0	0.97	*-3.14
Estimation 1	ATT	54.3	41.0	13.3	4.21	*3.16
Observations	1153					

ATT (Average treatment effect on the treated)
* statistically significant at the 1% level

The coefficient for course mark estimation using OLS is 15.2 (table 6.21), which is statistically significant ($p<0.01$). The results of the estimations shown in tables 6.21 and 6.24 are similar and lend support to the view that the educational interventions designed to improve the academic performance of GEPS students in the first-year chemistry course were successful, subject to the various caveats identified above.

Pass rates

To calculate the effect of the educational interventions included in the AD courses in first-year chemistry (CEM1009H and CEM1010F) on the course pass rates achieved by AD students, relative to mainstream students, it is necessary to identify the course premium. The course premiums going to the CEM1010F cohorts are 15.2 and 13.3 for the standard OLS and PSM estimations, respectively. The result of the standard OLS estimation is preferred (table 6.21) to the PSM estimations as many of the variables are not "matched" and there is a lack of "common support". The effect of the premium of 15.2 percentage points on the pass rate achieved by the CEM1010F cohorts is shown in table 6.25.

Table 6.25 Course pass rates for the GEPS cohorts

	Total	Percentage
Course performance		
Number of students	248	100.0
Pass (no premium)	39	15.7
Pass (premium of 15.2 percentage points)	161	64.9

The mean pass rate for the seven-year period is 64.9%. If it is assumed that these same students had attended the mainstream course, however, they would not have enjoyed the premium of 15.2 percentage points. Then pass rate for the 248 students who started the course would have fallen to 15.7%. In other words, 122 students may be said to have passed the course they otherwise would not have passed. This represents 49.2% of the cohorts.

The effect of the premium on the pass rates offers evidence that the GEPS courses in first-year chemistry (CEM1009H and CEM1010F) contribute positively towards AD students' academic performance, bearing in mind the different methods of assessment and the selection problem discussed above.

6.3.3 Concluding remarks

In this section the effectiveness of educational interventions in the first-year AD courses in chemistry (CEM1009H and CEM1010F) is investigated. To the extent that the GEPS cohorts outperformed the mainstream cohorts, conditional on the selected control variables, it is possible to draw the following conclusions.

The GEPS courses had a positive impact on AD students' academic performance relative to the mainstream cohorts for the seven-year period and the educational interventions have been applied consistently throughout the seven-year period.

That said, the findings are qualified, given that GEPS and mainstream students were subject to different, though similar, forms of assessment and that there is the unaccounted selection problem that arises as the majority of the GEPS cohorts do not go on to complete the second of the two first-year AD courses in chemistry (CEM1010F).

These findings are, however, similar to those reported for the first-year AD courses in microeconomics and mathematics. This lends additional weight to the view that the educational interventions included in the CEM1009H and CEM1010F courses were effective in improving the academic performance of AD students.

6.4 Summary discussion

In this section the key findings as regards the first-year case studies are discussed.

The characteristics of each of the three AD groups and the comparable mainstream groups are shown in table 6.26. In general, the microeconomics and chemistry AD cohorts have a similar set of characteristics, except that the chemistry course (CEM1009H) has a higher proportion

of students who did mathematics (HG) and physical science (HG), and a lower proportion of students who come from the Western Cape Province. The profile of the mathematics AD students, however, is substantially different. This group contains a greater proportion of black students, male students, students who attended former DET schools, and students who took mathematics and physical science (HG), and a smaller proportion of students who have English as their home language, are on financial aid, attended former HRD schools, took English first language (HG), and reside in the Western Cape Province. Finally, the chemistry students have lower average matriculation points and adjusted matriculation points scores, relative to the other two groups.

Table 6.26 Control variables for each of the first-year AD and mainstream courses

	Economics ECO1010H	Mathematics ASPECT	Chemistry CEM1009H	Economics Mainstream	Mathematics Mainstream	Chemistry Mainstream
Personal characteristics	**% share**	**% share**	**% share**	**% share**	**% share**	**% share**
Black	56.1	84.2	64.1	34.9	25.5	12.0
Indian	7.9	4.5	5.8	10.1	10.4	8.4
Coloured	25.7	10.4	22.8	17.0	12.2	11.0
White	10.4	1.0	6.8	38.0	51.8	67.3
English home language (Enghome)	43.4	16.8	34.7	62.9	70.4	80.5
Male	49.5	68.6	54.1	52.3	78.0	39.7
Financial Aid (Finaid)	43.0	39.6	54.5	17.4	12.7	10.3
	Mean	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Age	18.4	19.1	19.1	18.9	18.9	19.0
School attended	**% share**	**% share**	**% share**	**% share**	**% share**	**% share**
HRD	17.8	9.4	20.4	10.5	9.8	9.0
DET	21.7	58.7	38.1	12.3	12.0	5.2
Matriculation points	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Mean matriculation points score (Matpt)	33.9	36.0	32.8	37.3	41.7	41.1
Mean adjusted matriculation points score (Adjmatpt)	23.5	22.1	20.5	24.9	25.9	25.8
Matriculation subjects	**% share**	**% share**	**% share**	**% share**	**% share**	**% share**
English first language (HG) (Eng FL HG)	68.7	36.1	51.1	82.7	85.6	89.9
Afrikaans first language (HG) (Afrik FL HG)	4.5	0.1	3.2	5.2	4.7	8.6
Xhosa first language (HG) (Xhosa FL HG)	15.7	7.7	13.4	3.3	2.1	1.2
Zulu first language (HG) (Zulu FL HG)	4.0	10.9	8.6	3.2	1.9	2.0
Mathematics (HG) (Math HG)	51.7	96.3	75.0	72.5	99.8	93.9
Physical Science (HG) (PS HG)	37.4	98.3	77.0	65.3	99.9	97.9
Economics	21.6			10.3		
Province						
Western Cape	51.7	19.8	39.8	46.3	42.7	57.4
Year						
1999		12.9	11.8		12.0	9.5
2000		12.6	17.5		9.8	7.5
2001	27.6	10.4	14.6	20.7	9.6	14.4
2002	23.8	14.9	16.7	19.3	14.3	18.0
2003	11.3	13.4	14.0	21.9	17.5	14.6
2004	20.9	15.8	12.3	16.6	17.4	19.6
2005	16.4	20.0	13.4	21.4	19.6	16.4
Observations	751	404	701	1215	1547	945

Therefore, it is fair to say that although the students in the three AD groups have a relatively low level of academic ability (preparedness), on average, as measured by their academic performance in the matriculation examination, they differ from one another in a number of respects.

The profiles of the students from the three mainstream courses show a greater degree of similarity than do the profiles of the AD students. That said, a smaller proportion of mainstream chemistry students declared themselves black, are male, received financial aid and attended a former DET school, but a greater proportion have English as their home language. Students taking the mainstream microeconomics course have lower matriculation and adjusted matriculation points scores, on average, and a smaller proportion took mathematics (HG) and physical science (HG) in their matriculation examination than mainstream students taking mathematics or chemistry.

The course results for each of the AD and mainstream groups for each of the three courses are given in table 6.27. In all cases, more than 90.0% of each of the AD and mainstream students wrote the final examination and, and with the exception of CEM1010F, the AD students achieved a higher pass rate than their peers on the mainstream. As regards the mean course mark, only the ECO1010H students outperformed the mainstream students.

Table 6.27 Results for each of the first-year AD and mainstream courses

	Economics		Mathematics		Chemistry		
	ECO1010H	**ECO1010S**	**ASPECT END1007W**	**Mainstream MAM1003W**	**GEPS CEM1009H**	**GEPS CEM1010F**	**Mainstream CEM1000W**
Percentage of cohorts who wrote final examination	95.1	92.5	94.3	91.5	96.3	93.5	97.5
Pass rate	67.5	62.0	70.5	65.9	69.6	64.9	67.0
Mean course mark %[1]	53.7	51.2	57.5	58.6	55.5	54.3	57.3
Observations	751	1215	404	1547	701	248	945

[1] For students who wrote the final examination only

MVA estimations

The results of each the OLS estimations for the first-year courses in microeconomics, mathematics and chemistry are shown in table 6.28.

Table 6.28 Results of the examination and course mark standard OLS estimations for each of the three first-year courses

	Base cases	Microeconomics	Mathematics	Chemistry
Dependent variable		**Exam mark**	**Course mark**	**Course mark**
Independent variables				
D GEPS (CEM1010F)				**15.20
D ASPECT (END1007W)			**10.60	
D 1010H		**6.00		
Adjmatpt		**0.78	**0.91	**1.96
D Eng FL HG	Eng SL HG		1.13	-0.09
D Eng FL HG ABC	Eng SL HG	-0.29		
D Eng FL HG DEF	Eng SL HG	-0.68		
D Math HG A	Math HG DEF Math SG		**17.50	
D Math HG B	Math HG DEF Math SG		**8.00	
D Math HG C	Math HG DEF Math SG		*2.21	
D Math HG ABC	Math SG	**6.26		**6.19
D Math HG D	Math SG	**4.20		1.65
D Math HG EF	Math SG	**3.82		-0.55
D PS HG	PS SG	**2.61		
D PS HG AB	PS HG DEF PS SG		1.79	
D PS HG C	PS HG DEF PS SG		-1.29	
D PS HG ABC	PS SG			**6.01
D PS HG D	PS SG			*3.12
D PS HG EF	PS SG			**5.48
D Economics		-1.09		
Age		0.17	**0.99	*0.56
D Enghome		**-2.96	-1.51	-1.40
D Male		1.08	0.38	-0.14
D White		**4.11	**4.27	**4.29
D Finaid		0.71	-0.19	-1.29
D HRD	Model C Private	1.30	1.56	-0.14
D DET	Model C Private	-0.81	*2.90	1.30
D WC		-0.26	*-1.60	0.99
D Commerce	Humanities Engineering Science	*1.66		
D First time	Repeats	1.24		
D 2000	1999		-0.96	-0.32
D 2001	1999		-1.84	2.36
D 2002	2001 1999	**2.80	**-4.94	-1.14
D 2003	2001 1999	-1.30	**-11.00	-0.14
D 2004	2001 1999	**3.53	**-11.70	-2.22
D 2005	2001 1999	**3.22	**-6.21	-1.84
Constant		**18.70	8.32	*15.30
R^2		0.152	0.373	0.375
F-stat.		**14.10	**45.30	**28.90
Observations		1838	1854	1183

** and * statistically significant at the 1% and 5% levels, respectively

The coefficient for each of the AD courses is positive and statistically significant ($p<0.01$). These results imply that the educational interventions included in each of the three AD courses were successful in improving the academic performance of AD students relative to their peers on the mainstream. That said, the methods employed to secure internal validity in each of the three studies are not entirely successful; there remains the possibility of omitted variable bias and the sample-selection problem.

The coefficients of the variables *Adjmatpt*, *D Math HG ABC* (*D Math HG A*, *D Math HG B* and *D Math HG C*) and *D White* are positive and statistically significant ($p<0.05$) in explaining students' academic performance. Academic ability, as measured by the adjusted matriculation points score and the mathematics (HG) result, plays a crucial role in determining whether students succeed in the first-year courses in microeconomics, mathematics and chemistry. The importance of proficiency in mathematics suggests that every effort should be made by the South Africa's secondary and tertiary education systems to improve students' competence in this area.

There are several international studies that identify the student's performance in the school-leaving examination as the key determinant of first-year university academic performance (Devadoss and Foltz 1996 (USA) (first-year economics), McKenzie and Schweitzer 2001 (Australia) (first-year general), McKenzie et al. 2004 (Australia) (first-year general), Win and Miller 2005 (Australia) (first-year general), Shulruf et al. 2008 (New Zealand) (first-year general), Mora and Escardíbul 2008 (Spain) (first-year general)).

A number of South African studies report similar findings (Bokhorst et al. 1990 (first-year psychology), Jawitz 1992 (engineering), Sawyer 1994 (commerce), Jawitz 1995 (engineering), De Villiers and Rwigema 1998 (commerce), Edwards 2000 (first-year economics), Van Rooyen 2001 (bridging programme), Van der Flier et al. (2003) (mathematics and science foundation programme), Van Walbeek 2004 (first-year microeconomics), Smith and Edwards 2007 (first-year microeconomics and macroeconomics), Horn and Jansen (2009) (first-year economics)).

Several international studies report the important role played by mathematics in determining academic performance at university. These include Lumsden and Scott (1987) (UK), Levin and Wyckoff (1988) (USA), Myatt and Waddell (1990) (Canada), Astin and Astin (1992) (USA), McKenzie and Schweitzer (2001) (Australia), Bachan and Reilly (2003) (USA), Durden and Ellis (2003) (USA), Ballard and Johnson (2004) (USA), Gardner et al. (2007) (USA), Veenstra et al. (2007) (USA), Kinney and Yakolev (2008) (USA), Kherfi (2008) (United Arab Emirates), Veenstra et al. (2008) (USA), De Winter and Dodou (2011) (Netherlands), and Min et al. (2011) (USA).

Several South African studies report similar findings for first-year economics (Van Walbeek 2004, Parker 2006, 2007, 2010, Smith and Edwards 2007, Horn and Jansen 2009), mathematics (Van der Flier et al. 2003), and chemistry (Potgieter et al. 2010).

The coefficients for years 2002, 2004 and 2005 are positive and statistically significant ($p<0.01$) for the first-year microeconomics examinations. This suggests that the 2002, 2003 and 2004 cohorts outperformed the 2001 cohort by at least 2.80 percentage points, on average, conditional on the control variables. The coefficients for the years 2002, 2003, 2004 and 2005 are negative and statistically significant ($p<0.01$) for the first-year mathematics examinations. This suggests that the 2002, 2003, 2004 and 2005 cohorts underperformed the 1999 cohort by at least 4.94 percentage points, on average, conditional on the control variables. The variation in each cohort's academic performance by year is possibly due to the supply-side factors mentioned above. These include the quality of lecturers and tutors, course administration and presentation, textbook, and standard of the tests and examination. The academic preparedness of students may also play a role, although the matriculation results and the estimations discussed above do not suggest that there was a significant variation in students' academic performance for the period under consideration. That said, the finding that the 2002 to 2005 mathematics cohorts underperformed the 1999 cohort is disconcerting and may warrant more investigation.

The results of each of the OLS estimations for each of the AD courses are given in table 6.29.

Table 6.29 Results of the examination and course mark standard OLS estimations for each of the AD courses

	Base cases	ECO1010H MCQ[1] OLS	ECO1010H SQ[2] OLS	END1007W OLS	CEM1009H OLS	CEM1010F OLS
Dependent variable		**Exam mark**	**Exam mark**	**Course mark**	**Course mark**	**Course mark**
Independent variables						
Adjmatpt		**0.75	**0.95	-0.08	**0.46	0.48
D Eng FL HG	Eng SL SG			0.85		-0.66
D Eng FL HG ABC	Eng SL SG	-2.54	-1.60			
D Eng FL HG DEF	Eng SL SG	0.05	-0.60			
D Math HG A	Math HG DEF Math SG			**15.60		
D Math HG B	Math HG DEF Math SG			**12.80		
D Math HG C	Math HG DEF Math SG			*4.70		
D Math HG ABC	Math SG	**6.64	**7.13		**3.74	**6.27
D Math HG D	Math SG	**5.13	**6.13		*2.40	2.25
D Math HG EF	Math SG	**5.95	**5.86			
D PS HG	PS SG	**3.13	*3.18			
D PS HG AB	PS HG DEF PS SG			2.20		
D PS HG C	PS HG DEF PS SG			0.59		
D PS HG ABC	PS SG					0.31
D PS HG D	PS SG					1.87
D PS HG EF	PS SG					-0.06
D Economics		-1.99	-1.98			
Age		-0.98	0.54	0.30		-0.53
D Enghome		**-5.28	**-6.23	**-7.47	*-2.64	-4.16
D Male		**4.08	-0.58	1.26		-2.19
D White		**10.40	*4.52		**6.49	2.42
D Finaid		1.47	-0.28	-2.41		-1.25
D HRD	Model C Private	0.39	3.24	-0.87		0.35
D DET	Model C Private	-3.40	1.55	0.51		-0.08
D WC		0.97	-2.00	0.81		*5.51
D Commerce	Humanities Engineering Science	**5.75	*3.51			
D 2000	1999			-0.76	**6.98	*-5.69
D 2001	1999			-0.15		*-6.26
D 2002	2001 1999	-0.62	**4.04	-0.58		*-5.89
D 2003	2001 1999	**-12.50	-4.06	**-8.03		-2.19
D 2004	2001 1999	**-7.67	1.14	**-6.89	**11.70	-3.22
D 2005	2001 1999	0.96	-2.84	*-5.57	**5.27	-4.72
Constant		**35.80	14.60	**51.70	**47.40	**58.20
R^2		0.185	0.169	0.304	0.242	0.150
F-stat.		**7.49	**6.71	**7.86	**9.43	*1.67
Observations		714	714	381	674	232

[1] Multiple-choice questions estimation
[2] Structured/essay questions estimation
** and * statistically significant at the 1% and 5% levels, respectively

Only the coefficients of Mathematics (HG) are positive and statistically significant ($p<0.05$) for the three AD cohorts. The importance of proficiency in mathematics for AD students suggests that every effort should be made by the university to improve students' competence in this area.

Of the other variables, the coefficients of the variables *Adjmatpt* and *D White* are positive and statistically significant for the economics and chemistry courses ($p<0.05$). The poor academic performance of the ASPECT cohorts in the years 2003–2005, relative to the year 1999, is cause for concern and may warrant further investigation.

The coefficient of the variable *D Enghome* is negative and statistically significant ($p<0.05$), for all three of the AD cohorts. This result has been discussed in some detail in this chapter and begs the question as to why this should be the case. More research is required to explain this peculiar phenomenon.

Chapter 7

Analysis of second-year data

Three case studies are presented in this chapter. These are an analysis of the effectiveness of the first-year AD courses in microeconomics, mathematics and chemistry in improving the academic performance of AD students relative to mainstream students in the same set of second-year courses. The analysis follows the same trajectory as employed for each of the first-year studies.

These studies make an important advance with respect to the literature in this area in addition to those already mentioned in Chapter 1. The academic performance of each student is tracked until such time as they pass, withdraw from, or are excluded from the second-year course. Smith and Edwards' (2007) study considered only the academic performance of students the first time that they took the second-year microeconomics course.

The second-year studies considered in this chapter are all subject to an additional sample-selection problem. Not all the students who start first-year courses in any one of the three subjects go on to take the second-year course in the same subject. It is possible that there is a different set of variables, in addition to the fact that the student qualifies to go on to the second-year course, which determine whether the student goes on to do the second-year course. Unfortunately, it is not possible to test whether this is indeed the case, given the available data.

7.1 Microeconomics (Commerce)[71]

The empirical aim of this case study is to measure the impact of the educational interventions included in the first- and second-year microeconomics courses on the academic performance of AD students in the second-year mainstream microeconomics course (ECO2003F), relative to the academic performance of mainstream students. This case study analyses the effectiveness of the educational interventions for two periods: the first (2000–2002) and the

[71] In Smith and Ranchhod (forthcoming) an earlier version of this analysis is reported.

second (2003–2005).[72] In the first period AD students were given no additional academic support in the second-year course. In the second period, however, AD students were offered the opportunity to attend voluntary workshops, which were designed to address the difficulties posed by the more mathematical nature of the second-year course as of 2003.

The effect of the educational interventions in the first-year AD microeconomics course (ECO1010H) on AD students' academic performance in ECO2003F is estimated for the first period. Insofar as the academic performance of the ECO1010H cohorts is improved, relative to mainstream students, there might be long-run benefits that follow from the educational interventions included in the ECO1010H course.

The combined effect of the first-year interventions and the voluntary workshops on AD students' academic performance in ECO2003F is also estimated for the second period. If the academic performance of the ECO1010H students is improved, relative to mainstream students, it follows that there might be long-run and short-run benefits that follow from the ECO1010H course and workshop attendance, respectively.

Furthermore, the effect of the voluntary workshops on AD students' academic performance in ECO2003F is estimated for the second period. The latter estimation makes it possible to isolate the short-run benefits of the educational interventions, which are included in the voluntary workshops and are designed to enable students to deal with the more mathematical nature of the second-year microeconomics course, independently of the generic contribution of the ECO1010H course.

The academic performance of the AD cohorts is compared to two mainstream groups. The first group consists of those students who took ECO1010S in their first year. It is these students who were used as the mainstream comparison group in the first-year study described in Chapter 6. The second mainstream group consists of all the students who attended the first-semester mainstream course in microeconomics (ECO1010F). This group includes those students who repeated the first-semester first-year microeconomics course (ECO1010F) in the second semester (ECO1010S).

[72] The period covered by each of the three second-year studies is 2000–2005. The 1999 cohorts can only take a second-year course in 2000.

7.1.1 Characteristics of the academic development and mainstream cohorts

The chief characteristics of the AD (ECO1010H) and mainstream (ECO1010S) cohorts for each of the two periods are presented in table 7.1.[73]

Table 7.1 Control variables for second-year microeconomics[74]

	PERIOD 1 2000−2002			PERIOD 2 2003−2005		
	AD ECO1010H	Mainstream ECO1010S	Tests	AD ECO1010H	Mainstream ECO1010S	Tests
Personal characteristics	**% share**	**% share**	**z-stat**	**% share**	**% share**	**z-stat**
Black	55.6	28.9	**6.1	62.0	29.3	**7.5
Indian	5.9	6.1	0.1	7.5	14.2	*2.5
Coloured	22.2	17.1	1.5	30.5	22.0	*2.2
White	16.3	47.8	**7.9	0.0	34.6	**5.4
English home language (Enghome)	46.1	68.4	**5.1	35.8	68.7	**7.5
Male	52.3	42.5	**2.2	44.4	44.3	0.0
Financial aid (Finaid)	42.8	16.7	**6.4	41.9	17.1	**6.2
	Mean	**Mean**	**t-stat**	**Mean**	**Mean**	**t-stat**
Age at entry (Age)	18.3	18.5	*2.0	18.3	18.9	**6.5
School attended	**% share**	**% share**	**z-stat**	**% share**	**% share**	**z-stat**
HRD (HRD)	17.0	10.5	1.5	20.1	13.4	*2.0
DET (DET)	18.3	9.2	**5.3	25.4	11.0	**4.3
Matriculation points	**Mean**	**Mean**	**t-stat**	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	32.4	37.4	**19.1	36.2	39.7	**13.5
Mean adjusted matriculation points score (Adjmatpt)	21.5	25.3	**15.0	25.3	26.4	**3.8
Matriculation subjects	**% share**	**% share**	**z-stat**	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	71.6	86.8	**4.2	65.6	87.0	**5.7
Afrikaans first language (HG) (Afrik FL HG)	3.3	5.3	1.17	6.8	5.3	0.7
Xhosa first language (HG) (Xhosa FL HG)	14.7	2.2	**4.9	16.5	2.0	**5.6
Zulu first language (HG) (Zulu FL HG)	2.6	2.2	0.3	6.8	3.3	**3.3
Mathematics (HG) (Math HG)	46.1	67.5	**4.9	67.4	76.8	*2.3
Physical Science (HG) (PS HG)	37.6	55.3	**4.1	41.6	58.1	**3.8
Province						
Western Cape (WC)	45.8	44.3	0.3	52.0	43.1	*2.0
Other						
Commerce Faculty (Commerce)	53.6	93.0	**9.8	94.6	92.7	0.9
Courses attendance						
Mean number /4	1.6	1.2	**6.2	1.5	1.2	**5.3
Year						
D 2000	26.5	25.8	0.2			
D 2001	39.5	34.2	1.3			
D 2002	34.0	39.9	1.4			
D 2003				40.7	19.0	**5.5
D 2004				22.7	45.9	**5.5
D 2005				36.6	35.1	0.4
Observations	306	228		279	246	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ECO1010H and ECO1010F students
** and * statistically significant at the 1% and 5% levels, respectively

It is clear from the data presented in table 7.1 that the ECO1010H and ECO1010S cohorts differ markedly from one another; with the exception of the variables *Indian*, *Coloured*, *HRD*, *Zulu FL HG* (first period), and *Male* and *Commerce* (second period), the null

[73] The table comparing the control variables for the AD and mainstream (ECO1010F) (including the students who went on to do ECO1010S) students can be found in appendix A, table A3.
[74] As regards the variable *Course attendance* in this table, a student can attend the second-year course up to a maximum number of four times.

hypothesis of equal means and proportions can be rejected. These findings are not surprising, given the different criteria for placement into the first-year courses, and the relatively high rate of flow from the first-year courses through to the second-year course.

7.1.2 Data and results

Analysis of data

This section compares academic course performance and throughput rates for AD (ECO1010H) and mainstream students (ECO1010F and ECO1010S) for each of the two periods.[75] The data are presented in table 7.2.

Table 7.2 ECO2003F academic performance and throughput rates: AD (ECO1010H) and mainstream cohorts (ECO1010S and ECO1010F (includes ECO1010S))

	2000–2002					2003–2005				
	1010H	**1010S**	**z-stat**	**1010F**	**z-stat**	**1010H**	**1010S**	**z-stat**	**1010F**	**z-stat**
ECO2003F										
Started ECO2003F	306	228		2217		279	246		2513	
Pass first time	113	94		1594		129	87		1809	
Percentage	36.9	41.2	1.0	71.9	*13.9	46.2	35.4	*2.5	72.0	*10.4
Pass	205	158		1987		186	174		2318	
Percentage	67.0	69.3	0.6	89.6	*11.0	66.7	70.3	0.9	92.2	*13.3
Write final examination	290	218		2172		264	227		2462	
Percentage	94.8	95.6	0.4	98.0	*3.4	94.6	92.3	1.1	98.0	*3.5
			t-stat		**t-stat**			**t-stat**		**t-stat**
Mean final mark percent[1]	50.6	50.2	0.5	58.7	*12.7	50.1	51.3	1.4	60.3	*14.4
			z-stat		**z-stat**			**z-stat**		**z-stat**
ECO1010H/F										
Started ECO1010H/F	503	348		2759		357	346		2832	
Passed ECO1010H/F first time	307			1944		262			2075	
Percentage	61.0			70.5	**6.6	73.4			73.3	0.3
Started ECO2003F	306	228		2217		279	246		2513	
Percentage	60.8	65.5	1.1	80.4	**11.3	78.2	71.1	*2.1	88.7	**5.8
Passed ECO2003F	205	158		1987		186	167		2318	
Percentage	40.8	45.4	1.2	72.0	*13.7	52.1	48.3	0.9	81.9	*13.0

[1] Excluding students who did not write the final examination
Pass rates are calculated on basis of best final mark excluding performance in the supplementary examination
** and * statistically significant at the 1% and 5% levels, respectively

First, the academic performance of the AD (ECO1010H) and mainstream (ECO1010S) cohorts is compared. The pass rate for the ECO1010S students doing ECO2003F is 69.3% in the first period, which is 2.3 percentage points higher than that achieved by the ECO1010H cohorts, a difference that is statistically insignificant (p>0.10). In the second period the difference is 3.6 percentage points (70.3% versus 66.7%), and is also statistically

[75] The ECO1010F cohorts include those students who repeated the course in the following semester (ECO1010S cohorts).

insignificant (p>0.10). The ECO1010H cohorts' mean final mark for ECO2003F is 0.4 percentage points greater than that achieved by the ECO1010S cohorts in the first period and 1.2 percentage points smaller in the second period. Both these differences are statistically insignificant (p>0.10). Finally, a smaller proportion of the cohorts who started ECO1010H passed ECO2003F, relative to the ECO1010S cohorts in the first period (40.8% versus 45.4%). However, the positions are reversed in the second period (52.1% versus 48.3%). Neither of these differences is statistically significant (p>0.10).

These findings indicate that the ECO1010H and ECO1010S cohorts performed on a par in the second-year microeconomics course, even though the AD students have a lower level of academic ability as measured by their matriculation points score. The implication is that the educational interventions included in the ECO1010H course enabled the ECO1010H students to improve their academic performance in the second-year microeconomics course relative to the ECO1010S cohorts, as they had done in the first-year microeconomics course, as discussed in Chapter 6.

The academic performance of the AD and mainstream (ECO1010F) students is now discussed. The pass rate for ECO2003F is 89.6% for the ECO1010F cohorts in the first period, which is 22.6 percentage points greater than that for the ECO1010H cohorts. In the second period the difference is 25.5 percentage points (92.2% versus 66.7%). In both periods a greater proportion of the ECO1010H cohorts did not write the final examination, and a smaller proportion passed the course at the first attempt.[76] Also, the mean mark achieved by the ECO1010H students for ECO2003F is 8.1 percentage points lower than that achieved by the ECO1010F students in the first period (50.6% versus 58.7%) and 10.2 percentage points lower in the second period (50.1% versus 60.3%).

Finally, a smaller proportion of the cohorts who started ECO1010H passed ECO2003F relative to the ECO1010F cohorts in the first (40.8% versus 72.0%) and second (52.1% versus 81.0%) periods. That said, the throughput rate for both the ECO1010H and ECO1010F cohorts improved in the second period; the improvement for the ECO1010H cohorts is 11.3 percentage points and for the ECO1010F cohorts 9.9 percentage points. All these differences are statistically significant (p<0.05) with the exception of the percentage of AD and

[76] Duly performed (DP) requirements to write the examination were introduced only in 2005. This is the reason for the relatively high proportion of students who sat the examination.

ECO1010F students who passed the first-year microeconomics course in the second period at the first time of writing.

The relatively poor academic performance of the AD students is not unexpected, given their relatively poor performance in the matriculation examination. That said, the AD students did benefit from the first-year AD course in microeconomics, which improved their academic performance relative to the ECO1010S students, as was discussed in Chapter 6.

Estimation results

Two variables are included in these estimations in addition to those identified in Chapter 5; whether the student is in the Commerce Faculty (*D Commerce*) as the majority of students doing ECO2003F are registered in the Commerce Faculty, and the number of times the student took the second-year course (*Courses attended*). The latter variable is an integer and ranges from 1 to 4.

(a) MVA estimations

To evaluate the impact of the AD course (ECO1010H) on students' academic performance in second-year microeconomics, the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using OLS.

The Heckman two-step estimator and OLS are used to evaluate the impact of the first-year AD course in microeconomics (ECO1010H) and workshop attendance on students' academic performance in the second-year microeconomics course. The focus of the discussion is the academic performance of the ECO1010H and ECO1010S cohorts relative to the ECO1010F cohorts; the ECO1010F cohorts include the ECO1010S cohorts. The analysis is conducted for two periods: the first (2000–2002) and the second (2003–2005).

First period

The results of the Heckman two-step and OLS estimations for the combined ECO1010H, ECO1010S and ECO1010F cohorts for the first period (2000–2002) are presented in table 7.3. These cohorts include 2679 students of whom 2571 wrote the final examination.

Table 7.3 Results of the Heckman two-step and standard OLS estimations for the first period (2000−2002); ECO1010H and ECO1010S versus ECO1010F (includes ECO1010S)

	Base cases	OLS[1]	Std Err	t-stat	OLS[2]	Std Err	t-stat
Dependent variable Course mark							
Independent variables							
Probit							
Matpt		0.02	0.01	1.94			
Age		-0.06	0.04	-1.67			
D Enghome		-0.25	0.16	-1.54			
D HRD	Model C Private	-0.03	0.19	-0.18			
D DET	Model C Private	-0.30	0.21	-1.41			
D White		0.21	0.14	1.50			
ECO1010 course mark		0.024	0.005	**5.01			
Constant		1.14	0.90	1.27			
IMR		-87.5	55.5	-1.58			
OLS							
D 1010H		-2.88	7.44	-0.39	1.02	0.79	1.28
D 1010S		-0.65	6.29	-0.10	-4.46	0.68	**-6.54
Adjmatpt		0.54	0.66	0.83	1.03	0.06	**16.1
D Eng FL HG	Eng SL HG	-1.36	8.97	-0.15	-0.73	1.01	-0.72
D Math HG ABC	Math SG	1.36	5.69	0.24	2.96	0.64	**4.65
D Math HG DEF	Math SG	0.46	5.52	0.08	0.94	0.63	1.49
D PS HG	PS SG	1.01	4.26	0.24	2.07	0.47	**4.38
Age		0.69	1.72	0.40	-0.02	0.18	-0.14
D Enghome		2.67	5.71	0.47	0.16	0.59	0.27
D Male		-0.19	3.41	-0.05	0.51	0.38	1.37
D White		0.33	4.87	0.07	2.69	0.49	**5.45
D Finaid		1.03	5.43	0.19	1.13	0.61	1.86
D Commerce	Humanities	-2.21	6.62	-0.33	-1.04	0.74	-1.40
D HRD	Model C Private	1.18	6.87	0.17	0.62	0.73	0.85
D DET	Model C Private	4.81	10.6	0.46	1.03	1.12	0.91
D WC		0.05	3.50	0.02	0.01	0.39	0.01
Courses attended		0.22	3.22	0.07	-0.78	0.36	*-2.17
D 2001	2000	-0.75	4.11	-0.18	-0.75	0.46	-1.64
D 2002	2000	-2.22	4.28	-0.52	-1.34	0.47	**-2.84
Constant		34.80	39.60	0.88	28.00	4.29	**6.51
R^2					0.244		
F-stat.							**48.00
Wald Chi^2 (19)		4.12					
Observations		2679			2571		

[1] Heckman two-step estimation includes students who did not write the final examination
[2] Standard OLS estimation excluding students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

The Heckman probit estimation (OLS[1]) includes the variables *Matpt*, *Age*, *D Enghome*, *D HRD*, *D DET* and *D White* for the reasons outlined in Chapter 5. The exclusion variable is the mark achieved by the student in the first-year microeconomics examination (*ECO1010 course mark*); this variable is determined independently of the ECO2003F course mark. Only the positive coefficient of the latter variable is statistically significant ($p<0.01$). The coefficient of IMR is negative but statistically insignificant ($p>0.10$), which suggests that

omitting the students who did not write the final examination from the OLS estimation does not result in a biased estimate of the coefficient of the treatment variable.[77]

Turning to the OLS estimation (OLS^2), the coefficient for the variable *D 1010H* is 1.02 and is statistically insignificant ($p>0.10$). The coefficient for the ECO1010S dummy variable *D 1010S* is, however, -4.46 and is statistically significant ($p<0.01$).[78] The difference between the two coefficients is, using a Wald test, statistically significant ($p<0.01$). The ECO1010H students outperformed the ECO1010S students by 5.48 percentage points, on average, conditional on the independent variables in the first period. The results also imply that the ECO1010H cohorts performed on a par with ECO1010F cohorts, conditional on the independent variables.

Of the other independent variables, the coefficients of *Adjmatpt*, *D Math HG ABC*, *D PS HG* and *D White* are positive and statistically significant ($p<0.01$). These findings are similar to those reported in studies cited in Chapter 4 regarding the determinants of academic performance in first-year economics courses. These findings are also similar to those reported in Chapter 6 regarding the determinants of academic performance in the multiple-choice and structured/essay questions in first-year microeconomics. Furthermore, the coefficient of the variable *D 2002* is negative and statistically significant ($p<0.01$), which suggests that students scored 1.51 percentage points less in 2002 relative to the base year, 2000, on average.

Two quadratic terms, $Adjmatpt^2$ and Age^2, were also included in an equation not shown, to establish the returns to academic ability, as measured by the adjusted matriculation points score and by age. The returns to academic ability are positive and statistically significant ($p<0.01$). This implies that the course mark increases at a faster rate, on average, than does the adjusted matriculation points score. The returns to age are positive, but statistically insignificant ($p>0.10$).

In summary, the ECO1010H course enabled the AD students to achieve a higher course mark in the second-year microeconomics course than that achieved by a comparable group of

[77] 94.8% of the ECO1010H cohorts, 95.6% of the ECO1010S cohorts, and 98.0% of the ECO1010F cohorts wrote the ECO2003F examination.
[78] Quantile estimations were run for the 20^{th}, 40^{th}, 50^{th}, 60^{th} and 80^{th} percentiles. In all cases, the coefficients of the ECO1010H and ECO1010S variables are statistically insignificant ($p>0.05$) with reference to 1.02 and -4.46, respectively.

mainstream students (ECO1010S), conditional on the explanatory variables. The results suggest that the academic performance of the ECO1010H cohorts was on a par with that achieved by the ECO1010F cohorts (including the ECO1010S students who repeated the first-year course), conditional on the control variables.

Second period

AD students who had attended ECO1010H in their first year were given the opportunity of attending voluntary workshops to enable them to cope with the increased demands of ECO2003F, which had become more mathematical in nature in the second period.

The results of the two sets of estimations for the second period (2003–2005) are presented in table 7.4. The first set (OLS^1 and OLS^2) exclude workshop attendance as a control variable. The purpose of these estimations is to determine the effect of the ECO1010H course and the workshops on AD students' academic performance relative to mainstream students. The purpose of the second set of estimations (OLS^3 and OLS^4) is to isolate the effect of workshop attendance on the academic performance of AD students relative to mainstream students. The cohorts include 3038 students, of whom 2953 wrote the final examination.

Table 7.4 Results of the Heckman two-step and standard OLS estimations for the second period (2003−2005); ECO1010H and ECO1010S versus ECO1010F (includes ECO1010S)

		Without workshops				With workshops			
	Base cases	**OLS[1]**	**OLS[2]**	**Std Err**	**t-stat**	**OLS[3]**	**OLS[4]**	**Std Err**	**t-stat**
Dependent variable Course mark									
Independent variables									
Probit									
Matpt		0.08		0.01	**5.80	0.08		0.01	5.80**
Age		0.01		0.06	0.06	0.01		0.06	0.06
D Enghome		0.01		0.13	0.08	0.01		0.13	0.08
D HRD	Model C Private	0.04		0.17	0.26	0.04		0.17	0.26
D DET	Model C Private	0.69		0.29	*2.34	0.69		0.29	2.34*
D White		-0.06		0.12	-0.53	-0.06		0.12	-0.53
ECO1010 course mark		0.01		0.01	1.83	0.01		0.01	1.83
Constant		-1.70		1.23	-1.39	-1.70		1.23	-1.39
IMR		-72.8		53.60	-1.36	-72.8		53.2	-1.36
OLS									
D 1010H		-0.66	-1.37	0.80	-1.71	-2.39	-3.23	0.96	-3.36**
D 1010S		-3.13	-4.22	0.73	**-5.81	-3.11	-4.20	0.73	-5.79**
WSHOPS						0.48	0.52	0.15	3.50**
Adjmatpt		0.24	0.94	0.07	**13.6	0.24	0.93	0.07	13.5**
D Eng FL HG	Eng SL HG	-0.82	-0.70	1.07	-0.66	-0.58	-0.44	1.07	-0.42
D Math HG ABC	Math HG	2.75	4.46	0.73	**6.11	2.80	4.49	0.73	6.16**
D Math HG DEF	Math HG	0.10	0.17	0.78	0.22	0.23	0.31	0.78	0.39
D PS HG	PS SG	1.82	3.09	0.49	**6.32	1.86	3.12	0.49	6.40**
Age		-0.27	-0.47	0.23	*-2.02*	-0.26	-0.46	0.23	-2.00*
D Enghome		-0.80	-0.70	0.56	-1.25	-0.68	-0.57	0.56	-1.01
D Male		-0.27	-0.47	0.38	-1.24	-0.28	-0.49	0.38	-1.28
D White		2.19	2.38	0.47	**5.08	2.14	2.32	0.47	4.97**
D Finaid		-0.75	-0.69	0.65	-1.06	-0.77	-0.71	0.65	-1.10
D Commerce	Humanities	-1.38	-0.38	0.94	-0.41	-1.39	-0.41	0.93	-0.44
D HRD	Model C Private	-0.14	0.21	0.68	0.32	-0.21	0.13	0.68	0.19
D DET	Model C Private	-6.71	-1.98	1.16	-1.71	-6.87	-2.20	1.16	-1.90
D WC		-0.83	-0.98	0.39	*-2.48	-0.84	-0.98	0.39	-2.48*
Course attended		-1.52	-2.14	0.38	**-5.70	-1.53	-2.15	0.38	-5.73**
D 2004	2003	-0.90	-2.17	0.49	**-4.41	-0.90	-2.16	0.49	-4.39**
D 2005	2003	-0.20	0.81	0.45	1.78	0.19	0.79	0.45	1.75
Constant		63.20	40.50	5.32	**7.60	62.7	40.2	5.31	7.56**
R^2			0.248				0.251		
F-stat.			**50.8				49.0**		
Wald Chi^2 (19)		7.04				7.41			
Wald Chi^2 (20)									
Observations		3038	2953			3038	2953		

[1] Heckman two-step estimation without controls for workshop attendance
[2] OLS estimation without controls for workshop attendance
[3] Heckman two-step estimation with controls for workshop attendance
[4] OLS estimation with controls for workshop attendance
** and * statistically significant at the 1% and 5% levels, respectively

As regards the Heckman probit estimation (OLS[1]), only the positive coefficients of the variables *Matpt* and *D DET* are statistically significant ($p<0.05$). The coefficient of IMR is negative but statistically insignificant ($p>0.10$), which suggests that omitting the students

who did not write the final examination from the OLS estimation does not result in a biased estimate of the coefficient of the treatment variable.[79]

Turning to the standard OLS estimation (OLS^2), the coefficient for the variable *D 1010H* is -1.37 and is statistically insignificant ($p>0.10$) and the coefficient for the ECO1010S variable *D 1010S* is -4.22 and is statistically significant ($p<0.01$).[80] The difference between the two coefficients is, using a Wald test, statistically significant ($p<0.05$). The ECO1010H students outperformed the ECO1010S students by 2.85 percentage points, on average, conditional on the independent variables.

These results lend support to the view that the ECO1010H course and the second-year voluntary workshops enabled AD students to achieve a higher course mark in the second-year microeconomics course than that achieved by a comparable group of mainstream students (ECO1010S), conditional on the explanatory variables. Another implication of the results is that the ECO1010H students performed on a par with the ECO1010F students, conditional on the control variables. However, the premiums enjoyed by the ECO1010H students relative to the two groups of mainstream students declined in the second period (2.85 percentage points in the second period relative to 5.48 percentage points in the first period), implying that the ECO1010H course was not successful as in the past in preparing AD students for the more mathematical second-year microeconomics course.

The results of the estimations for the second period controlling for voluntary workshop attendance (*WSHOPS*) are now discussed (OLS^3 and OLS^4). The purpose of these estimations is two-fold. First, to identify the premium that goes to workshop attendance, conditional on the independent variables; second, to determine the effect of the first-year AD course (ECO1010H) on academic performance of AD students in second-year microeconomics, relative to mainstream students, once the effect of workshop attendance is taken into account.

The result for the Heckman probit estimation 1 (OLS^3) is the same as for the estimation without workshops (OLS^1) as the specification is the same, which suggests that omitting the

[79] 94.6% of the ECO1010H cohorts, 92.3% of the ECO1010S cohorts, and 98.0% of the ECO1010F cohorts wrote the ECO2003F examination.

[80] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, with the exception of the 20th percentile, the coefficients of the ECO1010H and ECO1010S variables are negative and statistically insignificant ($p>0.05$) with reference to -1.37 and -4.22, respectively.

students who did not write the final examination from the OLS estimation does not bias the treatment variable coefficient.

Turning to the OLS estimation (OLS[4]), the coefficient for the variable *D 1010H* is -3.23 and is statistically significant ($p<0.01$). The coefficient for the ECO1010S variable *D 1010S* is -4.20, and is statistically significant ($p<0.01$).[81] The difference between the two coefficients is, using a Wald test, statistically insignificant ($p>0.10$): the ECO1010H cohorts did no better or worse than the ECO1010S cohorts, on average, conditional on workshop attendance and the other independent variables. The results also show that the ECO1010H students underperformed the ECO1010F students by 3.23 percentage points, on average, conditional on the control variables. Taking these results together, it seems that the ECO1010H course did not equip AD students with the skills necessary to make a success of ECO2003F.

The coefficient for workshop attendance is 0.52 and is statistically significant ($p<0.01$).[82] This implies that the students' course mark increases by 0.52 percentage points, on average, for each of the 12 workshops attended. The educational interventions, specifically the focus on improving students' understanding of mathematical concepts and the application of mathematical techniques, enabled those students who attended the workshops to outperform their peers, conditional on the independent variables.[83]

It is possible however, that workshop attendance is a function of the students' level of motivation. Students who are motivated to succeed may be more likely to attend the workshops; they may have achieved good results whether they attended the workshops or not. In this regard it is worth noting that the ECO1010H students who achieved higher marks in the final examination of the first-year microeconomics course were more likely to attend the ECO2003F workshops.[84] This finding suggests that it is the more academically able AD students who are more likely to attend the workshops, though the relationship is not strong.

[81] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficients of the ECO1010H and ECO1010S variables are negative and statistically insignificant ($p>0.05$) with reference to -4.31 and -5.00, respectively.
[82] Quantile estimations were run for the 20th, 40th, 50th, 60th and 80th percentiles. In all cases, the coefficient of the workshop variable is positive and statistically insignificant ($p>0.10$) with reference to 0.52.
[83] 102 of the 279 students making up the ECO1010H cohorts, or 36.6% of the cohorts, did not attend a single workshop.
[84] The mean mark achieved in first-year microeconomics by the AD students who attended between seven and twelve workshops is 62.7%, between one and six workshops 58.2%, and no workshops 56.4%, and the correlation coefficient is 0.25 between the economics first-year mark and workshop attendance.

The results in respect of the control variables are now discussed. The coefficients of the variables *Adjmatpt* and *D White* are positive and statistically significant ($p<0.01$). A background in mathematics (HG) improves students' academic performance. For example, students who achieved an A, B or C in mathematics (HG) (*D Math HG ABC*) scored, on average, 5.70 percentage points more than students who had done mathematics (SG). The size of the coefficient is greater than that identified in the first period (3.00). This finding is consistent with the fact that the course content became more mathematically orientated in the second period. Similarly, the coefficient for the variable *D PS HG* increased from 1.66 to 3.13 percentage points. All these coefficients are statistically significant ($p<0.01$). These findings are similar to those reported in Chapter 4 and in Chapter 6.

Turning to the remaining variables, the coefficient of English home language (*D Enghome*) is positive in the first period and negative in the second period, but statistically insignificant ($p>0.10$). In previous studies cited in Chapter 4, contradictory results have also been reported for this variable. The type of school attended does not seem to be an important factor in determining academic performance, conditional on the other independent variables. The coefficient of the variable *Courses attended* is negative in both periods, but statistically significant only in the second period ($p<0.01$). The latter result suggests that for each time the student attends the second-year microeconomics course, their course mark decreases, on average, conditional on the independent variables. This finding suggests that students become less motivated to succeed each time they attend the course.

The quadratic terms $Adjmatpt^2$, $WSHOP^2$ and Age^2 are also included in an estimation (not shown) to determine the returns to academic ability, workshop attendance and age. There are increasing returns to academic ability, and diminishing returns to workshop attendance and age. The variables *Adjmatpt* and $Adjmatpt^2$, and *WSHOPS* and $WSHOPS^2$, are jointly statistically significant ($p<0.01$), but the variables *Age* and Age^2 are jointly statistically insignificant ($p>0.10$).

Finally, the R^2s vary between 0.237 and 0.249. This implies that at least 23.7% of the variation in the final course mark is explained by the independent variables included in the estimations.

In summary, these findings suggest that the educational interventions included in the ECO1010H course improved the academic performance of the AD students by 5.24 percentage points in the first period, relative to the ECO1010S students, on average.

The results also imply that the educational interventions included in the ECO1010H course gave the ECO1010H cohorts no advantage in ECO2003F relative to the ECO1010S cohorts in the second period, when the ECO2003F became more mathematical in nature. Furthermore, the results imply that students who attended the workshops derived considerable benefit from so doing, in the form of a 0.52 percentage point increase in their course mark per workshop attended, on average, conditional on the explanatory variables. This finding suggests that the purpose of the workshops, that is to improve students' understanding of mathematical theory and to practice the application of mathematical techniques, was met.

Determinants of academic performance for each of the ECO1010H, ECO1010S and ECO1010F cohorts

The OLS estimations for each of the ECO1010H cohorts, ECO1010S cohorts and ECO1010F cohorts for each of the two periods are presented in table 7.5.

Table 7.5 Results of the OLS estimations for each of the ECO1010H and ECO1010S and ECO1010F (includes ECO1010S) cohorts for the two periods

		2000–2002			2003–2005		
	Base cases	**ECO1010H**	**ECO1010S**	**ECO1010F**	**ECO1010H**	**ECO1010S**	**ECO1010F**
Dependent variable							
Course mark							
Independent variables							
Adjmatpt		**0.67	*0.54	**1.16	0.01	*0.61	**1.23
D Eng FL HG	Eng FL SG	-1.40	-2.24	-0.04	*-4.36	0.59	0.59
Math HG	Math SG	**3.38	-1.22	**1.98	*3.53	0.60	*1.96
D PS HG	PS SG	2.00	*3.07	**2.31	1.45	0.37	**4.44
Age		0.50	-0.24	-0.81	-0.43	-1.41	-0.47
D Enghome		-2.60	-0.25	0.83	-0.99	0.45	-0.86
D Male		-0.95	-0.85	*0.83	0.31	-1.94	-0.27
D White		**6.27	2.59	**2.45		2.45	**2.70
D Finaid		0.80	2.23	0.71	-1.18	0.79	-1.06
D Commerce	Humanities	0.69	*-5.37	-1.20	3.99	1.79	-0.29
D HRD	Model C Private	3.34	2.23	0.27	*-3.47	2.27	0.99
D DET	Model C Private	-1.00	0.33	2.09	-2.41	-1.35	-1.06
D WC		-2.35	-0.83	0.19	0.33	-0.64	*-0.87
Courses attended		-0.52	1.57	**-1.30	**-2.80	0.83	**-2.70
D 2001	2000	-0.73	-1.05	-0.82			
D 2002	2000	-0.24	0.47	**-1.82			
D 2004	2003				-1.60	*-4.46	**-2.72
D 2005	2003				0.14	-1.27	*1.13
Constant		**27.60	**43.90	**27.40	**60.80	**58.80	**32.30
R^2		0.108	0.083	0.207	0.147	0.097	0.185
F-stat.		**2.07	1.14	**36.30	**2.85	1.41	**34.80
Observations		290	218	2172	264	227	2462

** and * statistically significant at the 1% and 5% levels, respectively

Turning to table 7.5, it can be seen that no consistent pattern emerges; it seems that the determinants of academic performance differ between the three sets of cohorts over the two periods. This implies that the three sets of cohorts are not particularly well matched on the control variables. As regards the AD cohorts, the coefficients of the variable *D Math HG* are positive and statistically significant for both periods ($p<0.05$). This result indicates that particular attention should be given to improving the mathematical skills of AD students, who took school-leaving mathematics on the standard grade.

The coefficient of the variable *Adjmatpt* is positive and statistically significant in the first period ($p<0.01$), and the coefficients of the variables *D Eng FL HG*, *D DET* and *Courses attended* are negative and statistically significant in the second period ($p<0.05$). The latter results imply that AD students who took English first language (HG) as a school-leaving subject, or who attended a former DET school, or who repeated the course, underperformed their peers, on average, conditional on the control variables.

(b) PSM estimations

The results of the PSM estimations are presented in tables 7.6 and 7.7.

Table 7.6 Results of the PSM probit and matching estimations for each of the two periods

	2000–2002 Estimation 1			2003–2005 Estimation 2		
Independent variables	**Probit estimation**	**% bias before matching "Xs"**	**% bias after matching "Xs"**	**Probit estimation**	**% bias before matching "Xs"**	**% bias after matching "Xs"**
	1	**2**	**3**	**4**	**5**	**6**
Adjmatpt	**-0.29	**131.1	**58.5	**-0.14	**-34.3	**-41.3
D Eng FL HG	-0.02	**-38.2	**-27.9	0.06	**-51.9	**33.6
D Math HG ABC	-0.48	**-75.0	*13.4	**-0.75	**-59.3	**20.4
D Math HG DEF	0.29	*19.6	**43.3	0.16	**38.7	10.0
D PS HG	*-0.57	-**36.0	**44.3	**-0.44	**-33.5	**34.1
Age	*-0.17	*-18.0	-8.6	**-0.42	**-57.4	*-21.4
D Enghome	*-0.51	**-46.3	**-31.9	**-0.81	**-69.5	*20.9
D Male	*0.44	*19.6	**31.7	*0.41	0.3	-0.9
D White	**-2.10	**-71.5	1.2			
D Finaid	0.40	**59.6	11.0	0.26	**56.6	**-37.7
D Commerce	**-2.13	**-99.2	*22.8	-0.52	8.0	-7.4
D HRD	0.03	*18.8	**-27.3	0.02	*17.9	**-31.8
D DET	-0.03	**26.6	**24.6	-0.01	**38.1	-2.6
D WC	0.52	2.9	-15.7	**0.74	*17.8	0.7
Course repeated	0.01	*18.5	13.2	-0.22	-10.0	*-21.3
D 2001	**0.86	11.0	**32.7			
D 2002	0.21	-12.3	*-21.1			
D 2004				**0.77	**50.10	0.6
D 2005				*0.39	-3.0	-4.6
Constant	*11.90			**12.2		
LR chi^2	*403.20			**157.60		
Pseudo R^2	0.582			0.290		
Observations	507			415		

** and * statistically significant at the 1% and 5% levels, respectively

On checking the balance of the independent variables for period one (columns 2 and 3) (table 7.6) after the matching process, it was found that the reduction in bias was considerable across most of the variables. That said, the difference between the pre- and post-matching values for many variables is still statistically significant ($p<0.05$). In addition the conditions for "common support" are only partly met (appendix D, figure D4). Therefore, the results of the PSM estimations must be interpreted with great caution.

As regards period two (2003–2005), the differences between the pre- and post-matching values for many variables are also statistically significant ($p<0.05$). The conditions for "common support", however, are partly met (appendix D, figure D5). Nevertheless, the results of the PSM estimations must be considered with some caution.

That said, the results of the PSM estimations are reported in table 7.7 and are briefly discussed below. The mean final course mark for the ECO1010H students is greater than that achieved by the ECO1010S students in the first period (50.6% versus 50.2%), and less than that achieved by the ECO1010S students in the second period (50.1% versus 50.9%) before PSM, and the differences are statistically insignificant (p>0.10). Using PSM the ECO1010H cohorts underperform the mainstream cohorts by 2.8 percentage points, statistically insignificant (p>0.10), in the first period, and outperform the mainstream cohorts by 0.2 percentage points, statistically insignificant (p>0.10), in the second period.

Table 7.7 Results of the PSM estimations for the first and second periods

Dependent Variable	Sample	Treated ECO1010H	Controls ECO1010S	Difference	Std Error	t-stat
Mark ECO2003F 2000−2002	Unmatched	50.6	50.2	0.4	0.86	-0.43
Estimation 1	ATT	50.6	53.4	-2.8	2.91	-0.96
Observations	507					
Mark ECO2003F 2003−2005	Unmatched	50.1	50.9	-0.8	1.01	-0.81
Estimation 2	ATT	50.1	49.9	0.2	1.80	0.11
Observations	415					

ATT (Average treatment effect on the treated)

The PSM results imply that the ECO1010H course and the workshops had neither a positive nor a negative effect on AD students' academic performance, relative to the mainstream control group. The differences in the mean course marks achieved by the ECO1010H and ECO1010S cohorts, using OLS, are 5.48 and 2.85 percentage points in the first and second periods, respectively. Given that the qualified results of the PSM process and that the coefficients of the IMR are statistically insignificant, the OLS coefficients are preferred in calculating the premium going to the AD students.

Pass rates

In this section the effect of the premium earned by the ECO1010H cohorts in the first period, and by those AD students who attended the workshops in the second period, on the overall pass rates is calculated.

Table 7.8 shows the effect of the premiums on the pass rate of the ECO1010H cohorts in ECO2003F in the first period, relative to the ECO1010S cohorts.

Table 7.8 Pass rates of the ECO1010H cohorts relative to ECO1010S cohorts for the first period (2000−2002)

	Total	Percentage
Number of students	306	100.0
Pass (Premium of 5.48 percentage points)	205	67.0
Pass (no premium)	105	34.3

The average pass rate for the three-year period is 67.0%. However, if the ECO1010H students had attended the ECO1010S course, they would not have enjoyed a premium of 5.48 percentage points (table 7.3), and their pass rate would have fallen to 34.3%. In other words, 98 students may be said to have passed the course they otherwise would not have passed. This represents 32.7% of the cohorts.

In the second period 279 students, who had completed ECO1010H, could attend one or more of the 12 workshops offered per semester.[85] Between them they attended 1054 workshops; an average of 3.8 workshops per student. The premium per workshop is 0.52 percentage points (table 7.4). Therefore, the average premium per student is 1.98 percentage points. Table 7.9 shows that the effect of the removal of the workshop premium is to reduce the pass rate from 61.6% to 43.0%, a difference of 18.6 percentage points. Furthermore, if each student had attended 12 workshops the premium would have increased to 6.24 percentage points and the pass rate to 73.1%: a difference of 30.1 percentage points relative to the pass rate in the absence of the workshops.[86]

Table 7.9 Pass rates for the ECO1010H cohorts relative to the ECO1010S cohorts for the second period (2003−2005)

	Total	Percentage
Course performance		
Number of students	279	100.0
Pass No workshops attended (no premium)	120	43.0
Pass 3.8 workshops attended (premium of 1.98 percentage points)	186	61.6
Pass 12 workshops attended (premium of 6.24 percentage points)	204	73.1

[85] Eighteen students (less than 7% of the ECO1010H cohorts) who had completed the mainstream first-year microeconomics course also attended one or more of the workshops. The effect of workshop attendance on the academic performance of the ECO1010H cohorts only, conditional on the same selection of independent variables, was also estimated. The coefficient for the variable *WSHOPS* is 0.56 and is statistically significant ($p<0.01$).

[86] As was noted previously, there are diminishing returns to workshop attendance, but the coefficient on the variable $WSHOP^2$ is relatively small (-0.10).

Relatively small increments in the course mark have a disproportionate effect on the pass rate achieved by the ECO1010H students, as they are lumped around the pass mark of 50.0% as they lack the requisite knowledge, ability or skills to achieve superior results.

7.1.3 Concluding remarks

The results of the OLS estimations lend some support to the view that the educational interventions included in the first-year AD course in microeconomics (ECO1010H) contribute positively towards AD students' academic performance in ECO2003F in the first period (2000–2002 cohorts). This implies that the educational interventions incorporated in the ECO1010H course (to improve students' quantitative, writing, study and English language skills) played a positive role in improving AD students' academic performance in the second-year microeconomics course. In particular, the premium earned by the ECO1010H students enabled them to increase their pass rate by 32.7 percentage points relative to the students who took the ECO1010S microeconomics course in their first year.

These findings could also be taken to suggest that ECO1010S students have some un-observable characteristics (possibly lack of motivation, inability to grasp concepts, negative attitude towards the discipline) that cause them to underperform AD students and their peers on the mainstream in the second-year microeconomics and other courses. Unfortunately, it is not possible, given the nature of the available data, to test for this possibility.

As regards the second period (2003–2005 cohorts), workshop attendance enabled AD students to overcome some of the disadvantages they experienced in respect of their relative under-preparedness in mathematical techniques and applications in the second period; for each workshop attended their course mark increased by 0.52 percentage points, on average, conditional on the independent variables. This translates into an average premium of 1.98 percentage points and an improvement in the pass rate for the ECO1010H students of 18.6 percentage points, relative to the mainstream students who took the ECO1010F microeconomics course in their first year. That the workshops did not deliver a larger premium is probably due to the fact that the AD students attended too few of the voluntary workshops that were introduced to improve their competence in applying mathematical techniques.

7.2 Mathematics (Engineering)

The empirical aim of this case study is to measure the impact of the educational interventions included in the first-year AD course in first-year mathematics (END1007W) in improving AD students' academic performance in second-year mathematics (MAM2080W), relative to mainstream students.

7.2.1 Characteristics of the academic development and mainstream cohorts

The chief characteristics of the AD (ASPECT) and mainstream cohorts are presented in table 7.10. The mainstream cohorts exclude the 33 ASPECT students who attended the mainstream course in first-year mathematics (MAM1003W). These students have an average matriculation points score of 41.1 and a similar set of academic characteristics to those exhibited by the mainstream cohorts, as shown in table 7.10.

Also treated independently are the 17 students who started MAM1003W and subsequently transferred to the ASPECT first-year mathematics course END1007W. These students have an average matriculation points score of 36.6, which is 0.5 points less than that achieved by the ASPECT cohorts, and they have a similar set of academic characteristics to those exhibited by the ASPECT cohorts, as shown in table 7.10.

Table 7.10 Control variables second-year mathematics

	ASPECT	Mainstream	Tests
Personal characteristics	**% share**	**% share**	**z-stat**
Black	87.9	25.0	**20.4
Indian	2.3	9.1	**3.9
Coloured	9.2	12.0	1.4
White	0.7	53.9	**16.8
English home language (Enghome)	13.8	71.6	**18.5
Male	68.9	77.8	**3.3
Financial Aid (Finaid)	37.7	12.0	*10.7
	Mean	**Mean**	**t-stat**
Age	19.1	18.9	1.5
School attended	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	7.5	9.1	0.9
Department of Education and Training (DET)	60.7	11.6	**18.5
Matriculation points	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	36.1	42.3	**22.9
Mean adjusted matriculation points score (Adjmatpt)	22.1	26.3	**20.1
Matriculation subjects	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	35.4	86.6	**19.1
Afrikaans first language (HG) (Afrik FL HG)	0.7	4.8	**3.4
Xhosa first language (HG) (Xhosa FL HG)	8.2	1.7	**5.9
Zulu first language (HG) (Zulu FL HG)	11.1	1.7	**7.4
Mathematics (HG) (Math HG)	96.7	99.8	**5.5
Mathematics (HG) ABC (Math HG ABC)	60.0	94.9	**16.8
Physical Science (HG) (PS HG)	98.4	99.8	**3.1
Physical Science (HG) ABC (PS HG ABC)	68.9	95.2	**13.7
Province			
Western Cape (WC)	17.7	43.2	**8.2
Course attendance			
Number /4	1.4	1.2	**4.9
Year			
1999	14.1	12.3	0.9
2000	14.1	9.9	*2.1
2001	11.1	10.4	0.4
2002	15.4	14.2	0.5
2003	11.1	16.9	2.5
2004	15.1	17.4	0.9
2005	19.1	19.1	0.0
Observations	305	1264	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ASPECT and mainstream students
** and * statistically significant at the 1% and 5% levels, respectively

Turning to table 7.10, it can be seen that the two groups differ from one another; with the exception of the variables *Coloured*, *Age*, *HRD* and *Math HG*, the null hypothesis of equal means and proportions can be rejected. This difference is to be expected, given the different criteria for placement into the mainstream and AD programmes.

7.2.2 Data and results

Analysis of data

The course mark and throughput rates for the ASPECT and mainstream cohorts in first- and second-year mathematics are shown in table 7.11. The student's best course mark is used to calculate the pass rate in the second-year course; 390 students, or 24.1% of the total, took the

course more than once. Students' subsequent performance in the supplementary examination is not taken into account as this information is not available for all the cohorts who are the subject of this analysis.

Table 7.11 Course results for the ASPECT and mainstream cohorts

	ASPECT	Mainstream	z-stat
Second-year mathematics			
Started second-year mathematics	305	1264	
Percentage of the cohorts who wrote the final examination	87.9	93.6	*3.4
Passed second-year mathematics	234	1113	
Percentage	76.7	88.1	*5.1
Mean course mark %[1]	55.9	60.5	*6.5
First-year mathematics			
Started first-year mathematics	404	1547	
Passed first-year mathematics at the first attempt	285	1019	
Percentage	70.5	65.9	1.8
Started second-year mathematics	305	1264	
Percentage	75.5	81.7	*2.8
Passed second-year mathematics	234	1113	
Percentage	57.9	71.9	*5.4
Mean course mark %[1]	57.5	58.6	1.2

* statistically significant at the 1% level
[1] For students who wrote the final examination only

As regards academic performance in the second-year mathematics course, ASPECT students achieved a lower course mark (55.9% versus 60.5%), on average, and a lower pass rate (76.7% versus 88.1%) than the mainstream students; both differences are statistically significant ($p<0.01$).

The 33 ASPECT students who attended the first-year mainstream course achieved an average course mark of 61.9%, and a pass rate of 90.9%. The figures for the 17 mainstream students who transferred to the first-year ASPECT course are 57.3% and 88.2%, respectively.

Of the ASPECT students, 75.5% went on to the second-year mathematics course; 81.7% of the mainstream first-year students did so. This difference in the continuation rates is statistically significant ($p<0.01$) and contributed to the higher throughput rate exhibited by the mainstream cohorts over the two years, relative to the ASPECT cohorts. Of the 404 ASPECT students who started the first-year mathematics course, 57.9% went on to pass the second-year course. The equivalent figure for the mainstream cohorts is 71.9% and the difference is statistically significant ($p<0.01$). Finally, ASPECT students achieved a lower pass rate than mainstream students in the second-year mathematics course (76.7% versus 88.1%), as they had done in the first-year course (75.5% versus 81.7%).

Estimation results

One variable is included in the estimations in addition to those identified in Chapter 5: the number of times the student took the second-year mathematics course (*Courses attended*).

(a) MVA estimations

To evaluate the impact of the AD course (END1007W) on academic performance in second-year mathematics, the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using OLS.

Table 7.12 shows the results of the two OLS estimations; the Heckman two-step estimation (OLS^1) and the standard OLS estimation excluding those students who did not write the final examination (OLS^2). These estimations are used to determine the impact of the first-year AD course in mathematics (END1007W) on students' academic performance in the second-year mathematics course.

Table 7.12 Results of the Heckman two-step and OLS and estimations for second-year mathematics

	Base cases	OLS[1]	Std Err	t-stat	OLS[2]	Std Err	t-stat
Dependent variable							
Course mark							
Independent variables							
Probit							
Matpt		0.02	0.01	1.41			
Age		-0.03	0.04	-0.91			
D Enghome		0.13	0.14	0.92			
D HRD	Model C Private	-0.09	0.17	-0.55			
D DET	Model C Private	0.35	0.15	*2.37			
D White		0.51	0.14	**3.61			
Mathematics first-year course mark		0.027	0.003	**8.85			
Constant		-0.41	0.90	-0.45			
IMR		-24.50	5.73	**-4.28			
OLS							
ASPECT		0.38	2.05	0.19	2.50	0.91	**2.75
ASPECT (mainstream)		0.86	4.32	0.20	1.01	1.89	0.53
Mainstream (transfer to ASPECT)		2.19	5.49	0.40	1.83	2.57	0.71
Adjmatpt		0.44	0.25	1.77	0.60	0.11	**5.63
D Eng FL HG	Eng SL HG	1.00	2.71	0.37	1.15	1.25	0.92
D Math HG A	Math HG DEF Math SG	4.38	2.47	1.77	7.26	1.09	**6.63
D Math HG B	Math HG DEF Math SG	1.09	2.28	0.48	2.94	1.04	**2.83
D Math HG C	Math HG DEF Math SG	-0.36	2.15	-0.17	0.76	1.00	0.76
D PS HG AB	PS HG DEF PS SG	-0.92	2.48	-0.37	-0.12	1.14	-0.11
D PS HG C	PS HG DEF PS SG	-0.15	2.17	-0.07	0.06	1.01	0.06
Age		-0.05	0.50	-0.10	-0.01	0.20	-0.04
D Enghome		-0.89	1.93	-0.46	-0.62	0.80	-0.77
D Male		-0.28	1.42	-0.19	-0.09	0.63	-0.14
D White		0.48	1.85	0.26	2.96	0.72	**4.10
D Finaid		-0.23	1.69	-0.14	-0.31	0.77	-0.40
D HRD	Model C Private	-0.05	2.56	-0.02	-0.13	1.07	-0.12
D DET	Model C Private	-1.41	2.92	-0.48	0.89	1.26	0.71
D WC		0.40	1.35	0.30	0.09	0.60	0.15
Courses attended		-2.21	1.10	*-2.01	-2.94	0.50	**-5.86
D 2000	1999	-0.82	2.38	-0.34	-1.05	1.05	-1.00
D 2001	1999	-2.44	2.32	-1.05	-2.64	1.03	*-2.56
D 2002	1999	-1.98	2.20	-0.90	-2.28	0.98	*-2.32
D 2003	1999	-4.08	2.16	-1.89	-4.87	0.96	**-5.09
D 2004	1999	-3.57	2.15	-1.66	-4.43	0.96	**-4.61
D 2005	1999	-5.03	2.15	*-2.34	-5.00	0.95	**-5.28
Constant		56.60	12.9	**4.40	45.00	5.28	**8.53
R^2					0.226		
F-stat.							**17.20
Wald Chi^2 (25)				36.93			
Observations		1619			1498		

[1] Heckman two-step estimation includes students who did not write the final examination
[2] Standard OLS estimation excluding students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

The Heckman probit estimation (OLS[1]) includes the variables *Matpt*, *Age*, *D Enghome*, *D HRD*, *D DET*, *D White* and *Mathematics first-year course mark* for the reasons outlined in Chapter 5. The course mark for second-year mathematics is determined independently of the

mathematics first-year course mark, which increases the suitability of the latter variable as the exclusion variable. White students, students from former DET schools, and students who did relatively well in the first-year mathematics examination are more likely to write the final examination, on average.

The coefficient of IMR is negative and statistically significant ($p<0.01$), which suggests that omitting the students who did not write the final examination from the OLS estimation does result in a biased estimate of the coefficient of the treatment variable. That said, relatively few students did not write the final examination: 118 students, or 7.5%, of the cohorts. However, 12.1% of the ASPECT cohorts, as opposed to 6.4% of the mainstream cohorts, did not write the final examination, which lends additional weight to the results of the Heckman two-step estimation.

The coefficient of the ASPECT dummy variable is 0.38 and statistically insignificant ($p>0.10$). Of the other variables, only the negative coefficients of the variables *Courses attended* and *D 2005* are statistically significant ($p<0.05$).

Turning to the standard OLS estimation (OLS^2), the coefficient for the variable *D ASPECT* is 2.50 and is statistically significant ($p<0.01$).[87] ASPECT students who qualified to write the examination outperformed the mainstream students by 2.50 percentage points, on average, conditional on the independent variables. The coefficients for the 33 ASPECT students who attended the first-year mainstream course and the 17 mainstream students who transferred to the first-year ASPECT course are positive but statistically insignificant ($p>0.10$), as they were for the first-year estimations discussed in Chapter 6.

Looking at the other variables, the coefficients for the variables *Adjmatpt*, *D Math HG A*, *D Math HG B* and *D White* are positive and statistically significant ($p<0.01$). These findings are similar to those cited in Chapter 4 and Chapter 6.

The coefficient for the variable *Courses attended* is -2.94 and is statistically significant ($p<0.01$). This finding implies that the student's final course mark decreases by 2.94

[87] Quantile estimations were run for the 20^{th}, 40^{th}, 50^{th}, 60^{th} and 80^{th} percentiles. In all cases, the coefficient of the ASPECT variable is positive and statistically insignificant ($p>0.10$) with reference to 2.50.

percentage points for each time they take the course, on average, conditional on the explanatory variables. Again, as for the microeconomics estimations, this finding suggests that students become less motivated to succeed each time they attend the course. Finally, the coefficients of the variables *D 2001*, *D 2002*, *D 2003*, *D 2004* and *D 2005* are all negative and statistically significant ($p<0.05$), which suggests that these cohorts underperformed the 1999 cohort, conditional on the explanatory variables.

An estimation (not shown) including the interaction terms $Adjmatpt^2$ and Age^2 found that there are increasing returns to the adjusted matriculation points score and decreasing returns to age. However, only the coefficient of the former variable is statistically significant ($p<0.01$).

These findings imply that the educational interventions designed to improve the academic performance of the ASPECT cohorts in first-year mathematics were successful in improving the academic performance of those AD students *who qualified to write the final second-year examination*, relative to mainstream students. However, a relatively large proportion of AD students did not qualify to write the final MAM2080W examination (12.1% of the second-year cohorts). As regards the latter group of students, the educational interventions included in END1007W did not enable them to cope with the demands imposed on them by MAM2080W. This may be an important reason for the relatively low throughput rate achieved by the ASPECT cohorts in the second-year mathematics course.

Determinants of academic performance for each of the ASPECT and mainstream cohorts

The OLS estimations for each set of the ASPECT and mainstream cohorts are presented in table 7.13. No consistent pattern emerges; it seems that the determinants of academic performance differ between the two sets of cohorts. This implies that the two cohorts are not particularly well matched on the control variables.

Table 7.13 Results of the OLS estimations for each of the ASPECT and mainstream cohorts

	Base cases	ASPECT	Mainstream
Dependent variable			
Course mark			
Independent variables			
Adjmatpt		-0.01	**0.80
D Eng FL HG	Eng SL HG	1.43	1.89
D Math HG A	Math HG DEF Math SG	**6.97	**5.28
D Math HG B	Math HG DEF Math SG	**6.54	1.03
D Math HG C	Math HG DEF Math SG	*2.56	-1.05
D PS HG AB	PS HG DEF PS SG	2.13	0.33
D PS HG C	PS HG DEF PS SG	0.22	0.82
Age		*-0.65	0.20
D Enghome		**-6.11	0.07
D Male		0.20	-0.22
D White			**2.90
D Finaid		-0.55	-0.64
D HRD	Model C Private	2.03	-0.53
D DET	Model C Private	-1.14	*3.86
D WC		*3.65	0.01
Courses attended		-1.16	**-3.16
D 2000	1999	**-5.34	0.14
D 2001	1999	-2.64	-2.32
D 2002	1999	-2.36	*-2.32
D 2003	1999	*-5.19	**-4.61
D 2004	1999	**-6.96	**-4.40
D 2005	1999	**-5.35	**-5.20
Constant		**70.80	**36.10
R^2		0.191	0.231
F-stat.		**2.76	**15.8
Observations		268	1182

** and * statistically significant at the 1% and 5% levels, respectively

As regards the ASPECT cohorts, the coefficients of Mathematics (HG) A, B and C are positive and statistically significant ($p<0.05$), and the coefficient of the variable *D Enghome* is negative and statistically significant ($p<0.01$). These findings are the same as those reported in the first-year OLS estimation reported in Chapter 6.

The same approach was used as in the first-year study, and a dummy variable was created for students who declared English to be their home language and who took English first language (HG) as a school-leaving subject. The sign of the coefficient of this variable is negative and statistically significant ($p<0.05$).[88] Whatever the cause of this result, it is surprising that it should persist into the second year of study.

The coefficient of the variable *Age* is negative and statistically significant ($p<0.05$), and that of the variable *D WC* is positive and statistically significant ($p<0.01$).

[88] Sixty-seven ASPECT students who declared that they did not have English as their home language took English first language (HG) as a school-leaving subject.

As regards the mainstream cohorts, the variables *Adjmatpt*, *D Math HG A*, and *D White* are positive and statistically significant ($p<0.01$). The coefficient of the variable *Courses attended* is, however, negative and statistically significant ($p<0.01$), as it is for second-year microeconomics, which again suggests that students become less motivated to succeed each time they attend the course.

(b) PSM estimation

The purpose of PSM is to construct a control group from the mainstream cohorts that shows a greater similarity to the treated group (ASPECT cohorts) across the range of independent variables. The ASPECT students who did the first-year mainstream course in mathematics, and the mainstream students who transferred to the AD first-year course in mathematics, are excluded from this estimation. The result of the probit estimation is presented in table 7.14.

Table 7.14 Result of the PSM probit and matching estimation for second-year mathematics

	Probit estimation	**% bias before matching "Xs"**	**% bias after matching "Xs"**
Independent variables			
Adjmatpt	**-0.08	**-128.2	14.6
D Eng FL HG	*-0.43	**-123.0	-5.9
D Math HG A	**-1.48	**-108.6	-2.1
D Math HG B	**-0.95	-11.0	-3.5
D Math HG C	**-0.75	**29.9	-0.9
D PS HG AB	**-1.07	**-126.0	-1.7
D PS HG C	**-0.55	**58.8	3.0
Age	*0.11	*11.6	-4.3
D White	**-1.67	**-149.0	-1.5
D Enghome	**-0.49	**-144.0	-3.1
D Male	-0.22	**-20.4	2.6
D Finaid	-0.17	**62.1	13.9
D HRD	0.01	-5.6	-5.6
D DET	**0.52	**118.8	-1.1
D WC	-0.09	**-57.6	-4.6
Courses attended	0.16	**29.2	8.5
D 2000	0.508	*13.0	-0.1
D 2001	-0.10	2.5	-9.9
D 2002	-0.01	3.5	-4.3
D 2003	*0.50	*-16.5	0.8
D 2004	0.20	-6.1	2.8
D 2005	*0.44	-0.3	10.5
Constant	2.04		
Pseudo R^2	0.556		
LR chi^2 (22)	**771.00		
Observations	1450		

** and * statistically significant at the 1% and 5% levels, respectively

On checking the balance of the independent variables after the matching process, it was found that the reduction in bias was considerable across all the variables. Indeed, none of the differences between the variables remained statistically significant ($p>0.05$). The conditions

for "common support", however, are only partly met (appendix D, figure D6). Therefore, the results of the PSM estimations must be interpreted with some caution.

That said, the result of the PSM estimation is reported in table 7.15 and is briefly discussed below. The mean course mark for the ASPECT cohorts (55.7%) is less than that for the mainstream cohorts (60.5%) before PSM, and the difference is statistically significant ($p<0.01$). After PSM, however, the mean for the mainstream control group falls to 55.3%, which is 0.4 percentage points less than that achieved by the ASPECT cohorts. This difference is statistically insignificant ($p>0.10$).

Table 7.15 Result of the PSM estimation for second-year mathematics

Dependent Variable	Sample	Treated ASPECT	Controls Mainstream	Difference	Std Error	t-stat
Course mark	Unmatched	55.7	60.5	-4.8	0.74	*-6.46
Estimation 1	ATT	55.7	55.3	0.4	1.36	0.29
Observations	955					

ATT (Average treatment effect on the treated)
* statistically significant at the 1% level

In summary, the coefficients of the variable *ASPECT* are as follows: 2.50 and statistically significant ($p<0.01$) in the standard OLS estimation (table 7.12, OLS^2); 0.4 and statistically insignificant ($p>0.10$) in the Heckman two-step estimation (table 7.12, OLS^1); and 0.4 and statistically insignificant ($p>0.10$) in the PSM estimation (table 7.15).

The coefficient used to calculate the premium going to the ASPECT cohorts is that derived using the standard OLS estimation (OLS^2) as relatively few students did not write the final examination and the conditions for "common support" are not met. That said, the effect of the coefficients derived using the Heckman two-step and PSM are also used to calculate the premium going to the ASPECT students bearing in mind that the coefficients are statistically insignificant ($p>0.10$).

The results of the three estimations lend some support to the view that the educational interventions incorporated in the AD first-year mathematics course (END1007W) improved the academic performance of most of the AD students in the mainstream second-year mathematics course MAM2080W.

Pass rates

Using the results of the three estimations (table 7.12 and table 7.15), it is possible to identify the premiums associated with taking the first-year AD course in mathematics (END1007W). The effect of this premium on the pass rate attained by the ASPECT cohorts over the seven-year period is presented in table 7.16.

Table 7.16 Course pass rates for the ASPECT cohorts for the period 1999 to 2005

	Total	Percentage
Course performance		
Number of students	305	100.0
Pass (no premium)	179	58.7
Pass (premium of 2.50 percentage points)	234	76.7
Pass (no premium)	209	68.5
Pass (premium of 0.40 percentage points)	234	76.7

Using the result of the standard OLS estimation, ASPECT students outperform their peers on the mainstream by an average of 2.50 percentage points, conditional on the independent variables. This represents an upper bound. The mean examination pass rate for the seven-year period is 76.7%. However, if it is assumed that these same students attended the first-year mainstream course in mathematics (MAM1003W), the results suggest they would not have enjoyed the premium of 2.50 percentage points, and the pass rate for the 305 students who started the course falls to 58.7%. In other words, 55 students may be said to have passed the course they otherwise would not have passed. These students represent 18.0% of the cohorts.

However, the results of the Heckman two-step and PSM estimations imply that the premium going to ASPECT students is 0.4 percentage points. In this instance the pass rate falls to 68.5%; 25 students, or 8.2% of the cohorts, pass the course they otherwise would not have passed.

7.2.3 Concluding remarks

In this section the effectiveness of educational interventions in the first-year AD course in mathematics (END1007W) on students' performance in the second-year mainstream course in mathematics (MAM2080W) is investigated.

To the extent that the ASPECT cohorts outperformed the mainstream cohorts, it is possible to draw the following conclusions. The ASPECT first-year course in mathematics has a modest positive impact on the academic performance of AD students relative to the mainstream cohorts for the seven-year period. These findings lend some support to the view that the educational interventions in the first-year mathematics course are effective in promoting improved academic performance in a subsequent higher-level course in the same subject. The pass rate for the ASPECT cohorts is 8.2% to 18.0% greater than it would have been had the AD students attended the first-year mainstream course in mathematics.

7.3 Chemistry (Science)

The empirical aim of this case study is to measure the effect of the educational interventions included in the first-year AD courses in chemistry (CEM1009H and CEM1010F) in improving the academic performance of AD students in the second-year chemistry courses (CEM2007F and CEM2008S), relative to mainstream students.

7.3.1 Characteristics of the academic development and mainstream cohorts

The chief characteristics of the GEPS and mainstream cohorts doing the first-semester second-year chemistry course (CEM2007F) are presented in table 7.17.

Table 7.17 Control variables second-year chemistry

	GEPS	Mainstream	Tests
Personal characteristics	**% share**	**% share**	**z-stat**
Black	75.9	21.4	**8.4
Indian	8.3	4.8	1.1
Coloured	13.9	11.1	0.7
White	1.9	61.9	**9.7
English home language (Enghome)	20.4	71.4	**7.6
Male	41.7	51.6	1.5
Financial Aid (Finaid)	64.8	11.1	**8.6
	Mean	**Mean**	**t-stat**
Age	19.0	18.9	0.4
School attended	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	20.4	8.7	*2.4
Department of Education and Training (DET)	46.3	15.9	**5.0
Matriculation points	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	32.6	42.0	**17.7
Mean adjusted matriculation points score (Adjmatpt)	20.4	26.1	**14.4
Matriculation subjects	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	38.9	79.4	**6.3
Afrikaans first language (HG) (Afrik FL HG)	2.8	9.5	2.0
Xhosa first language (HG) (Xhosa FL HG)	18.5	1.6	**4.4
Zulu first language (HG) (Zulu FL HG)	12.0	8.7	0.8
Mathematics (HG) (Math HG)	72.2	98.4	**5.7
Mathematics (HG) ABC (Math HG ABC	14.8	85.7	**10.8
Physical Science (HG) (PS HG)	77.8	98.4	**4.8
Physical Science (HG) ABC (PS HG ABC)	17.6	88.1	**10.8
Province			
Western Cape (WC)	28.7	49.2	**3.1
	Mean	**Mean**	**t-stat**
Course attendance	1.2	1.0	**4.1
Year	**% share**	**% share**	**z-stat**
1999	8.3	18.3	*2.3
2000	14.8	17.5	0.4
2001	12.0	4.8	*2.0
2002	0.3	12.7	*2.4
2003	13.9	10.3	0.9
2004	13.9	19.8	1.2
2005	12.0	16.7	1.1
Observations	108	126	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between GEPS and mainstream cohorts
** and * statistically significant at the 1% and 5% levels, respectively

It can be seen that the two sets of cohorts differ markedly from one another; with the exception of the variables *Indian*, *Coloured*, *Male*, *Age* and *Zulu FL HG*, the null hypothesis of equal means and proportions can be rejected.

7.3.2 Data and results

Analysis of data

The course mark and throughput rates for the GEPS and mainstream cohorts in CEM2007F and CEM2008S are presented in table 7.18. Following the method of the previous two case studies, the best course mark obtained is used to calculate the pass rate. Students' subsequent

performance in the supplementary examination is not taken into account as this information is not available for all the cohorts that are the subject of this analysis.

Table 7.18 Course marks and throughput rates: GEPS and mainstream cohorts

	GEPS	Mainstream	z-stat
Second-year chemistry (CEM2007F)			
Started CEM2007F	108	126	
Number of students who wrote the final examination	107	123	
Percentage	99.1	97.6	1.3
Passed CEM2007F	96	111	
Percentage	88.9	88.1	0.2
Mean course mark %[1]	57.1	65.1	*4.8
Second-year chemistry (CEM2008S)			
Started CEM2008S	115	123	
Number of students who wrote the final examination	114	120	
Percentage	99.1	97.6	1.3
Passed CEM2008S	97	110	
Percentage	84.3	89.4	1.2
Mean course mark %[1]	58.4	68.1	*6.1
Throughput rates			
Started first-year chemistry	701	945	
Passed first-year chemistry at the first attempt (CEM1009H and CEM1010F)	186	633	
Percentage	26.5	67.0	*16.0
Passed CEM2007F	96	111	
Percentage	13.7	11.7	1.2
Passed CEM2008S	97	110	
Percentage	13.8	11.6	1.2

[1] For students who wrote the final examination only
* statistically significant at the 1% level

Turning to the second-year first-semester chemistry course (CEM2007F), a greater percentage of the GEPS students wrote the final examination (99.1% versus 97.6%) and passed the course (88.9% versus 88.1%). The differences are, however, statistically insignificant ($p>0.10$). As regards the second-year second-semester chemistry course (CEM2008S), a higher proportion of GEPs students wrote the examination (99.1% versus 97.6%) but a smaller proportion passed the course (84.3% versus 89.4%). Both differences are statistically insignificant ($p>0.10$).[89] In both courses, however, mainstream students achieved a higher course mark, and the differences are statistically significant ($p<0.01$). Thus a larger proportion of mainstream students achieve relatively high marks for the two courses. This is not surprising as AD students usually struggle to achieve marks in excess of 60.0%.

Considering the throughput rates, a greater proportion of the GEPS students who took CEM1009H went on to pass CEM2007S and CEM2008F, relative to mainstream students (13.8% versus 11.6%) who took CEM1000W, even though a much smaller proportion of

[89] These findings suggest that the bias that results from omitting the students who did not write the examination may not be large.

students passed the first-year AD courses than passed the first-year mainstream course (26.5% versus 67.0%).[90]

Estimation results

One variable is included in the estimations in addition to those identified in Chapter 5: the number of times the student took the second-year chemistry course (*Courses attended*).

(a) MVA estimations

To evaluate the impact of the first-year AD courses on students' academic performance in second-year chemistry, the production function represented by equation (1) in Chapter 5 (p. 79) is estimated using OLS.

Tables 7.19 and 7.20 show the results of the estimations for CEM2007F and CEM2008S. In the absence of students' test scores, and given that AD and mainstream students did not write the same first-year final examination, it is not possible to run the Heckman two-step estimation as there is no suitable exclusion variable. Instead, standard OLS and logit estimations are run for each of the two second-year courses. The OLS estimation has a continuous (course mark) dependent variable and the logit estimation has a binary (pass/fail) dependent variable. The latter estimation makes it possible to account for all the students who took each of the two courses, including those who did not write the final examination.

[90] Students might have failed the first-year course, left the university, been excluded from the university, transferred to another faculty, or decided not to continue with chemistry (private communication from the course convener of CEM1009H).

Table 7.19 Results of the OLS and logit estimations for CEM2007F

	Base cases	OLS	Std Err	t-stat	Logit	Std Err	z-stat	dF/dx
Dependent variable			**Course mark**			**Pass**		
Independent variables								
D GEPS		3.71	2.68	1.38	1.72	0.97	1.78	0.07
Adjmatpt		1.69	0.26	**6.52	0.22	0.11	*2.05	*0.01
D Eng FL HG	Eng SL HG	1.05	2.52	0.42	0.62	0.95	0.65	0.03
D Math HG ABC	Math SG	3.21	3.07	1.05	1.92	1.06	1.81	0.09
D Math HG DEF	Math SG	-0.28	2.47	-0.11	0.96	0.84	1.15	0.03
D PS HG ABC	PS SG	0.37	3.18	0.12	0.51	1.08	0.48	0.02
D PS HG DEF	PS SG	1.07	2.67	0.40	-0.46	0.95	-0.49	-0.02
Age		0.26	0.57	0.46	-0.36	0.17	*-2.14	-0.01
D Enghome		-5.55	2.67	*-2.08	-1.74	1.16	-1.49	-0.09
D Male		-1.29	1.41	-0.92	-1.32	0.59	*-2.26	*-0.06
D White		9.80	2.58	**3.80	2.64	0.95	**2.78	**0.09
D Finaid		5.01	1.86	**2.69	2.37	0.75	**3.17	**0.08
D HRD	Model C Private	3.39	2.56	1.33	2.72	1.27	*2.14	*0.05
D DET	Model C Private	-0.67	2.35	-0.28	0.71	0.79	0.90	0.03
D WC		1.77	1.72	1.03	0.44	0.69	0.64	0.01
Courses attended		5.05	2.69	1.88	-0.54	0.87	-0.61	-0.02
D 2000	1999	2.81	2.53	1.11	-0.97	0.90	-1.07	-0.04
D 2001	1999	0.67	3.22	0.21	-0.71	1.09	-0.65	-0.02
D 2002	1999	3.07	2.50	1.23	1.76	1.33	1.32	0.05
D 2003	1999	4.19	2.89	1.45	-0.07	1.06	-0.07	0.01
D 2004	1999	4.87	2.59	1.88	1.51	1.41	1.07	0.05
D 2005	1999	-2.04	2.60	-0.79	-1.34	0.91	-1.46	-0.07
Constant		1.78	14.30	0.12	1.58	4.69	0.34	
R^2		0.446						
F-stat.				**7.56				
LR Chi^2 (22)							**58.00	**58.40
Pseudo R^2					0.331			0.333
Observations		230			234			234

OLS estimation excludes students who did not write the final examination
Logit estimation includes students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

The results of the OLS and logit estimations for CEM2007F are shown in table 7.19. As regards the OLS estimation the coefficient of the variable *D GEPS* is 3.71 but is statistically insignificant (p>0.10). In general, the standard errors are relatively large for small-sample estimations and thus it is unlikely that the coefficient for any given variable is statistically significant (p<0.05) (small-sample problem).[91] The coefficients of the variables *Adjmatpt*, *D White* and *D Finaid* are positive and statistically significant (p<0.01).

The coefficient for the variable *D Enghome* is, however, negative and statistically significant (p<0.05). A dummy variable was created, in another equation not shown, for the 112 students, including 22 GEPS students, who declared English to be their home language and who took English first language (HG) as a school-leaving subject. The sign of the coefficient

[91] When the coefficient is large and the standard errors are relatively large, and the result is statistically insignificant, then the estimates lack the precision required to make strong statements about the magnitudes and signs of the parameter values.

of this variable is negative and statistically significant ($p<0.05$). Thirty students, including 20 GEPS students, who declared that they did not have English as their home language, took English first language (HG) as a school-leaving subject.

Turning to the logit estimation, the coefficient of the GEPS dummy variable is positive and statistically insignificant ($p>0.05$). The coefficients of the variables *Age* and *D Male* are negative, and the coefficient for the variable *D HRD* is positive. All three coefficients are statistically significant ($p<0.05$), in addition to those identified in the OLS estimation. The coefficients of the variables *Adjmatpt* and *D White* are also positive and statistically significant ($p<0.01$) for both the standard OLS and logit estimations, as they are for students taking the first-year chemistry course as reported in Chapter 6.

The marginal effects for each of the independent variables are shown in the last column of table 7.19. For example, for each one-point increase in the adjusted matriculation points score, the probability of a student's passing CEM2007F increases by 1.0 percentage point, on average. The probability of passing for students who received financial aid is increased by 8.0 percentage points, on average. Both coefficients are statistically significant ($p<0.05$).

The results of the OLS and logit estimations for the second-year second-semester course (CEM2008S) are presented in table 7.20.

Table 7.20 Results of the OLS and logit estimations for CEM2008S

	Base cases	OLS	Std Err	t-stat	Logit	Std Err	z-stat	dF/dx
Dependent variable			**Course mark**			**Pass**		
Independent variables								
D GEPS		3.97	2.70	1.47	0.94	0.90	1.04	0.06
Adjmatpt		1.51	0.26	**5.73	0.23	0.10	*2.24	*0.01
D Eng FL HG	Eng SL HG	4.00	2.55	1.57	0.87	0.86	1.01	0.06
D Math HG ABC	Math SG	6.22	3.18	1.96	1.09	1.03	1.06	0.07
D Math HG DEF	Math SG	2.33	2.37	0.98	1.19	0.79	1.52	0.06
D PS HG ABC	PS SG	0.21	3.16	0.07	-0.65	1.11	-0.58	-0.04
D PS HG DEF	PS SG	0.81	2.59	0.31	-1.14	0.96	-1.18	-0.09
Age		-0.44	0.58	-0.76	0.06	0.20	0.28	0.01
D Enghome		-7.59	2.68	**-2.83	-1.26	0.98	-1.29	-0.09
D Male		1.13	1.44	0.79	-0.61	0.51	-1.19	-0.03
D White		6.87	2.57	**2.68	1.88	0.90	*2.09	*0.09
D Finaid		1.06	1.86	0.57	0.38	0.58	0.66	0.02
D HRD	Model C Private	-1.19	2.55	-0.47	1.50	0.96	1.56	0.06
D DET	Model C Private	-1.12	2.35	-0.48	0.65	0.68	0.96	0.04
D WC		5.72	1.78	**3.22	0.75	0.68	1.11	0.04
Courses attended		0.08	2.57	0.03	0.89	0.86	1.03	0.06
D 2000	1999	2.19	2.66	0.82	0.49	0.77	0.63	0.02
D 2001	1999	4.78	3.41	1.40	0.91	1.10	0.82	0.04
D 2002	1999	9.64	2.59	**3.72	2.76	1.24	*2.22	*0.08
D 2003	1999	4.65	3.01	1.55	-0.07	0.87	-0.09	-0.01
D 2004	1999	5.01	2.64	1.90	2.37	1.23	1.93	*0.08
D 2005	1999	1.55	2.74	0.57	-0.09	0.77	-0.12	-0.01
Constant		22.10	14.50	1.53	-7.34	5.18	-1.42	
R^2		0.461						
F-stat.				**8.21				
LR Chi^2 (22)							**47.90	*48.90
Pseudo R^2					0.260			0.266
Observations		234			238			238

OLS estimation excludes students who did not write the final examination
Logit estimation includes students who did not write the final examination
** and * statistically significant at the 1% and 5% levels, respectively

As regards the OLS estimation, the coefficient of the GEPS dummy variable is 3.97 but statistically insignificant (p>0.10). The coefficients of the same variables are statistically significant at, at least, the 5% level as for the CEM2007F OLS estimation, with the exception of the variable *D Finaid*. The only variable that is statistically significant (p<0.01) in the CEM2008S OLS estimation and not in the CEM2007F OLS estimation is *D WC*. Again, the coefficient of the variable *D Enghome* is statistically significant (p<0.01) in the OLS estimation. Following a now familiar procedure, a dummy variable was created for students who declared English to be their home language and who took English first language (HG) as a school-leaving subject. The sign of the coefficient of this variable is positive and statistically insignificant (p>0.10) in an estimation not shown here.

Turning to the logit estimation, the coefficient of the GEPS dummy variable is positive but statistically insignificant (p>0.10). Of the control variables, only *D White* and *Adjmatpt* are statistically significant (p<0.05). The coefficients of the variables *Adjmatpt* and *D White* are

also positive and statistically significant ($p<0.05$) for both the standard OLS and logit estimations, as they are for students taking the first-year chemistry course as reported in Chapter 6.

The marginal effects for each of the independent variables are shown in the last column of table 7.20. For example, for each one-point increase in the adjusted matriculation points score, the probability of a student's passing CEM2008S increases by 1.0 percentage point, on average. Also, the probability of passing for white students is increased by 9.0 percentage points, on average. Both coefficients are statistically significant ($p<0.05$).

It seems that the determinants of the course mark in the two courses CEM2007F and CEM2008S are broadly the same. This is not surprising as the students who take CEM2007F usually go on to take CEM2008S.

In summary these results imply, bearing in mind the small sample size, that the first-year AD courses CEM1009H and CEM1010F had a positive, though limited, impact on the academic performance of the GEPS cohort in the second-year chemistry courses, conditional on the selected independent variables.

Furthermore, students' academic ability as measured by their adjusted matriculation points score has a positive effect on the academic performance in both second-year courses. White students also achieved higher course marks and pass rates, conditional on the selected control variables. However, students who declared English to be their home language achieved a lower course mark for the two second-year courses, conditional on the control variables (OLS estimations). As was noted previously, this peculiar phenomenon warrants more research.

Determinants of academic performance for each of the ASPECT and mainstream cohorts

The samples sizes of the GEPS cohorts and mainstream cohorts are too small to run meaningful separate estimations for the purposes of comparison.

(b) PSM estimation

PSM estimations were run for each of the two courses, using both the final course mark (continuous) and pass/fail (dichotomous) dependent variables.

There was little reduction in bias across the independent variables after balancing and most of the differences remained statistically significant ($p<0.01$). In addition the conditions for "common support" were not met, and a number of regions of the propensity score values have no observations from both the treated (GEPS) and untreated (mainstream) groups. These results are probably due to the small sample sizes, which militate against a successful matching process. Therefore, given the failure of the PSM process, it was decided not to present the results of the estimations. They add no econometric value to the analysis of the effect that the first-year AD courses have on the academic performance of AD students in the second-year mainstream chemistry courses.

7.3.3 Concluding remarks

In this case study the effectiveness of educational interventions in the first-year AD courses in chemistry (CEM1009H and CEM1010F) on students' academic performance in the second-year mainstream courses in chemistry (CEM2007F and CEM2008S) is investigated.

The results suggest that the GEPS first-year courses have a positive, though relatively weak, impact on students' academic performance relative to the academic performance of mainstream students for the seven-year period.

7.4 Summary discussion

In this section the key findings as regards the second-year case studies are discussed.

The course results for each of the AD and mainstream cohorts for each of the three subjects are given in table 7.21.

Table 7.21 Results for each of the second-year AD and mainstream courses

	ECO2003F			MAM2080W		CEM2007F		CEM2008F	
	ECO1010H	**ECO1010S**	**ECO1010F 2000–2005**	**ASPECT**	**M'stream 1999–2005**	**GEPS**	**M'stream 1999–2005**	**GEPS**	**M'stream 1999–2005**
Course results									
Percentage of the cohorts who wrote final examination	94.7	93.9	98.0	87.9	93.6	99.1	97.6	99.1	97.6
Pass rate	66.9	70.0	91.0	76.7	88.1	88.9	88.1	84.3	89.4
Mean course mark %[1]	50.4	50.8	59.5	55.9	60.5	57.1	65.1	58.4	68.1
Observations	585	474	4730	305	1264	108	126	115	123

[1] For students who wrote the final examination only

With the exception of the ASPECT cohorts, more than 90.0% of each of the AD and mainstream cohorts wrote the final examination, and with the exception of the second-year chemistry course, CEM2007F, the mainstream cohorts achieved a higher pass rate than the corresponding AD cohorts. As regards the mean course mark, the mainstream cohorts outperformed the AD cohorts in each of the three second-year courses.

MVA estimations

The results of each the standard OLS estimations for each of the second-year courses (microeconomics, mathematics and chemistry) are shown in table 7.22.

Table 7.22 Results of the standard OLS estimations for each of the three second-year courses

	Base case	ECO2003F 2000–2002	ECO2003F 2003–2005	MAM2080W 1999–2005	CEM2007F 1999–2005	CEM2008S 1999–2005
Dependent variable						
Course mark						
Independent variables						
D 1010H		1.02	**-3.23			
D 1010S		**-4.46	**-4.20			
WSHOPS			**0.52			
D ASPECT				**2.50		
ASPECT (mainstream)				1.01		
Mainstream (transfer to ASPECT)				1.83		
D GEPS					3.71	3.97
Adjmatpt		**1.03	**0.93	**0.60	**1.69	**1.51
D Eng FL HG	Eng SL HG	-0.73	-0.44	1.15	1.05	4.00
D Math HG A	Math HG DEF Math SG			**7.26		
D Math HG B	Math HG DEF Math SG			**2.94		
D Math HG C	Math HG DEF Math SG			0.76		
D Math HG ABC	Math SG	**2.96	**4.49		3.21	6.22
D Math HG DEF	Math SG	0.94	0.31		-0.28	2.33
D PS HG	PS SG	**2.07	**3.12			
PS HG AB	PS HG DEF PS SG			-0.12		
PS HG C	PS HG DEF PS SG			0.06		
PS HG ABC	PS SG				0.37	0.21
PS HG DEF	PS SG				1.07	0.81
Age		-0.02	*-0.46	-0.01	0.26	-0.44
D Enghome		0.16	-0.57	-0.62	*-5.55	**-7.59
D Male		0.51	-0.49	-0.09	-1.29	1.13
D White		**2.69	**2.32	**2.96	**9.80	**6.87
D Finaid		1.13	-0.71	-0.31	**5.01	1.06
D Commerce	Humanities	-1.04	-0.41			
D HRD	Model C Private	0.62	0.13	-0.13	3.39	-1.19
D DET	Model C Private	1.03	-2.20	0.89	-0.67	-1.12
D WC		0.01	*-0.98	0.09	1.77	**5.72
Courses attended		*-0.78	**-2.15	**-2.94	5.05	0.08
D 2000	1999			1.05	2.81	2.19
D 2001	2000 1999	-0.75		*-2.64	0.67	4.78
D 2002	2000 1999	**-1.34		*-2.28	3.07	**9.64
D 2003	1999			**4.87	4.19	4.65
D 2004	2003 1999		**-2.16	**-4.43	4.87	5.01
D 2005	2003 1999		0.79	**-5.00	-2.04	1.55
Constant		28.00	**40.20	**45.00	1.78	22.1
R^2		0.244	0.251	0.226	0.446	0.461
F-stat.		**48.00	**49.0	**17.20	**7.56	**8.21
Observations		2679	2953	1498	230	234

** and * statistically significant at the 1% and 5% levels, respectively

The coefficient for each of the AD groups is positive relative to the relevant mainstream group. The difference between the coefficients for ECO1010H (*D 1010H*) and ECO1010S (*D 1010S*) in ECO2003F (first period) is 5.48 percentage points, and is statistically significant ($p<0.01$). In the second period the difference is 0.97 percentage points and is statistically insignificant ($p>0.10$). The coefficient of the variable *ASPECT*, 2.50, is statistically significant ($p<0.01$), but the coefficients of the variable *GEPS* in the two second-

year chemistry courses are not ($p>0.10$). As regards ECO2003F (second period), the coefficient for the variable *WSHOPS* is 0.52 and statistically significant ($p<0.01$).

These results can be taken to imply that the educational interventions included in each of the three first-year AD courses were successful in improving the academic performance of AD students in the second-year courses relative to their peers on the mainstream. However, the results of the OLS estimations are not compelling, given that the coefficients are relatively small and that they are only weakly supported by the results of the PSM estimations.[92] Of greater importance is the finding that the premium going to workshop attendance in the second-year microeconomics course (second period) is positive and statistically significant ($p<0.01$). This finding implies that AD students can draw substantial benefits from additional educational interventions designed to enable them to master the specific difficulties they experience in second-year mainstream courses.

The coefficients of the variables *Adjmatpt* and *D White* are positive and statistically significant ($p<0.01$) in explaining students' academic performance for each of the five second-year courses. The coefficients of the variables *D Math HG ABC* (microeconomics), and *D Math HG A* and *D Math HG B* (mathematics), are also positive and statistically significant ($p<0.01$), but the former is statistically insignificant ($p>0.10$) for the two chemistry courses. The latter result implies that mathematical understanding is less important in determining academic performance in second-year chemistry than it is in second-year mathematics and microeconomics. This result, however, could be a function of the small-sample problem discussed in Chapter 3.

Academic ability, as measured by the adjusted matriculation points score, and the mathematics (HG) grade, plays a crucial role in determining the degree to which students succeed in the three second-year courses as it does for the first-year courses. These results provide additional evidence that those students with relatively poor results in the matriculation mathematics examination need additional support.

[92] In general, the results of the PSM estimations must be interpreted with caution as the joint requirement of "balancing the independent variables" and "common support" is rarely met.

That said, these findings are qualified by the fact that the methods employed to secure the internal validity in each of the three case studies are not entirely successful; there remains the possibility of omitted variable bias and the sample-selection problem.

As regards the results of each of the OLS estimations for the AD and mainstream students taking the second-year courses in microeconomics and mathematics, only the variables *D Math HG* and *D Math HG ABC* are statistically significant ($p<0.05$) for the two groups of students. The coefficient of the variable *D Enghome* is negative and statistically significant ($p<0.05$) for the ASPECT cohorts, as it is for the AD and mainstream students who took CEM2007F and CEM2008S. As was previously noted, this surprising finding for first- and second-year AD students warrants further investigation.

Chapter 8

Analysis of graduation data

This chapter consists of three case studies, that is, the analysis of the effectiveness of the first-year AD courses in the faculties of commerce, engineering and the built environment, and science in improving the graduation performance of AD students relative to mainstream students.[93]

As regards the Commerce Academic Development Programme (CADP), the AD first-year courses are microeconomics, accounting, statistics, and information systems. ASPECT first-year courses include mathematics, physics, engineering, and language and communication, and the first-year courses offered by GEPS are mathematics, physics, and chemistry, with an elective chosen from one of biology, computer science, and earth and environmental science.

The analysis follows the same format as in the previous chapters. In this instance, however, the three AD programmes (CADP, ASPECT and GEPS) are considered simultaneously at each stage, as the analysis of the three programmes has much in common.[94]

8.1 Characteristics of the academic development and mainstream cohorts

To determine the extent of the similarity between each of the AD and mainstream cohorts, tests for differences of means and proportions are conducted for each of the continuous and discrete variables. The results of this analysis are presented in tables 8.1 and 8.2.

Table 8.1 presents the data for the control variables for the CADP, mainstream and COMB06 cohorts. COMB06 students are a sub-group of mainstream students, who, like most CADP students, plan to major in accounting and to go on to do the Post Graduate Diploma in Accounting (PGDA).

[93] The period for the Commerce and Science studies is 1999–2004, and for the Engineering study it is 1999–2003. It takes seven years for all the CADP and GEPS students (4-year programmes), and eight years for all the ASPECT students (5-year programme), to complete their university careers.
[94] In Smith (2009b) an earlier version of this analysis is reported.

Table 8.1 Control variables for the CADP, mainstream and COMB06 cohorts

	CADP	Mainstream	Tests	COMB06	Tests
Personal characteristics	**% share**	**% share**	**z-stat**	**% share**	**z-stat**
Black	68.4	16.6	**23.5	33.0	**12.1
Indian	7.2	10.4	*1.9	8.1	0.6
Coloured	24.4	13.1	**5.9	23.4	0.4
White	0.0	59.9	**12.0	35.5	**13.9
English home language (Enghome)	28.6	81.2	**23.1	64.6	**12.4
Male	47.7	55.6	**3.0	48.6	0.3
Financial Aid (Finaid)	61.3	8.3	**30.6	18.2	**16.3
	Mean	**Mean**	**t-stat**	**Mean**	**Mean**
Age at entry (Age)	18.2	18.6	**5.2	18.6	**5.2
School attended	**% share**	**% share**	**z-stat**	**% share**	**% share**
HRD (HRD)	23.1	8.9	**8.7	15.8	**3.1
DET (DET)	36.6	3.7	**26.0	10.0	**12.5
Matriculation points	**Mean**	**Mean**	**t-stat**	**Mean**	**Mean**
Mean matriculation points score (Matpt)	33.5	41.0	**31.4	38.3	**20.3
Mean adjusted matriculation points score (Adjmatpt)	23.5	26.9	**19.3	25.8	**14.2
Matriculation subjects	**% share**	**% share**	**z-stat**	**% share**	**% share**
English first language (HG) (Eng FL HG)	49.1	94.7	**31.8	85.8	**14.9
Afrikaans first language (HG) (Afrik FL HG)	5.6	7.4	1.3	6.8	0.8
Xhosa first language (HG) (Xhosa FL HG)	26.8	1.1	**29.5	3.5	**14.2
Zulu first language (HG) (Zulu FL HG)	5.3	1.0	**6.6	2.7	*2.5
Mathematics (HG) (Math HG)	41.9	86.6	**23.9	71.7	**10.7
Physical Science (HG) (PS HG)	28.1	74.7	**19.6	57.6	**10.2
Province					
Western Cape (WC)	23.1	8.9	**8.7	15.8	**2.7
Programmes[1]					
D COMB01 (General)		0.5			
D COMB03 (Actuarial Science)		9.7			
D COMB04 (Business Science)		49.4			
D COMB06 (Accounting)		24.4			
D COMB07/17 (Economics and Law)		1.0			
D COMB08 (Information Systems)		8.0			
D COMB12 (PPE)		1.6			
D COMB13 (Economics and Finance)		0.5			
D COMB16 (Accounting and Law)		0.3			
Year					
D 1999	16.4	15.8	0.3	12.8	1.5
D 2000	11.7	16.5	*2.5	16.8	*2.3
D 2001	19.1	18.5	0.3	21.4	0.8
D 2002	12.7	16.2	1.8	17.1	1.9
D 2003	15.1	16.7	0.8	16.5	0.7
D 2004	24.9	16.3	**4.5	15.3	**4.5
Observations	376	5088		1241	

[1] The students' programme on entry to the university might differ from the programme on exit from the university

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between the CADP and mainstream cohorts

** and * statistically significant at the 1% and 5% levels, respectively

The CADP and mainstream cohorts, and the CADP and COMB06 cohorts, differ markedly from one another; in nearly all cases the null hypothesis of equal means and proportions can be rejected. That said, the characteristics of the COMB06 cohorts approximate more closely those of the CADP cohorts than do the characteristics of the mainstream cohorts.

The data in respect of the control variables for the ASPECT and GEPS cohorts, and their respective mainstream cohorts, are presented in table 8.2 below. The ASPECT cohorts exclude the ASPECT students who did the mainstream course in first-year mathematics and

those mainstream students who transferred to the ASPECT programme during their first year at university.

Table 8.2 Control variables for the ASPECT, GEPS and mainstream cohorts

	Engineering			Science		
	ASPECT	**Mainstream**	**Tests**	**GEPS**	**Mainstream**	**Tests**
Personal characteristics	**% share**	**% share**	**z-stat**	**% share**	**% share**	**z-stat**
Black	85.5	22.8	**18.6	67.9	12.5	**27.6
Indian	4.2	10.2	**3.0	6.5	9.2	1.6
Coloured	9.2	12.2	1.4	22.9	11.0	**7.7
White	1.1	54.9	**15.7	2.6	66.9	**28.3
English home language (Enghome)	14.9	70.2	**16.1	31.3	78.8	**22.3
Male	67.2	78.4	**3.7	60.4	52.6	**3.1
Financial Aid (Finaid)	32.8	12.2	**8.3	54.7	10.4	**23.6
	Mean	**Mean**	**t-stat**	**Mean**	**Mean**	**t-stat**
Age	19.0	18.8	1.4	19.1	19.0	0.4
School attended	**% share**	**% share**	**z stat**	**% share**	**% share**	**z-stat**
Houses of Representatives and Delegates (HRD)	9.5	9.6	0.1	21.3	9.4	**8.2
Department of Education and Training (DET)	62.6	10.1	**18.8	38.3	5.4	**20.4
Matriculation points	**Mean**	**Mean**	**t-stat**	**Mean**	**Mean**	**t-stat**
Mean matriculation points score (Matpt)	36.2	41.2	**16.2	32.3	40.7	**17.7
Mean adjusted matriculation points score (Adjmatpt)	22.3	25.6	**14.4	20.1	25.5	**14.4
Matriculation subjects	**% share**	**% share**	**z-stat**	**% share**	**% share**	**z-stat**
English first language (HG) (Eng FL HG)	32.8	87.4	**18.3	50.4	89.9	**21.4
Afrikaans first language (HG) (Afrik FL HG)	0.8	6.6	**24.5	3.5	8.1	**4.3
Xhosa first language (HG) (Xhosa FL HG)	6.9	2.0	**4.2	11.9	1.4	**12.4
Zulu first language (HG) (Zulu FL HG)	11.5	1.5	**8.5	8.1	1.6	**6.8
Mathematics (HG) (Math HG)	95.4	99.9	**6.8	74.7	94.7	**14.2
Mathematics (HG) ABC (Math HG ABC)	52.3	89.2	**13.5	14.7	72.3	**25.3
Physical Science (HG) (PS HG)	98.1	99.8	**3.5	79.4	94.8	**11.8
Physical Science (HG) ABC (PS HG ABC)	66.4	91.8	**11.1	16.4	74.2	**11.8
Province						
Western Cape (WC)	16.8	43.5	**7.7	38.3	56.4	**7.9
Year						
1999	19.8	18.2	0.6	13.2	14.7	0.9
2000	19.5	16.0	1.2	18.7	15.0	*2.2
2001	17.2	16.5	0.4	16.1	16.4	0.2
2002	22.9	22.7	0.1	20.2	20.3	0.1
2003	20.6	26.7	*2.0	16.3	16.5	0.1
2004				15.5	17.1	0.9
Observations	262	1019		689	1685	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ASPECT and mainstream students
** and * statistically significant at the 1% and 5% levels, respectively

It is clear that the two sets of cohorts differ markedly from one another. This is not surprising given the different methods of placement into the mainstream and AD programmes.

The three AD cohorts share a similar set of characteristics. Black students make up the majority of each cohort, and a minority of each cohort have English as their home language. Black students however, make up a greater proportion of the ASPECT cohorts, and fewer ASPECT students declare English as their home language. The CADP cohorts are the only AD cohorts that have a minority of male students, and the ASPECT cohorts are the only AD cohorts that have less than half the students receiving financial aid and more than half coming

from former DET schools.[95] In general the AD cohorts have a low level of academic preparedness as reflected in their matriculation and adjusted matriculation points scores compared to the mainstream cohorts. However, the only AD cohorts that have a minority of students who took mathematics and physical science on the higher grade are the CADP cohorts.

8.2 Data and results

8.2.1 Analysis of data

This section compares the graduation performance of the AD and mainstream cohorts. These cohorts include only those students who began their university careers in one of the three faculties that are the subject of this thesis. Not all students graduate from the programme in which they started, as they may choose to change programmes, or faculties, during the course of their university career. Also, it is not known how many students who left the university prior to graduation went on to graduate from another tertiary institution.

The data for the CADP, mainstream and COMB06 cohorts for the intake years 1999–2004 are presented in table 8.3. The CADP cohorts consist of 376 students and the two mainstream cohorts consist of 5088 and 1241 students, respectively.

Table 8.3 Graduation performance of the CADP, mainstream and COMB06 cohorts

	CADP	Mainstream including COMB06		COMB06	
Graduation performance	**% share**	**% share**	**z-stat**	**% share**	**z-stat**
Graduated	49.5	79.9	*14.5	66.9	*6.2
Minimum time	38.7	62.3	*6.3	35.2	1.0
Minimum time + 1 year	40.3	28.4	*3.5	43.0	0.8
Minimum time + 2 years	18.3	8.0	*4.7	18.6	0.1
Minimum time + 3 years	2.7	1.3	1.6	3.3	0.2
Excluded	35.4	9.4	*16.2	16.2	*7.9
Left university in good academic standing	15.1	10.7	*2.4	16.9	0.6
Observations	376	5088		1241	

* statistically significant at the 1% level

[95] At this time more students were receiving bursaries from the corporate sector than is currently the case. Also, a number of students did not meet the financial aid criteria (personal communication, course convener).

The data in table 8.3 shows that 49.5% of the CADP cohorts graduated as opposed to 79.9% of the mainstream cohorts, and the difference is statistically significant ($p<0.01$). The graduation rate of the CADP cohorts, however, compares more favourably to the rate achieved by the COMB06 students, of whom 66.9% graduated. A much higher proportion of CADP students were excluded from university and not allowed to continue their studies as they did not meet the requirements to do so than were mainstream and COMB06 students, and this difference is also statistically significant ($p<0.01$). Furthermore, a not insignificant proportion of students left the university in good academic standing. For example, 15.1% of the CADP cohorts did not continue with their university careers though they qualified to do so.

The minimum time laid down for the completion of a degree in the Faculty of Commerce depends on the programme. The minimum time for Business Science (COMB04), Actuarial Science (COMB03) and CADP students is four years. For all other programmes it is three years. A much greater proportion of those mainstream students who graduated did so within the minimum time than was the case for the CADP and COMB06 students. Also, similar proportions of the CADP and COMB06 graduates graduated in the minimum time, and in minimum time plus one, two or three years.

The data comparing the graduation performance of the ASPECT and engineering mainstream cohorts for the years 1999–2003, and of the GEPS and science mainstream cohorts for the years 1999–2004, are presented in table 8.4.

The engineering cohorts include only students who intended to study one of the engineering courses, for example chemical, civil or mechanical, among others. There are 262 ASPECT students and 689 GEPS students. The corresponding mainstream figures are 1019 and 1685 for engineering and science, respectively.

The minimum time for a degree in the Faculty of Engineering and the Built Environment is four years for mainstream students and five years for ASPECT students. For the Faculty of Science, the minimum time is three years for mainstream students and four years for GEPS students.

Table 8.4 Graduation performance of the ASPECT, GEPS and mainstream cohorts

	Engineering			Science		
	ASPECT	**Mainstream**	**z-stat**	**GEPS**	**Mainstream**	**z-stat**
Graduation performance	**% share**	**% share**		**% share**	**% share**	
Graduated	53.8	75.4	**6.7	42.4	76.9	**16.5
Graduate engineering/science	53.1	71.4	**5.5	33.5	65.3	**13.8
Minimum time	41.1	57.8	**3.7	42.8	56.3	**4.0
Minimum time + 1 year	39.0	29.7	*2.1	41.4	27.9	**4.4
Minimum time + 2 years	14.9	9.1	*2.2	12.7	11.7	0.5
Minimum time + 3 years	5.0	3.4	0.9	3.1	4.2	0.9
Excluded	38.2	17.3	**7.4	49.3	12.7	**18.9
Left university in good academic standing	8.0	7.3	1.2	8.3	10.4	1.7
Observations	262	1019		689	1685	

** and * statistically significant at the 1% and 5% levels, respectively

ASPECT and GEPS students achieved lower graduation rates than their peers on the mainstream and the difference is statistically significant ($p<0.01$).[96] Of the ASPECT graduates, 98.7% graduated with an engineering degree, and of the mainstream graduates, the figure is 94.7%. The proportions for the GEPS and mainstream science students are lower: 79.0% of the GEPS students who graduated, and 84.9% of the mainstream students who graduated, did so in the science faculty.

As was the case for commerce students, a much higher proportion of ASPECT and GEPS students were excluded relative to their peers on the mainstream, and the difference is statistically significant ($p<0.01$). Also, as was the case for commerce students, the proportion of graduates completing their degrees in the minimum time is lower for ASPECT and GEPS students than for mainstream students, and the differences are statistically significant ($p<0.01$). The proportion of AD students who complete their degrees in the minimum time plus one year is, however, greater than for mainstream students across all three faculties. These findings suggest that successful AD students require additional time to meet the academic standards necessary to graduate.[97]

Finally, ASPECT students achieve the highest (53.8%) and GEPS students the lowest (42.4%) graduation rates, with CADP students achieving a graduation rate of 49.5%. The

[96] Of the 17 students who transferred from the mainstream to the ASPECT programme in their first semester at university, 9 graduated (52.9%). Of the 37 ASPECT students who attended mainstream courses from their first semester at university, 75.7% graduated.

[97] The requirements for exclusion are less severe for AD students than for mainstream students. These less onerous requirements are linked to the fact that AD students are given an extra year to complete their degree.

weighted mean graduation rate for the three AD programmes is 46.7%, and for the mainstream cohorts it is 78.6%. Conversely the AD cohorts have a weighted average exclusion rate of 43.2%, compared to the mainstream's 11.1%.

As regards the graduation rates for the AD programmes shown in tables 8.3 and 8.4 it is worth noting that Pinto (2001) reports that the average graduation rate for students on the SFP at UKZN for the 1991–1994 cohorts was 41.4%, and 37.9% for the students at University of Witwatersrand's College of Science for the 1991–1995 cohorts.

To put the mainstream graduation rates in context, Besterfield-Sacre et al. (1997) (USA) report that less than 50% of engineering students graduate; Caroni (2011) predicts that 12% of Greek students at the National Technical University of Athens will never graduate; MacGillivray (2009) reports that over 20% of students drop out of university programmes in science and engineering in the UK, and more than 40% of students drop out of the same programmes at universities in Australia; Morgan et al. (2001) (Ireland) report that 20% of engineering students do not graduate; and Wolffram et al. (2009) state that 50% of students withdraw from engineering degrees in Germany.

8.2.2 Estimation results

MVA estimations

Logit estimations are used to estimate the impact of the AD programmes on the graduation rates achieved by AD students. The production function represented by equation (1) in Chapter 5 (p. 79) is estimated using a binary dependent variable (graduate/not graduate) for each of the three faculties: commerce, engineering and science.

Also, extended specifications, which are not shown and include the quadratic terms Age^2 and $Adjmatpt^2$, are estimated for each of the three faculties.

The results of the logit estimations for each of the three faculties are shown in table 8.5.

Table 8.5 Results of the logit estimations for each of the three faculties

	Base cases	Commerce		Engineering		Science	
		1	2	3	4	5	6
Dependent variable Graduate/not graduate		**Logit 1**	**dF/dx**	**Logit 2**	**dF/dx**	**Logit 3**	**dF/dx**
Independent variables							
D CADP		-0.08	-0.02				
D ASPECT				-0.12	-0.02		
D GEPS						-0.24	-0.06
Adjmatpt		**0.15	**0.02	**0.15	**0.03	**0.15	**0.03
D Eng FL HG	Eng SL HG	0.14	0.02	0.19	0.03	0.15	0.03
D Math HG	Math SG	*0.24	*0.04				
D Math HG ABC	Math HG DEF Math SG			**0.64	**0.13	0.21	0.05
D PS HG	PS SG	**0.45	**0.08	-0.11	-0.02		
D PS HG ABC	PS HG DEF PS SG					0.09	0.02
Age		**-0.10	**-0.02	0.04	0.01	-0.07	-0.01
D Enghome		0.10	0.02	0.32	0.07	-0.01	0.00
D Male		-0.08	-0.01	*-0.34	**-0.06	**-0.32	**-0.06
D Finaid		0.01	0.00	-0.30	-0.06	0.02	0.01
D White		**0.74	**0.11	**0.57	**0.11	**0.64	**0.13
D HRD	Model C Private	-0.04	-0.01	-0.35	-0.07	0.01	0.00
D DET	Model C Private	0.33	0.05	0.47	0.08	0.19	0.04
D WC		0.14	0.02	-0.15	-0.03	*0.27	*0.05
D ComB01	COMB06	*-1.09	*-0.23				
D ComB03	COMB06	0.29	0.04				
D ComB04	COMB06	**0.55	**0.08				
D ComB08	COMB06	0.09	0.01				
D ComB12	COMB06	0.21	0.04				
D ComB13	COMB06	0.39	0.06				
D ComB16/17	COMB06	0.10	0.02				
D 2000	1999	*-0.26	*-0.04	*-0.45	-0.09	0.12	0.03
D 2001	1999	**-0.74	**-0.13	-0.08	-0.02	0.07	0.02
D 2002	1999	-0.22	-0.04	-0.35	-0.07	*-0.38	*-0.08
D 2003	1999	-0.04	-0.01	**-0.71	**-0.14	-0.30	-0.06
D 2004	1999	-0.05	-0.01			-0.09	-0.01
Constant		**-1.89		**-3.83		-1.81	
Pseudo R^2		0.143		0.122		0.152	
LR chi^2 (25)		**828.60					
LR chi^2 (17)				**187.70			
LR chi^2 (18)						**456.50	
Observations		5464		1281		2374	

** and * statistically significant at the 1% and 5% levels, respectively

The sign of the coefficient for each of the three AD programmes is negative, but statistically insignificant. The educational interventions included in each of the three AD programmes have neither a positive nor a negative effect on the graduation rate achieved by AD students, conditional on the independent variables. The implications of these results are discussed in Chapter 9.

Turning to the control variables, the coefficients of the variables *Adjmatpt* and *D White* are positive and statistically significant for each of the three estimations ($p<0.01$). White students and students with a relatively high level of academic ability (preparedness), as measured by their adjusted matriculation points score, are more likely to graduate, conditional on the control variables.

As regards the commerce faculty estimation (column 1), the coefficients of the variables *D Math HG*, *D PS HG*, *Age*, *D ComB01*, *D ComB04*, *D 2000* and *D 2001* are all statistically significant at, at least, the 5% level in explaining whether the students graduated or not.[98] With the exception of the variables *Age*, *D ComB01*, *D 2000* and *D 2001*, the signs of the coefficients of the variables are positive. Students who took mathematics (HG) and physical science (HG) are more likely to graduate, and older students are less likely to graduate, conditional on the control variables.

Turning to the engineering faculty estimations (column 3), the variable *D Math HG ABC* has a positive coefficient, which is statistically significant ($p<0.01$). The coefficients of the variables *D Male* and *D 2003* are negative and statistically significant ($p<0.05$). An above-average grade for mathematics (HG) plays an important role in determining whether students graduate or not, and male students have a lower graduation rate than female students, conditional on the independent variables.

As regards the science faculty estimations (column 5), the variable *D WC* has a positive coefficient ($p<0.05$), and the coefficient for the variable *D Male* is negative and statistically significant ($p<0.01$). Students from the Western Cape Province are more likely to graduate than students from the rest of South Africa, conditional on the explanatory variables. Males, however, have a lower graduation rate than females, conditional on the selected control variables, as was the case for the engineering estimation.

The coefficients of the variables *D DET* and *D HRD* are statistically insignificant ($p>0.10$) across the three estimations. This suggests that students from these schools had graduation rates on a par with students from other types of school, conditional on the independent variables.

Finally, the pseudo R^2 ranges from 0.122 to 0.152, which implies that there is a good deal of unexplained variation in the graduation rate across the three faculties.

[98] There are no doubt unobservable variables, for example motivation, that might explain why COMB04 students outperform, and COMB01 students underperform, their peers on the mainstream, conditional on the independent variables.

The marginal effects for each of the independent variables are shown in the second, fourth and sixth columns of table 8.5. For example, for each one-point increase in the adjusted matriculation points score, the probability of a commerce student's graduating increases by 2.0 percentage points, on average (column 2). Also, the probability of a male science student's graduating is decreased by 6.0 percentage points, on average, relative to female science students (column 6). Both coefficients are statistically significant ($p<0.01$).

In estimations not shown, there are increasing returns to academic ability for each of the three sets of students, as measured by the quadratic term $Adjmatpt^2$. In all three cases, the variables *Adjmatpt* and $Adjmatpt^2$ are jointly statistically significant ($p<0.01$). There are decreasing returns to age, as measured by the quadratic term Age^2, for each of the three estimations. The variables *Age* and Age^2 are only jointly statistically significant for the commerce and engineering faculty estimations.

The results of the logit estimations showing the marginal effects for each of the AD and mainstream groups are presented in table 8.6. The purpose of the following analysis is to identify the variables that are statistically significant in explaining the graduation rates of AD and mainstream students.

Table 8.6 Results of the logit estimations for each of the three AD and corresponding mainstream cohorts

	Base cases	Commerce CADP dF/dx	Commerce Mainstream dF/dx	Engineering ASPECT dF/dx	Engineering Mainstream dF/dx	Science GEPS dF/dx	Science Mainstream dF/dx
		1	2	3	4	5	6
Dependent variable							
Graduate/not graduate							
Independent variables							
Adjmatpt		*0.02	**0.03	-0.01	**0.04	**0.03	**0.03
D Eng FL HG	Eng SL HG	-0.07	0.05	0.04	0.05	0.08	-0.03
D Math HG	Math SG	0.12	0.03				
D Math HG ABC	Math HG DEF Math SG			0.09	**0.16	0.03	0.04
D PS HG	PS SG	0.12	**0.07				
D PS HG ABC	PS HG DEF PS SG			0.02	-0.03	0.01	0.02
D White			**0.10	0.00	*0.09		**0.10
Age		-0.03	*-0.01	-0.01	0.01	-0.01	-0.01
D Enghome		-0.02	0.02	-0.21	*0.08	-0.01	0.03
D Male		-0.07	-0.01	**-0.22	-0.01	**-0.12	*-0.04
D Finaid		-0.03	0.00	-0.14	-0.05	-0.01	0.01
D HRD	Model C Private	0.01	0.00	-0.06	-0.07	0.04	-0.03
D DET	Model C Private	0.09	0.03	0.07	*0.12	0.03	0.06
D WC		-0.03	*0.03	0.07	-0.02	0.02	**0.06
D ComB1			*-0.23				
D ComB3			0.03				
D ComB4			**0.07				
D ComB8			0.01				
D ComB12			0.02				
D ComB13			0.05				
D ComB16/17			0.00				
D 2000	1999	0.18	**-0.06	-0.08	-0.09	-0.03	0.04
D 2001	1999	-0.03	**-0.15	0.05	-0.02	-0.08	0.06
D 2002	1999	0.13	*-0.05	0.08	*-0.09	-0.08	-0.07
D 2003	1999	-0.02	-0.01	-0.07	**-0.15	*-0.15	-0.01
D 2004	1999	0.07	-0.01			-0.11	0.03
Pseudo R^2		0.050	0.134	0.071	0.134	0.050	0.097
LR chi^2 (18)		26.20					
LR chi^2 (26)			**684.10				
LR chi^2 (16)				25.6			
LR chi^2 (16)					**153.00		
LR chi^2 (16)						*46.80	
LR chi^2 (16)							**175.9
Observations		376	5088	262	1019	689	1685

** and * statistically significant at the 1% and 5% levels, respectively

As regards the CADP estimation (column 1), the positive marginal effect of the variable *Adjmatpt* is statistically significant ($p<0.05$). A one-point increase in the adjusted matriculation points score increases by 2 percentage points, on average, the probability that a student graduates. The LR chi^2 is statistically insignificant, which indicates that the results of the estimation are such that nothing definite can be said about the determinants of graduation for CADP students. For mainstream commerce cohorts (column 2) the marginal effects of the variables *Adjmatpt* and *D PSHG* are positive and statistically significant ($p<0.01$). The marginal effect for the variable *D White* is positive and statistically significant ($p<0.01$). The probability of a white student's graduating is increased by 10 percentage points, on average.

The marginal effect for the variable *Age* is negative and statistically significant ($p<0.05$), and the marginal effect for the variable *D WC* is positive and statistically significant ($p<0.05$).

Turning to the ASPECT cohorts (column 3), only the negative marginal effect of the variable *D Male* is statistically significant ($p<0.01$). Again, the LR chi^2 is statistically insignificant, which indicates that nothing definite can be said about the determinants of graduation for ASPECT students. In the estimation for the mainstream engineering cohorts (column 4), the marginal effects of the variables *Adjmatpt*, *D Math HG ABC*, *D White*, *D Enghome* and *D DET* are positive and statistically significant at, at least, the 5% level. The marginal effects of the variables *D 2002 and D 2003* are negative and statistically significant at, at least, the 5% level.

For both the GEPS (column 5) and science mainstream (column 6) cohorts, the marginal effect of the variable *Adjmatpt* is positive and statistically significant ($p<0.01$), and the marginal effect of the variable *D Male* is negative and statistically significant ($p<0.01$). As regards the mainstream science cohorts, the marginal effects of the variables *Adjmatpt*, *D White* and *D WC* are positive and statistically significant ($p<0.01$).

In summary, the marginal effects of none of the variables are statistically significant ($p<0.05$) across the three groups of AD students. That said, the coefficient of the variable *D Male* is negative and statistically significant ($p<0.01$) for each of the ASPECT and GEPS cohorts. This finding warrants more investigation.

In general, the findings in respect of the of AD students suggest that the omitted variables are more important in explaining their graduation performance than is the case for mainstream students. The findings also imply that the initial placement process is more difficult for AD students, as the usual variables correlated with academic success are not statistically significant for these students. Furthermore, because the AD cohorts are more homogenous than the corresponding mainstream cohorts, and have smaller variations in several important independent variables (adjusted matriculation points score, mathematics (HG) and physical science (HG)), it is more difficult to generate results that are statistically significant ($p<0.05$).

For the mainstream cohorts the findings suggest that academic ability as measured by the students' adjusted matriculation points score, and the many advantages that accrued to the

white population prior to and since 1994, plays a crucial role in determining academic performance of mainstream students through to graduation.

PSM estimations

The purpose of PSM is to construct a control group from the mainstream cohorts that shows a greater similarity to the treated group (AD cohorts) across the range of independent variables.

As regards the commerce estimation, the variable *D White* and the mainstream programme variables are included in the probit estimation as matching variables as there are no white CADP students, nor CADP students on any of the mainstream programmes.[99] Thus the CADP cohorts (accounting majors) that have no white students are matched against the mainstream (COMB06) cohorts, excluding white students, who are also accounting majors. The CADP and mainstream students are then matched on the independent variables that are common to both cohorts.

The results of the PSM estimations for each of the three faculties are presented in tables 8.7 and 8.8.

[99] *D COMB01*, *D COMB03*, *D COMB04*, *D COMB06*, *D COMB7/17*, *D COMB08*, *D COMB12*, *D COMB13* and *D COMB16*

Table 8.7 Results of the graduation PSM probit and matching estimations

	Commerce			Engineering			Science		
	Probit estimation	**% bias before matching "Xs"**	**% bias after matching "Xs"**	**Probit estimation**	**% bias before matching "Xs"**	**% bias after matching "Xs"**	**Probit estimation**	**% bias before matching "Xs"**	**% bias after matching "Xs"**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Independent variables									
Adjmatpt	**-0.18	**-91.6	*-19.0	**-0.09	**-73.7	0.4	**-0.24	**-174.9	3.3
D Eng FL HG	*-0.33	**-118.0	-7.8	**-0.49	**-105.3	-0.7	-0.24	**-95.7	**18.3
D Math HG	**-0.54	**-105.8	13.9						
D Math HG ABC				**-0.94	**-63.8	2.7	**-0.98	**-142.7	**-24.0
D PS HG	**-0.44	**-105.0	1.6				**-0.56		
D PS HG ABC				**-0.55	**-39.8	-4.8			
Age	**-0.12	**-23.5	-1.7	0.02	7.1	5.9	0.02	**-142.6	-2.8
D Enghome	*-0.33	**-124.8	-5.2	*-0.41	**-111.3	-1.0	**-0.38	*9.5	**-23.7
D Male	-0.02	**-15.5	4.7	**-0.37	**-25.4	-0.7	-0.04	**-108.5	**16.7
D White				**-1.42	**38.9	-7.9	**0.45	**15.7	-1.0
D Finaid	**0.69	**134.1	1.2	-0.24	**-126.5	-1.5	**-1.59	**107.3	**24.6
D HRD	0.19	**39.5	-7.1	0.19	-1.5	-3.7	*0.31	**-182.8	-3.2
D DET	0.28	**89.9	5.5	**0.67	**102.6	-2.6	0.26	**33.6	-0.5
D WC	**0.38	**-14.6	-3.2	-0.07	**-53.0	-1.2	0.21	**86.8	-12.0
D 2000	-0.21	*-13.8	3.4	*0.38	8.7	10.3	**0.53	**-36.7	5.5
D 2001	0.05	1.0	7.9	0.05	-1.4	-6.0	**0.51	*9.9	**-34.4
D 2002	-0.07	-9.7	3.1	0.07	1.7	-7.9	*0.33	-0.9	**22.0
D 2003	**0.77	-4.2	-11.7	*0.44	-11.5	6.3	**1.21	-0.3	**14.7
D 2004	**0.84	**21.60	*-16.8				**0.93	-0.5	**19.7
Constant	**6.09			**2.62			**4.96	-4.3	**-22.4
Pseudo R^2	0.307			0.480			0.648		
LR chi^2 (16)	**467.9			**623.10			**1850.00		
Observations	1243			1281			2374		

** and * statistically significant at the 1% and 5% levels, respectively

The sign of the coefficients of the variables in the probit estimation, and whether they are statistically significant or not, indicate the probability that AD students qualify for the mainstream control group. In general, the coefficients of the matching variables are statistically significant ($p<0.05$), indicating that students in each of the AD programmes would not qualify for the comparable mainstream group.

On checking the balance of the independent variables after the matching process, it was found that the reduction in bias was considerable across the most of the variables for commerce and engineering estimations (columns 3 and 6). As regards the commerce estimation, only the differences between the pre- and post-matching values of variables *Adjmatpt* and *D 2004* remain statistically significant ($p<0.05$). For the engineering estimation, none of the differences between the variables remain statistically significant ($p>0.05$). As regards the science estimation (column 9), however, there is still considerable bias across the majority of the independent variables after the matching process. The differences remained statistically significant at, at least, the 5% level for the following variables: *D Math HG ABC*, *D Eng FL HG*, *Age*, *D Enghome* and *D Finaid*.

The conditions for "common support" are partly met for the commerce (appendix D, figure D7) and engineering (appendix D, figure D8) estimations. Most of the regions of the propensity score values have sufficient observations from both the treated (AD) and untreated (mainstream) groups; there seems to be a good chance that a student with a given propensity score could fall into the treated and control groups. Therefore, there are sufficient grounds to accept the results of PSM estimations in addition to the results of MVA logit estimations to identify the effect of the first-year AD courses on AD students' graduation performance relative to the graduation performance of mainstream students.

As regards the science estimation, the conditions for "common support" are barely met (appendix D, figure D9). Most of the regions of the propensity score values have insufficient or no observations from both the treated (ASPECT) and untreated (mainstream) groups; there seems to be a poor chance that a student with a given propensity score could fall into the treated and control groups. It cannot be said that the two samples come from the same population. Nevertheless, the results of the PSM estimation are reported in table 8.8, though they must be interpreted with great caution.

The results of the three PSM estimations are presented in table 8.8.

Table 8.8 Results of the graduation PSM estimations

Dependent variable Graduation	**Sample**	**Treated AD**	**Controls Mainstream**	**Difference**	**Std Err**	**t-stat**
CADP	Unmatched	0.49	0.62	-0.13	0.03	*-4.32
1243 obs	ATT	0.49	0.55	-0.06	0.04	-1.23
ASPECT	Unmatched	0.54	0.75	-0.23	0.03	-6.98*
1281 obs	ATT	0.54	0.58	-0.04	0.05	-0.94
GEPS	Unmatched	0.42	0.77	-0.35	0.02	*-17.2
2374 obs	ATT	0.42	0.54	-0.12	0.08	-1.53

ATT: Average treatment effect on the treated
* statistically significant at the 1% level

The graduation rate for each of the AD programmes is lower than that achieved by the comparable mainstream group, and in all cases the difference is statistically significant ($p<0.01$). For example, the graduation rate achieved by the CADP cohorts (49.0%) is less than that achieved by mainstream commerce students (62.0%).

After PSM the graduation rate for each of the AD cohorts is still less than that achieved by the comparable matched mainstream control groups, but the differences are statistically

insignificant (p>0.10). For example, the difference in the graduation rates achieved by the mainstream commerce control group falls from 13 to 6 percentage points.

These results suggest that the first-year courses AD courses offered by each of the three AD programmes had neither a positive nor a negative effect on the AD students' graduation performance, relative to their peers on the mainstream, conditional on the matching variables. This is the same finding that was arrived at using the logit estimations and reported in table 8.5. The implications of these uniform results across the three AD programmes are discussed in Chapter 9.

8.3 Summary discussion

In this section the data for the three faculties are combined. Firstly, logit estimations are used to compare the graduation rates of the three AD cohorts relative to the rates achieved by mainstream students. The results of these two estimations are presented in table 8.9. Estimation 1 is used to identify the relative success of each of the AD cohorts, and estimation 2 includes the three AD cohorts as a single variable, *D ADP*.

Secondly, separate logit estimations are run for each of the AD and mainstream cohorts to identify the variables that explain the graduation performance of these two diverse groups of students. The results of these estimations are presented in table 8.10.

Table 8.9 Results of the logit estimations for the Commerce, Engineering and Science faculties combined

	Base cases	Logit (1)	z-stat	dF/dx	Logit (2)	z-stat	dF/dx
		1	2	3	4	5	6
Dependent variable							
Graduate/not graduate							
Independent variable							
D ADP					-0.06	-0.70	-0.02
D CADP		-0.09	-0.59	-0.02			
D ASPECT		-0.12	-0.75	-0.03			
D GEPS		-0.02	-0.13	-0.01			
D Commerce	Science	0.10	1.21	0.02	0.08	1.08	0.02
D Engineering	Science	0.01	0.07	0.00	-0.02	-0.28	0.00
Adjmatpt		0.16	**17.0	**0.03	0.16	**16.7	**0.03
D Eng FL HG	Eng SL HG	0.08	0.66	0.01	0.08	0.68	0.02
D Math HG	Math SG	0.40	**4.72	**0.08	0.41	**4.74	**0.08
D PS HG	PS SG	0.45	**5.59	**0.09	0.45	**5.63	**0.09
Age		-0.05	*-2.42	*-0.01	-0.05	*-2.41	*-0.01
D Enghome		0.19	*2.37	**0.04	0.19	*2.27	**0.04
D Male		-0.18	**-3.08	**-0.03	-0.18	**-3.05	**-0.03
D Finaid		-0.09	-1.04	-0.02	-0.08	-1.00	-0.02
D White		0.73	**9.75	**0.13	0.73	**9.74	**0.13
D HRD		-0.08	-0.85	-0.02	-0.08	-0.85	-0.02
D DET		0.27	*2.12	*0.05	0.26	*2.09	*0.05
D WC		0.10	1.51	0.02	0.09	1.50	0.02
D 2000	1999	-0.21	*-2.27	*-0.04	-0.21	*-2.26	*-0.04
D 2001	1999	-0.46	**-5.01	**-0.09	-0.46	**-5.00	**-0.09
D 2002	1999	-0.32	**-3.55	**-0.06	-0.32	**-3.55	**-0.06
D 2003	1999	-0.29	**-3.16	**-0.05	-0.29	**-3.14	**-0.05
Constant		-2.97	**-6.00		-2.95	**-5.99	
Pseudo R^2		0.133			0.132		
LR chi^2 (21)		**1205.0					
LR chi^2 (19)					**1204.7		
Observations[1]		7800			7800		

[1] For the years 1999 to 2003 as not all students in the 2004 engineering cohort had passed through the system at the time of the analysis

** and * statistically significant at the 1% and 5% levels, respectively

Estimation 1

The coefficients of each of the three AD programmes (CADP, ASPECT and GEPS) are negative, but statistically insignificant (p>0.10) (column 1). These results mirror those reported above: the AD programmes have neither a positive nor a negative effect on the graduation performance of AD students relative to their peers on the mainstream across the three faculties, conditional on the independent variables.

The coefficients of the variables *Adjmatpt*, *D Math HG*, *D PS HG*, *D Enghome*, *D White* and *D DET* are all positive and statistically significant at, at least, the 5% level. These findings confirm that academic ability (preparedness) as measured by students' performance in the school-leaving examination, having English as a home language, which is the university's medium of instruction, and the advantages that accrued to the white population prior to and

since 1994, play a crucial role in determining students' academic performance through to graduation. The positive coefficients for the variables *D DET* and *D Enghome* are unexpected. Students who attended former DET schools have a higher graduation rate than students who attended other schools, conditional on the control variables. Also, in contrast to the findings reported in the first-year studies, students who declared English as their home language outperformed their peers through to graduation. The former finding may warrant further investigation.

The coefficients of the variables for each of the years 2000–2003, *Age* and *D Male* are negative and statistically significant at, at least, the 5% level. The finding as regards male students is driven by male students' relatively poor graduation performance in engineering and science, and does merit more investigation.[100]

The marginal effects for each of the independent variables are shown in columns 3 and 6. For example, for each one-point increase in the adjusted matriculation points score, the probability of a student's graduating increases by 3.0 percentage points, on average. Also, the probability of a white student's graduating is increased by 13.0 percentage points, on average. Both coefficients are statistically significant ($p<0.01$).

Estimation 2

The coefficient of the AD programme variable *D ADP* is negative but statistically insignificant ($p>0.10$). This finding is as expected, given that the coefficient for each of the variables *D CADP*, *D ASPECT* and *D GEPS* is negative and statistically insignificant ($p>0.10$). These results suggest that the AD programmes, collectively, have a statistically insignificant effect ($p>0.10$) on the graduation performance of AD students relative to their peers on the mainstream, conditional on the control variables.

The results of the logit estimations for the AD and mainstream cohorts are presented in table 8.10.

[100] In general there are fewer females than there are males in the Faculties of Engineering and the Built Environment, and Science. So it is possible that there is a greater self-selection by females into the programmes offered by these two faculties than there is into the Faculty of Commerce.

Table 8.10 Results of the logit estimations for AD and mainstream cohorts

		AD			Mainstream		
Dependent variable Graduate/not graduate		**Logit**	**z-stat**	**dF/dx**	**Logit**	**z-stat**	**dF/dx**
Independent variables		1	2	3	4	5	6
D CADP	D GEPS	-0.06	-0.32	-0.01			
D ASPECT	D GEPS	0.17	0.97	0.04			
D Commerce	D Science				0.10	1.16	0.02
D Engineering	D Science				-0.03	-0.30	-0.01
Adjmatpt		0.08	**3.84	**0.02	0.17	**16.5	**0.03
D Eng FL HG	Eng SL HG	0.20	1.03	0.05	0.09	0.59	0.02
D Math HG	Math SG	0.20	1.21	0.05	0.46	**4.52	**0.09
D PS HG	PS SG	0.10	0.55	0.02	0.52	**5.75	**0.09
D White		1.02	*2.01	*0.25	0.69	**8.67	**0.11
Age		-0.07	-1.65	-0.02	-0.04	-1.56	-0.01
D Enghome		-0.30	-1.33	-0.07	0.26	**2.83	**0.05
D Male		-0.48	**-3.65	**-0.12	-0.11	-1.65	-0.02
D Finaid		-0.19	-1.38	-0.05	-0.05	-0.51	-0.01
D HRD	Model C Private	0.08	0.41	0.02	-0.09	-0.79	-0.01
D DET	Model C Private	0.26	1.43	0.06	0.29	1.66	0.04
D WC		0.10	0.52	0.02	0.14	*2.01	*0.02
D 2000	1999	-0.10	-0.06	-0.01	-0.27	**-2.61	**-0.05
D 2001	1999	-0.28	-1.39	-0.07	-0.53	**-5.18	**-0.10
D 2002	1999	-0.07	-0.35	-0.02	-0.39	**-3.83	**-0.07
D 2003	1999	-0.48	*-2.22	*-0.11	-0.22	*-2.10	*-0.04
Constant		-0.51	-0.51		-3.78	**-6.66	
Pseudo R^2		0.042			0.106		
LR chi^2 (18)		**65.60			**750.50		
Observations		1126			6674		

** and * statistically significant at the 1% and 5% levels, respectively

For the mainstream cohorts the findings presented in table 8.10 (column 4) indicate that academic ability (preparedness) as measured by the students' adjusted matriculation points score, and whether they were successful in the mathematics (HG) and physical science (HG) school-leaving examinations, play an important role in determining the academic performance of mainstream students through to graduation. The advantages that accrued to the white population prior to and since 1994, whether the student's home language is English, and whether the student is domiciled in the Western Cape, are also positive factors in determining mainstream graduation rates. None of these findings is surprising and they are generally consistent with the literature cited in Chapter 4.

The picture presented by the data for AD students is markedly different. As per the logit estimation (column 1), only the coefficients of the variables *Adjmatpt*, *D White*, *D Male* and *D 2003* are statistically significant at, at least, the 5% level, in explaining the students' graduation performance.

The negative coefficient for the variable *D Male* is driven by the male students on the ASPECT and GEPS programmes and warrants further investigation. In this regard, the

graduation rates for male and female CADP students are 46.0% and 53.0%, respectively, and the difference is statistically insignificant ($p>0.10$). For male and female ASPECT students, the graduation rates are 46.0% and 69.0%, respectively, and the difference is statistically significant ($p<0.01$), and for male and female GEPS students 36.0% and 52.0%, respectively, and the difference is statistically significant ($p<0.01$). The difference in the graduation rates achieved by male and female students, across the three AD programmes, merits more investigation.[101]

The coefficient of the variable *D DET* is no longer statistically significant for either the AD or mainstream cohorts, as it was for two cohorts combined; students from former DET schools do not achieve higher graduation rates than students from other schools, conditional on the control variables. These contradictory findings imply that the effect of the variable *D DET* on graduation performance is relatively weak. Finally, it is surprising that the coefficient of variable *D Eng FL HG* is statistically insignificant for both the AD and mainstream cohorts, given that many students do not have English as their first language. It is probable that the positive effect of English on students' graduation rates is picked up by the variable *D Enghome*.

Although the LR chi^2 is statistically significant, the pseudo R^2 is only 4.2%. This implies that the omitted variables are more important in explaining AD students' graduation performance than is the case for mainstream students. The findings also imply, as was previously noted, that the initial placement process of AD students is more difficult, as the usual variables correlated with academic success are not statistically significant for AD students.

[101] Male and female mainstream commerce students both achieved graduation rates of 80%.
The graduation rates for male and female mainstream engineering students are 75% and 78%, respectively, and the difference is statistically insignificant ($p>0.10$).
The graduation rates for male and female mainstream science students are 74% and 80%, respectively, and the difference is statistically significant ($p<0.01$).

Chapter 9

Discussion and conclusion

This thesis used rigorous statistical methods and, in the spirit of postpositivism, endeavoured to develop well-warranted findings as regards the effectiveness of the educational interventions included in selected AD courses aimed at improving the academic performance of AD students relative to mainstream students.

The case studies presented in thesis were designed to answer the following four research questions:

a. What statistical methods can be used to estimate the effectiveness of AD programmes and courses?

b. What is the impact of the educational interventions included in selected first-year AD courses on the academic performance of AD students in these and subsequent second-year courses relative to mainstream students?

c. What is the impact of the first-year AD courses on the graduation performance of AD students for each of the selected programmes, relative to mainstream students?

d. What are the main determinants of academic performance, through to graduation, for AD and mainstream students?

9.1 Statistical methods

The findings of the case studies reported in this thesis are based on the results of the statistical analysis of non-experimental data. Students are placed into AD programmes (and courses); they are not randomly allocated to AD and mainstream courses and programmes.

This thesis made an explicit attempt to deal with a number of threats to internal validity that are generally ignored in studies designed to measure the effectiveness of AD courses and programmes. In doing so it laid down some requirements in terms of the statistical methods that should be used for non-experimental studies of this nature. The key threats to the internal validity of the nine case studies, the findings of which are reported in Chapters 6, 7 and 8, are the sample-selection problems, omitted variable bias and measurement error.

Matched groups, propensity score matching (PSM) and multivariate analysis (MVA) are used in an attempt to finesse the sample-selection and omitted variable problems. Furthermore, the Heckman two-step estimator is used to account for the fact that not all students who started a course went on to write the final examination.

The similarity of the AD and the selected mainstream cohorts, and the effects of the methods used to construct mainstream groups against which the academic performance of the AD students can be compared, are summarised in table 9.1.

Table 9.1 Similarity of the mainstream and AD cohorts

	Difference of means and proportions	Determinants of academic performance	PSM Balanced "Xs"	PSM "Common support"
	1	2	3	4
Microeconomics (first-year)	Different	Same	Yes	Yes
Microeconomics (second-year) period 1	Different	Different	No	No
Microeconomics (second-year) period 2	Different	Different	No	Yes
Mathematics (first-year)	Different	Different	No	No
Mathematics (second-year)	Different	Different	Yes	No
Chemistry (first-year)	Different	Different	No	No
Chemistry (second-year) CEM2007F	Different	Sample too small	No	No
Chemistry (second-year) CEM2008S	Not done	Sample too small	No	No
Graduation: Commerce	Different	Different	Yes	Yes
Graduation: Engineering	Different	Different	Yes	Yes
Graduation: Science	Different	Some similarity	No	No

Column 1 summarises the differences of means and proportions between the AD cohorts and mainstream cohorts for each of the case studies. In each of the case studies, the difference of means and proportions is statistically significant ($p<0.05$) for most of the independent variables. This is unsurprising, given the different set of criteria used for placing students onto mainstream and AD programmes, and implies that the AD cohorts and mainstream cohorts do not come from the same population.

The chief determinants of academic performance, with the exception of first-year microeconomics and the graduation study for the science programmes, are different. This suggests that the use of the ECO1010H and ECO1010S cohorts in the case study for first-year microeconomics was successful in creating matched AD and mainstream control groups across the range of control variables. That said, this strategy was not successful in creating matched AD and mainstream groups for the second-year microeconomics case study. In general, according to this approach most of the AD cohorts and their comparable mainstream cohorts come from different populations.

The purpose of PSM is to establish a mainstream control group that has a similar set of characteristics to the treated group (AD cohorts). Looking at columns 3 and 4 this strategy was successful in creating a comparable mainstream group only in the first-year microeconomics and the graduation studies for commerce and engineering. For second-year microeconomics (second period) and mathematics, this strategy was partly successful.

In summary, it is fair to say that the statistical methods used in this thesis do not fully resolve the threats to internal validity posed by the use of non-experimental data; the aims of the different strategies used to construct comparable mainstream groups are infrequently met. Therefore, in general, MVA is the chief method used to estimate the effectiveness of the educational interventions included in the various AD courses. The PSM findings are used in addition to the MVA findings when appropriate.

It follows that, in the absence of the random allocation of students to treatment and control groups, every effort should be made to use quasi- or natural experimental designs in studies of this nature.

9.2 Discussion of results

The effectiveness of the educational interventions in improving the academic performance of AD students relative to mainstream students is discussed in the following three sections.

Surprisingly, the results for each of the three AD programmes, for each of the first-year, second-year and graduation studies, are very similar despite their different student

population, subject matter, personnel and *modus operandi*, for example tutorials, articulation with mainstream courses, and length and depth of AD courses. The nature of the first-year interventions varies between the three programmes, as does the articulation between the AD and mainstream courses. For example, the first-year AD course in chemistry runs over 18 months and AD students write a different set of examinations to those written by their peers on the mainstream. The first-year AD course in mathematics is, however, a whole-year course, which runs parallel to the mainstream course, and AD and mainstream students write the same tests and examination.

In summary, AD courses are effective at the first-year level in improving the academic performance of AD students relative to their peers on the mainstream. Furthermore, the positive effect of the AD courses on students' academic performance persists into the second year although the effect is muted. The effect of the first-year AD courses on students' graduation rates is negative, but statistically insignificant ($p>0.10$), conditional on the control variables; the positive effect of the first-year AD courses in the first and second years on students' academic performance has dissipated by the time students come to write their final examinations at the third- or fourth-year levels.

These results carry some weight, given the large sample sizes employed, the rigorous nature of the statistical analysis, and the variation between each of the three AD programmes investigated in this thesis. That said, the unresolved threats to the internal validity of each of the case studies imply that the results should be considered with some caution.

9.2.1 First-year studies

The findings described in Chapter 6 provide strong evidence that the educational interventions included in the first-year AD courses in microeconomics, mathematics and chemistry enabled AD students to achieve a higher level of academic performance relative to their peers on the equivalent mainstream courses, conditional on the control variables.

Turning to table 9.2, the weighted mean premium across the three AD courses in microeconomics, mathematics and chemistry is 7.4 percentage points. The effect of this premium is to increase the weighted pass rate from 44.7% to 67.9%; that is, by 23.2 percentage points. As was previously noted, the disproportionate positive effect of the course

mark premium on the pass rate achieved by AD students is due to the fact that many AD students achieve relatively low examination and course marks.

Table 9.2 Premiums and pass rates for the first-year AD courses

	Observations	Premium Percentage points	Pass rate without premium Percentage	Pass rate with premium Percentage	Difference in pass rate Percentage points
Microeconomics (ECO1010H)	751	*3.0	58.6	67.5	8.9
Mathematics (END1007W)	404	*10.6	36.6	70.5	33.9
Chemistry (CEM1009H)	248	*15.2	15.7	64.9	49.2
Weighted means		7.4	44.7	67.9	23.2
Total	1403				

* statistically significant at the 1% level

These findings in respect of the effectiveness of first-year AD (or remedial) courses on first-year academic performance find support from a number of studies, both international (Ayaya 1996 (Lesotho), Congos and Schoeps 1999 (USA), Etter et al. 2001 (USA), Zeegers and Martin 2001 (USA), Lagerlöf and Seltzer 2009 (USA)) and South African (Curtis and De Villiers 1992, Edwards 2000, Van der Flier et al. 2003, Downs 2006, Smith and Edwards 2007), as was discussed in Chapter 4, although these studies are subject to the criticisms as regards research design and the threats to internal validity outlined in Chapter 3. All these studies report that AD-type educational interventions had a positive effect on students' academic performance for a given level of the academic programme. These studies, with the exception of Smith and Edwards (2007), did not investigate the effect of the educational interventions on AD students' academic performance in their succeeding years of study through to graduation.

Furthermore, mainstream students' adjusted matriculation points score and, particularly, whether or not they achieved a relatively high grade for mathematics (HG) play a crucial role in determining the level of their academic performance. White mainstream students also outperformed their peers, conditional on the control variables, across the three first-year courses. These findings are well supported by the literature discussed in Chapter 4.

AD students who achieved grades A, B or C for mathematics (HG) outperformed their peers who achieved grades D, E or F for mathematics (HG), or who had taken mathematics (SG), conditional on the control variables. The other consistent finding across the three first-year AD courses is that AD students who declared their home language to be English and who took English first language (HG) underperformed their peers, conditional on the control

variables. This finding is surprising as there is a rich South African literature that suggests that second-language instruction is linked to poor academic performance in general (Rollnick 2000, Webb 2002), and poor economics, mathematics and chemistry academic performance in particular (Banach et al. 1992, Howie 2003, Dawidowitz 2004, Smith and Edwards 2007). The cause of this surprising result remains unknown and warrants more investigation.

Several South African studies have identified other determinants of AD students' academic performance. For example, a number of studies report that the matriculation points score is statistically significant ($p<0.05$) in explaining AD students' academic performance in their first-year courses (Curtis and De Villiers 1992 (commerce), Jawitz 1992, 1995 (engineering), Zaaiman 1998 (engineering and science), Edwards 2000 (economics), Van Rooyen 2001 (bridging programme), Van der Flier et al. 2003 (mathematics and science)). Other variables reported to be statistically significant ($p<0.5$) in explaining AD students' academic performance are socioeconomic status (Van der Flier et al. 2003) and physical science (Potgieter et al. 2010).

9.2.2 Second-year studies

The findings presented in Chapter 7 imply that the educational interventions included in the first- and second-year AD courses in microeconomics, mathematics and chemistry had a positive, though muted, impact on the academic performance of AD students in the second-year courses, relative to mainstream students, conditional on the control variables.

A summary of the findings is presented in table 9.3.

Table 9.3 Premiums and pass rates for the second-year AD courses

	Observations	Premium Percentage points	Pass rate without premium Percentage	Pass rate with premium Percentage	Difference in pass rate Percentage points
Microeconomics (ECO2003F) first period	306	*5.2	34.3	67.0	32.0
Microeconomics (ECO2003F) second period	279	*1.9	43.0	61.6	18.6
Mathematics (MAM2080W)	305	*2.5	60.3	76.7	16.4
Chemistry (CEM2007F)	108	3.7	58.3	88.9	30.6
Chemistry (CEM2008S)	115	4.0	67.8	84.3	16.5
Weighted means		3.4	51.1	72.1	21.0
Total	1113				

* statistically significant at the 1% level

The weighted mean premium is 3.4 percentage points. This has the effect of increasing the weighted mean pass rate from 51.1% to 72.1%; that is by 21.0 percentage points. It is noted that the premiums going to the two chemistry courses are statistically insignificant ($p>0.10$). This may be a function of the small-sample problem discussed in Chapter 3.

Furthermore, the results strongly suggest, as they did for the first-year courses, that mainstream students' performance in the matriculation examination, and particularly whether they took mathematics (HG) or not, plays a crucial role in determining the level of their academic performance in each of the second-year courses. Also, white students continue to outperform their peers. For AD students, mathematics (HG) continues to play an important role in determining academic performance in the microeconomics and mathematics courses. The relatively poor academic performance of AD students who declared English as their home language and who took English first language (HG) is repeated for ASPECT students only at the second-year level. Whatever the cause of this strange phenomenon, the negative effect had largely dissipated by the end of the second year.

9.2.3 Graduation studies

The coefficients for each of the AD programmes are negative but statistically insignificant ($p>0.10$). These results imply that the educational interventions included in the first-year courses did not have a statistically significant effect on the graduation rate of AD students relative to mainstream students, conditional on the control variables. The implications of this finding are discussed in Section 9.3.

There is support for these findings in the international literature (USA), as discussed in Chapter 4. For example, Adelman (1998, 1999, 2006) , Little Hoover Commission (2000), Berkner et al. (2002), Attewell et al. (2006) and Viadero (2009) report that remediation has a statistically insignificant ($p<0.05$) effect on students' graduation performance relative to mainstream students. In contrast, Bettinger and Long (2005) report that in a quasi-experimental study students who took mathematics remediation classes achieved higher graduation rates than those who did not. Also, a number of USA studies report that students who attend remediation classes tend to exhibit higher persistence rates than mainstream students, though these studies do not mention graduation rates (Kulik et al. 1983, Schoencker

et al. 1998, Congos and Schoeps 1999, Lesik 2007). With the exception of Lesik (2007), these four studies did not counter the threats to internal validity as outlined in Chapter 3.

As regards South African studies, De Villiers and Rwigema (1998), Hay and Marais (2004), De Klerk et al. (2006), Onsongo (2006), Downs (2010) and Rollnick (2010, p. 51) report a positive effect of AD courses on later academic performance, as was discussed in Chapter 4. These studies are, however, subject to criticism as regards their use of statistical analysis as described in Chapter 3, which together render the findings questionable.

The key variables that have a positive effect on the graduation rates of mainstream students, on average, are the adjusted matriculation points score, mathematics (HG), physical science (HG), and whether or not students declared themselves white, were domiciled in the Western Cape, and had English as their home language. None of these findings is unexpected given the evidence cited in Chapter 4.

As regards the latter three findings, as was noted previously many advantages accrued to members of South Africa's white population under the apartheid system (Terreblanche 2002). These advantages make it likely that white children in South Africa have access to material resources that are unavailable to other children. They are more likely than other children to have parents who themselves have a tertiary qualification. Also, they are more likely than other children to come from family backgrounds where it is expected that they will go to university.

Van Walbeek (2004) reports that students from the Western Cape Province outperformed students from the rest of South Africa in their first-year microeconomics course at UCT. The latter finding was also reported for a first-year economics course at the University of Stellenbosch (Horn and Jansen 2009). Students from the Western Cape might outperform students from other parts of South Africa as schools in the Western Cape might offer education of higher quality than that offered by schools elsewhere in South Africa.[102] It is also possible that students from the Western Cape experience less dislocation in their transition to university as they have family and friends living relatively close to the university.

[102] The average pass rate for students schooled in the Western Cape Province for the years 1998 to 2004 is 84% and for South Africa as a whole it is 62% (Table 3.1).

Given the evidence in favour of first-language instruction reviewed at some length in Chapter 4 it is not unexpected that mainstream students who declare their home language English enjoy an advantage over their peers that is statistically significant ($p<0.05$).

Turning to the AD cohorts, the adjusted matriculation points score is important in explaining the graduation performance of the CADP and GEPS students. This finding is also reported by Adelman (1999, 2006) and Attewell et al. (2006) for USA students, and by De Villiers and Rwigema (1998) for a set of commerce AD students, as discussed in Chapter 4. Female students achieved higher graduation rates than male students in both the engineering and science faculties, conditional on the control variables, a finding also reported by Downs (2010) for South African science students.

Furthermore, the graduation rate for females exceeded that achieved by males for each of the three AD programmes, and the differences are statistically significant ($p<0.01$) for ASPECT and GEPS students. These findings are supported by De Winter and Dodou (2011) who report that females outperformed males through to BSc graduation, although the effect is relatively weak. Zhang et al. (2004) report that women exhibit higher graduation rates than did men in access courses in the natural science and engineering noting that males made up 70% to 80% of the intake between 1991 and 1999 but only 63% of graduates. Breytenbach (2008) in a South African study reports that female students are four times more likely than males to obtain a BSc in the minimum time. This data, however, included mainly educationally advantaged students. It is possible that these findings are the function of self-selection. Only females who reckon that they have the ability and enthusiasm to make a success of an engineering or science degree are likely to embark on such a course, and therefore, they are more likely to complete it. Min et al. (2011) found, however, using a data base including some 100 000 engineering students from nine universities in the USA covering 19 years, that females tend to forego their studies of engineering at an earlier stage than do males.

It is unexpected that the variables mathematics (HG), physical science (HG), English home language, financial aid, HRD, DET and Western Cape Province are all statistically insignificant ($p>0.05$) in explaining the graduation performance of AD students. Furthermore, none of the selected independent variables is consistently statistically significant ($p<0.05$) in

explaining AD students' academic performance in the first-year, second-year and graduation studies. The selected independent variables include the adjusted matriculation points score and the grades achieved by AD students for mathematics (HG), physical science (HG) and English first language (HG) in the school-leaving examination. This finding highlights a major challenge: to develop a means of identifying socially, economically and educationally disadvantaged students who have not achieved the requisite points for admission to university, but who have the potential to make a success of their university careers. This topic is taken up again below.

9.3 Implications of the results

The evidence presented in this thesis suggests that the first- and second-year AD courses enabled AD students to improve their academic performance in microeconomics, mathematics and chemistry relative to their peers on the mainstream, conditional on the selected control variables.

The results of the graduation studies reported in the previous section suggest, however, that the first-year AD courses did not have a statistically significant effect ($p>0.10$) on the graduation rate achieved by AD students relative to their peers on the mainstream. This implies that the first-year AD courses had neither a positive nor a negative effect on the graduation rate achieved by AD students relative to their peers on the mainstream.

Consider, however, a cohort of AD students and suppose that they had been admitted to the corresponding mainstream programme. The lack of statistically significant results, combined with the small estimated marginal effects, implies that the same number of AD students who did subsequently graduate from the AD programme would have graduated if placed on the corresponding mainstream programme, conditional on the control variables, and invoking the *ceteris paribus* assumption.

There is, however, good reason to believe that the *ceteris paribus* assumption might be too strong. The counterfactual question remains as to whether the same number of students would have graduated if they had been placed on a mainstream programme, for the reasons discussed below.

Firstly, the extent of any omitted variable bias is not known. Any residual bias affects the point estimates and may be positive or negative. In this regard, AD students are subject to a number of educational and socioeconomic disadvantages that are generally not experienced by mainstream students (Hagedorn et al. 2000, Taylor et al. 2002), and which may not be measured by matriculation results, school attended, or whether or not the students declared themselves to be "white".[103] If the residual bias is negative then the statistical insignificance of the first-year AD courses on AD students' graduation rates relative to mainstream students may be due to the omitted variables' effect, which the first-year AD courses offset. In other words in the absence of the first-year AD courses, AD students may have achieved even lower graduation rates relative to their peers on the mainstream.

Secondly, it is not possible to say what effect the presence of AD students in the first-year mainstream courses would have on the graduation rate achieved by AD and mainstream students, respectively. One possibility is that mainstream students might be placed at a disadvantage if faculty staff gave a disproportionate amount of attention to the academically less prepared AD students. Another possibility is that the AD students might receive insufficient attention as course conveners and lecturers focused on the requirements of the more able students. In the former case, mainstream graduation rates fall relative to AD graduation rates, and in the latter, AD graduation rates fall relatively to mainstream graduation rates.

Thirdly, the criteria for exclusion from the university are more stringent for mainstream students than for AD students. This is largely a function of the fact that AD students are allowed an extra year in which to complete their studies relative to their peers on the comparable mainstream programme. The difference in the criteria for exclusion makes it very likely that some AD students who graduated from an AD programme would have been excluded if placed on the comparable mainstream programme, unless an arbitrary decision was taken to relax the exclusion criteria for all mainstream students.

The lack of counterfactual evidence linked to possible omitted variable bias and the unknown effect of introducing AD students to mainstream programmes is not a trivial criticism of the

[103] The possible omitted variables are discussed in some detail below.

finding that the first-year AD courses did not have a statistically significant effect on AD students' graduation performance relative to mainstream students.

In addition, 46.6% of the 1327 students who entered the three AD programmes in the period 1999 to 2004 graduated. If the AD programmes had not existed, these 618 students from educationally and socioeconomically disadvantaged backgrounds would not have been allowed entrance to the university and they would not have graduated. In short, these students did not qualify for admission to the university, given the arbitrary standards applying at the time, but they met the accepted exit standards (Scott et al. 2005). The fact that 618 students from educationally and socially backgrounds graduated is not a trivial effect of the AD programmes.

The finding that the AD programmes do not have a statistically significant effect on the graduation rate achieved by AD students, conditional on the control variables, is now considered in some detail.

As was noted previously it is not unlikely that there is a specification problem related to omitted variable bias. It is possible that AD students have characteristics that impact negatively on their academic performance, which are not shared by their peers on the mainstream, and for which the selected control variables do not act as valid proxies.[104] Examples include the following: the role played by academic and cultural capital; the problems some students have in gaining epistemological access; the problems faced by second-language students as regards learning, reading and writing skills; the role played by the non-cognitive factors such as self-efficacy, alienation, stereotype threat, stress and anxiety, and motivation; and students' financial constraints.

It is also possible that an improved specification would show that the first-year AD courses do improve the graduation rate of AD students relative to mainstream students, conditional on the control variables. However, as was noted previously, it is a difficult task to construct such a detailed specification. Also, it is possible that as time passes and as AD students move through their university careers, other variables become important in explaining their academic performance, in addition to those included in the original specifications. For

[104] The results reported in this thesis suggest that the usual predictors of academic success do not generally apply to AD students who do not meet the standard admission requirements.

example Lourens and Smit (2003) report that the overall matriculation mark is not a statistically significant variable in predicting students' academic success in the second- and third-year courses. Also, students change as time passes and the choices, which they make whilst at university result in new variables influencing their academic performance (Min et al. 2011). In a similar vein, Ishitani and Snider (2006) make the point that some of the predictive variables may change through the course of the student's university career. The inclusion of these variables would improve the specification but at the same time complicate the study. These additional omitted variables may also be negatively correlated with the academic performance of AD students but not mainstream students.

The omitted variables mentioned above, which individually or together may explain the poor graduation performance of AD students relatively to their peers on the mainstream are now considered.

The first set of variables include the levels of academic and cultural capital acquired by AD students prior to their arrival at the university (Adelman 1998, 1999, 2006, Attewell et al. 2006, Heckman 2006a, Cunha and Heckman 2007, Heckman and Masterov 2007), for which their performance in the school-leaving examination is presumed to act as a proxy. The importance of accrued cultural and academic capital in explaining students' academic performance is a key finding across the sociology of education, namely, the reproductive function of education. According to this view, education functions to reproduce, not disrupt, social inequalities (Boughey 2007).

The development of academic and cultural capital is a function of psychological/cognitive and sociological variables. As regards psychological variables, the period of early childhood from conception to age three is critical for the child's attachment to its maternal figure, emotional regulation and language development, which form the basis for long-term physical and mental health and cognitive development (Piaget and Inhelder 1947, Bowlby 1988, Karoly et al. 1998). Furthermore, Karoly et al. (1998) report that at age two years and six months the human brain is 85.0% of its adult size, and by age three it has attained 90.0% of its total size. Poor nutrition has the effect of stunting brain growth and cognitive development (Glewwe et al. 2001).

As regards sociological variables, research confirms that there are a number of family and background factors that exert an influence on academic achievement (Teachman and Paasch 1998, Garg et al. 2002, 2007, Sánchez et al. 2006, Pym 2007). The sociological variables include family socioeconomic status, parents' level of education, nature and strength of school, community connections, and physical and mental health.

In particular, children from socioeconomically deprived backgrounds are less likely to achieve academic success than their better-resourced peers for a variety of reasons, including poor nutrition, less home-based cognitive stimulation, a lower level of teacher expectation and poorer academic-readiness skills (Barnett 1995, McLoyd 1998, Shonkoff and Phillips 2000, Campbell et al. 2001, Glewwe et al. 2001, Chevalier and Lanot 2002, Heckman and Masterov 2007). Many studies stress the importance of exposing young children to educational programmes from an early age (Campbell and Ramey 1994, Sylva 1997, Campbell et al. 2001, Heckman 2006b). Barnett (1995) reports, however, that the effect of such interventions on children's subsequent academic performance is mixed.

Furthermore, according to the "critical period" hypothesis, the later the remediation is in a child's life, the less effective it is in enabling the child to overcome its educational and socioeconomic disadvantages, as it is a function of human development that people find it more difficult to develop their abilities and acquire new skills as they get older (Papalia et al. 1990, Chugani 1998, Heckman and Masterov 2007). This hypothesis applies particularly to language acquisition (Snow and Hoefnagel-Höhle 1978, Johnson and Newport 1989).

The second variable is the extent to which AD students gain epistemological access to the university (Morrow 1994, Boughey 2002, 2005). Bowen and Bok (1998) found that black American students underperform their peers at university even when controlling for the difference in school-leaving and SAT scores. Furthermore, the black-white achievement gap is still apparent even when controlling for students' socioeconomic status. The authors argue that the chief reason for the black-white achievement gap is that black students are not given adequate support by the tertiary institutions and therefore fail to gain epistemological access.

A number of writers have stressed that students must be enabled to become part of the institution's and subject's community of practice (Lave and Wenger 1991, Lemke 2001, Haggis 2003, Gee 2005), that they learn to talk the language of science (Lemke 1990, Moje

1995), and that they gain mastery of a secondary discourse (Lea and Street 1998). Also, as noted by McFate and Olmsted (1999), it may be that the skills needed for success in subsequent courses are different to those needed to succeed in the first-year course. For example, engineering students at UCT need to demonstrate competence in completing a design project in their third and fourth years.

The third set of variables are the roles played by the relationships between learning, language, reading, writing and study skills, which may have a larger negative effect on the academic performance of AD relative to mainstream students, and for which the variables English home language and matriculation English do not act as suitable proxies.

As regards language (Section 4.3.1), Webb (2002) argues that the academic development of second-language students is compromised as language is a key instrument of learning, and that it is more difficult to assess the progress of students when the assessment is conducted in their second language. He also states that the development of high-level cognitive and social skills is dependent on language. An additional complication for second-language students is that they must also acquire, in addition to the language of instruction, the language of their discipline, be it economics, mathematics or chemistry. These factors, together, make it that much more difficult for students who have English as their second language to succeed at university.

Second-language students often have problems in understanding the material they are required to read (Block and Rollnick 2003), and De Beer (2006) suggests that poor reading skills are an important cause of students dropping out of higher education. Poor writing skills are a major factor in explaining the weak academic performance of university students in general and AD students in particular (Lemke 1990, Paxton 1995, Moore 1998, Dawidowitz 2004), and may be evidence of either poor language proficiency or poor conceptual understanding (Rollnick et al. 1992, Inglis 1993). In addition, poor writing skills compromise students' performance in tests and examinations (Rollnick et al. 2001).

It is generally acknowledged that the South African primary and secondary educational system has encouraged learners to rely on rote learning (atomistic or surface processing), and it has not encouraged the deep processing of information (Feltham and Downs 2002, Pretorious and Mampuru 2007). In Grayson's (1997) view the reliance on rote learning is the

chief cause of AD students' poor academic performance, a point echoed by Meyer and Shanahan (1999). As a result many students arrive at university without the requisite study skills (Schiavone 2002, Hahn and Polik 2004). Also, students with poor study habits are more likely to withdraw from university (Pantages and Creedon 1978, Abbott-Chapman et al. 1992).

The fourth set of variables are the roles played by the non-cognitive factors; self-efficacy, alienation, stereotype threat, stress and anxiety, effort, attitude and motivation. It is possible, for the reasons outlined below, that the academic performance of AD students is more likely to be negatively affected by these non-cognitive factors.

Self-efficacy exists when students perceive their actions as effective (Bandura 1997). Insofar as AD students are less likely to experience self-efficacy they are less likely to persist in a task they are doing. Furthermore, the failure of students to perceive their actions as effective leads them to experience anxiety and to exhibit relatively poor performances in tests and examinations.

As regards alienation, Loo and Rolison (1986) report that first-generation students become disconnected from their family and culture and that this experience can give rise to feelings of alienation, and Taylor et al. (2002) identify social isolation as affecting African-American men when they first attend college. Lemke (2001) and Gee (2005) note the cost to the student of becoming part of a community of practice: the students feel that they have changed and that they no longer connect with their families or feel at home. It is also possible that black South African students are more prone than their peers to experience feelings of alienation at university, as their opinions, experiences and cultures are no longer validated (Badenhorst et al. 1990). They may be required to identify with a Eurocentric approach to academic life and to reject the views of their families and friends. Given that most AD students are the first in their families to attend university it is likely that many of them will experience feelings of alienation.

The difference between the test scores achieved by African-Americans and their peers is due in part to stereotype threat (Steele and Aronson 1998, Taylor et al. 2002); African-Americans experience anxiety in test situations because they feel that they are expected to underperform their peers. Rising anxiety levels lead to lower levels of academic performance, and the

development of a self-fulfilling prophecy. The stereotype threat may well apply to black, Indian and coloured students at the historically white universities and especially to students on AD programmes. Zaaiman (1998) argues, however, that if there is a critical mass of disadvantaged students at historically white universities then the stereotype threat disappears. Also, as pointed out by Pym (2007), black, coloured and Indian students may feel stigmatised by being placed on AD programmes.

High levels of stress are likely to have a negative impact on students' academic performance (Ramsden 2001, Tchen et al. 2001, De Beer 2006, Swart 2008). Financial concerns (discussed below), alienation, anxiety in respect of meeting the university's academic requirements, and the stereotype threat are all likely to raise the levels of stress experienced by students in general and AD students in particular.

The fifth variable is AD students' lack of financial support and their need to seek employment. Students receiving financial aid (bursaries, loans, grants) may achieve higher levels of academic performance as they do not have to cope with the psychological stress associated with insufficient means, nor do they have to seek part-time employment (Thomas 2002, Alon 2005, Hatt et al. 2005, De Beer 2006, Stater 2009). The lack of financial support is one of the most cited reasons for the non-participation by non-traditional students in higher education (Wilson 2000, Taylor et al. 2002). As was previously noted, in South Africa some of the most successful AD programmes are associated with full financial support and accommodation for students (Grayson 1996, Rutherford 1997, De Villiers and Rwigema, 1998, Zaaiman 1998, Van Rooyen 2001, Woollacott and Henning 2004).

As regards financial aid, students may experience a number of concerns. They may not be entitled to financial aid, its payment may be delayed, or it may be insufficient to meet their needs. Also, it is possible that students from impoverished backgrounds feel obliged to use some of their financial aid to provide financial support to their families at home (Lubben et al. 2010). Hatt et al. (2005) (UK) and Stater (2009) (USA) report the positive effect of financial aid on low-income students' academic achievement. Kerkvliet and Nowell (2005) (USA) found, however, that the effects of financial aid differ by university and are sometimes negative, and Kim (2007) (USA) reports that higher student loan debt in the first year of college is associated with lower probabilities of degree completion among low-income and black students. Finally, Chevalier and Lanot (2002) (UK) found that poorer families are less

likely to invest in education, but that financial aid does not result in a significant increase in schooling investment as the money is used for other purposes. In the studies reported in this thesis the coefficient of the financial aid variable is always statistically insignificant ($p>0.05$), conditional on the control variables. One possibility is that financial aid has a positive effect on academic performance for some students, but a negative effect for others.

Students in need of financial support at UCT can apply for financial aid in the form of loans. Each student's family is required to make a means tested contribution up to a maximum of R12 000 per annum. Any scholarship goes first to paying the family contribution, then any top-up bursary and finally the outstanding loan amount. Currently it costs about R40 000 per annum to study at UCT. Perhaps it is unsurprising to read, in the light of these figure, that in a study of South African students the recipients of financial aid exhibited higher levels of stress than their peers who were not in receipt of financial aid (Petersen et al. 2009).

However, the PBS described by Woollacott and Henning (2004), which offers full bursaries and accommodation to AD students, and is reported to have been particularly effective in improving AD students' graduation rates (De Villiers and Rwigema 1998), is a good example of the use of financial aid in a South African context.

As regards the effect of employment on how long students stay registered at university (retention), Kerkvliet and Nowell (2005) report that at one university, students chose to work rather than attend lectures, whilst at another university, higher wages encouraged lecture attendance and retention. In the former case, students chose to work longer hours at the expense of attending lectures, as their wage rate per hour increased. In the latter case, students chose to work fewer hours, and attend more lectures, as their wage rate increased.

In conclusion, it seems unlikely that a few first-year AD courses, however well-constructed and delivered, can enable students to meet the varying cultural, academic, social and psychological demands made of them by the university. Perhaps it is not possible for a few first-year AD courses to teach students how to become participants in academic practice, and to socialise them into culture of an institution that is new to them (Mphahlele 1994, Bowen and Bok 1998, Taylor et al. 2002), to enable them to develop learning, reading, writing and study skills, and to help them develop strategies to cope with the variety of non-cognitive factors that can inhibit their academic performance.

It follows that there is much that must be done if the university is to graduate more students from educationally and socioeconomically disadvantaged backgrounds. This argument is taken up below.

9.4 Policy implications

Policy implications include the future role of AD programmes, the identification of students with academic potential, and the improvement of students' mathematical skills.

The future role of AD programmes

The results of the series of case studies reported in this thesis imply that the AD programmes, as constituted during the period of the study, were not successful in improving the graduation rates of educationally and socially disadvantaged students, conditional on the control variables. Insofar as AD students' academic performance is a function of the level of academic and cultural capital they have acquired prior to their arrival at university, it follows that AD programmes are an inefficient use of scarce resources. The resources should rather be put into primary and secondary education to ensure that students from educationally and socially disadvantaged backgrounds have the requisite amount of cultural and academic capital to enable them to succeed at university.

However, Scott et al. (2007) report that the black student intake at all South Africa's tertiary institutions for the year 2000 represented a select group, as they are the top decile of their age group in terms of achieved academic performance. Therefore, they must be expected to have a high level of potential to succeed. To take the view that any year's intake does not have the academic potential to make a success of their university career is to conflate the lack of academic preparedness with the lack of academic potential.

There is a well-developed argument that stresses the importance of marrying the twin objectives of equity of access to South Africa's tertiary institutions and equity of outcomes (graduation), so that there are enough graduates of a sufficiently high calibre to contribute positively to South Africa's economic development (Scott et al. 2005, Scott 2009). These

objectives are part of the South African government's policy of the transformation of South African society, aimed at fostering a social and economic dispensation in which all the people of South Africa can share.

The primary source of the future graduates must lie in the socioeconomically and educationally disadvantaged population, which makes up the greater proportion of the total population. Unfortunately, according to Scott et al. (2007) less than 5.0% of the 2000 cohort of black people of university age gained a higher education qualification. Given that a substantial improvement in the academic outcomes of South Africa's school system cannot be expected for a generation or more (Yeld 2009), it is necessary that tertiary institutions take all the steps necessary to improve their throughput rates for black students.

AD programmes were conceived with the aim of enabling tertiary institutions to promote access for educationally disadvantaged students and to improve their throughput rate. As currently practised, however, AD programmes do not enable tertiary institutions to meet the demand for an increased number of black graduates (Scott 2009).[105] It is probable that their impact is too limited in terms of helping AD students to gain epistemological access to the university, to enable them to overcome the problems they face as regards language, learning, reading and writing, and to meet the challenges posed by the non-cognitive factors identified in Section 9.3.

Furthermore, their effectiveness is restricted by the difficulty in integrating mainstream and AD curricular and teaching approaches, the uneven quality of AD programmes and courses, their marginal status, and the lack of capacity and resources in many institutions (Kloot 2011). Currently, South African AD programmes have a limited impact as they reach only 10.0% of the South Africa's student body.

Kloot (2011) goes further and argues that the effectiveness of an AD programme depends on the institutional environment in which it operates. In an unfavourable institutional environment, which is not uncommon, where AD programmes and practitioners are marginalised by faculty staff who tend to prioritise research over the activities of teaching

[105] See tables 8.3 and 8.4.

and learning, the ability of AD programmes to transform the tertiary education sector is limited.

Rollnick (2010) identifies three stages as regards the approach taken by tertiary institutions to the requirement that they increase their intake of under-prepared students. Stage 1 involves increasing admissions without putting in place any deep support structures. This is the so-called revolving door admissions policy as many students leave the institution at the end of their first year (Richardson 2000, Barefoot 2004). Seymour (2001) criticizes this approach as the institutions try to resolve the problems posed by the underprepared student without making the required fundamental changes to their curricula so as to enable students to gain epistemological access. This point is echoed by Mphahlele (1994).

The second stage identified by Rollnick (2010) is when the institution endeavours to change the students so that they fit the educational and epistemological demands made of them. To the extent that this approach is successful, there is an improvement in student retention and success.

In the third stage the institution adapts (transforms) its practices to take account of the changing characteristics of the student population. There is a change in the culture of the university; new curricula and pedagogies are put into practice, which facilitates students' epistemological access and helps to counter students' feelings of alienation (Smith and Naylor 2001, Thomas 2002). Richardson (2000) notes that there are a higher proportion of the stage three adaptations in South African tertiary institutions than there are in tertiary institutions in the United States. This is not surprising as the transformation of the tertiary sector is high on the South African government's agenda, and the universities' generally exhibit a strong commitment to their AD programmes.

In the light of Rollnick's (2010) analysis, there are two approaches that the university can take to enable AD students achieve higher graduation rates. The first approach is to extend AD courses into the second and third years in order to ensure that a greater proportion of AD students are retained in the system and ultimately graduate. This extension could take the form of additional support for students in the form of tutorials (Bédard et al. 2010), and life-skills programmes (Wood and Lithauer 2005, Dawidowitz and Schreiber 2008, Rollnick 2010, Pym and Kapp 2011), which together can help students achieve epistemological access,

develop their language, learning, reading and writing skills, and alleviate the stress and anxiety that they experience during the course of their studies at university.

There is, however, a second option. Tertiary institutions must be encouraged to meet the epistemological, educational and psychological needs of their students, as opposed to the students being required to meet traditional demands of the institution (Mehl 1988, Ndebele 1993, Mphahlele 1994, Boughey 2005, Gee 2005), while ensuring that greater access does not undermine the quality of the qualification. This implies that mainstream courses should be changed so as to meet the epistemological, educational and psychological needs of the majority of South Africa's students. To achieve this objective, tertiary institutions should redesign their curricula in relation to required participation rates and student population targets. AD practitioners and programmes can make a substantial contribution to the achievement of these goals.

Scott (2009) proposes the introduction of the four-year degree. The problem with the four-year degree is ensuring that scarce resources are not expended on those mainstream students who already manage to graduate within the prescribed time.[106] In other words, some means should be found to fast-track those mainstream students who currently graduate within the prescribed time. Expanded four- and five-year mainstream programmes running alongside programmes designed to fast-track better academically prepared students would be a significant step in the right direction. A particular advantage of the four- and five-year programmes would be that the criteria for exclusion would be less stringent than they currently are for mainstream students.[107] Thus, a greater proportion of students, who are currently on the mainstream, would graduate.[108]

Failure to pursue either of these two courses of action, namely, to increase the scope of AD programmes and/or to ensure that mainstream programmes are congruent with the needs of the majority of South Africa's student population, means that there will be limited progress in achieving equity of access and outcomes for a generation or more. The jury remains out as to whether the changes proposed above are sufficient to increase graduation rates.

[106] More than 50% of mainstream students included in this study graduated within the minimum period of time.
[107] The universities could relax their exclusion criteria for mainstream students should they choose to do so.
[108] Between 20% and 25% of mainstream students included in this study did not graduate.

Insofar as early-childhood and middle-childhood experiences determine a student's amount of academic and cultural capital, it is crucial that South Africa's primary- and secondary-school system does a better job in preparing a greater proportion of any year's school intake for the demands of tertiary education (Yeld 2009). Until this is done, the great majority of educationally and socially disadvantaged young people will not have the opportunity to fulfil their academic potential.

Identifying students with the potential to succeed at university

The results of the case studies reported in this thesis indicate that the usual predictors of academic success at university do not generally apply to AD students who do not meet the standard admission requirements. For example, the adjusted matriculation points score is positively related to the graduation rates achieved by the CADP and GEPS cohorts, but not the ASPECT cohorts. Mathematics (HG) is, unsurprisingly, positively related to academic performance in second-year microeconomics and mathematics, but not in chemistry.

As regards mainstream students, the adjusted matriculation points score, mathematics (HG) and physical science (HG) are strong predictors of graduation success across the three programmes, conditional on the control variables.

Therefore, it is imperative that alternative tests are refined and that potential AD students are required to take the tests prior to admission. It is also important that the test results are used in a transparent manner to admit students, and that research is conducted to determine their predictive ability as regards students' academic performance through to graduation. Taking these steps might improve the graduation rate achieved by AD students and reduce their relatively high exclusion rate.

That said, the development of alternative tests presents difficulties, given that the usual predictors of academic achievement, the adjusted matriculation points score, mathematics (HG) and English first language (HG), are not uniform predictors of graduation success for AD students. This implies that it is necessary to identify predictors of academic achievement that are distinct from the three identified above.

There is an extensive literature on the development of alternative tests to measure the academic potential of students, particularly those from educationally disadvantaged backgrounds (Yeld 2001).

A number of writers (Braun and Nel 1995, Herman 1995, Yeld and Haeck 1997) have expressed doubts about the validity and fairness of the results of the matriculation examination as predictors of future academic performance of educationally disadvantaged students from the former DET schools. Jackson and Young (1987, 1988) state that it is difficult to judge the academic preparedness of university applicants from educationally disadvantaged schools as at certain levels of academic performance the measures of South African school academic performance are unreliable; students with lower scores are a mixture of low academic performers and able students with the potential to make a success of their careers at university. However Van der Flier et al. (2003) found that the matriculation results had predictive power for the future academic performance of students on the UNIN UNIFY programme discussed in Chapter 4.

In response to the concerns about the validity and fairness of the matriculation results, efforts have been made to develop alternative means of assessment. The intention was to find solutions to the problem of selecting students who have the potential to succeed in tertiary education despite their educational disadvantage (Rutherford and Watson 1990, Zaaiman 1998). Dynamic testing is designed to measure the student's potential to learn (Murphy and Maree 2006). A pre-test is followed by a post-test with some teaching in between. Zaaiman et al. (2001) argue that this approach is not very useful in identifying students with potential as the method tends to favour those students who did relatively poorly on the pre-test.

There is a large literature on the development, execution and assessment of tests developed by UCT's Alternative Admissions Research Project (AARP) (Yeld 2001, Scott et al. 2005, Visser and Hanslo 2005, Cliff et al. 2007, Cliff and Hanslo 2008, Cliff et al. 2008, Scott 2009).

AARP's purpose was to develop tests designed to identify academically able students from educationally disadvantaged backgrounds who wrote the DET matriculation examination. The tests include the Placement Test in English for Educational Purposes (PTEEP), the Mathematics Achievement Test (MACH), and the Mathematics Comprehension Test

(MCOM).[109] The PTEEP and MCOM are unique in that they attempt to replicate dynamic testing within a test. As such the tests assess students' ability to learn and apply new information in unfamiliar contexts, and they are based on the skills required by students if they are to make a success of their first year at university (Haeck et al. 1997, Yeld and Haeck 1997). In contrast to Zaaiman et al. (2001), Yeld and Haeck (1997) found that the inclusion of scaffolding within the test widens the performance gap between weaker and stronger candidates; the tests are biased against the candidates who are most at risk of being excluded from university.

Cliff et al. (2003) report that the PTEEP is a good predictor for a group of students who have been selected on the basis of their academic performance in the matriculation examination for example, engineering students. The PTEEP is, however, less reliable when the sample of students is drawn from a population that exhibits greater diversity across arrange of academic, demographic and socioeconomic variables.

Rollnick (2010) states that it is difficult to identify students who have the potential to succeed as there are a number of determinants of academic performance in addition to academic potential including for example, gender, socioeconomic status, family/parental occupations and/or education, home language, prior educational experiences, access to resources, and the former "population group" to which people were assigned by the government before 1994.

In 2005, Higher Education South Africa (HESA) commissioned the National Benchmark Tests (NBT) to replace the AARP tests, which as of 2012 are no longer being used, to be taken by all prospective university students.[110] The test results provide schools and higher education institutions with information about the academic competence of students on entry to tertiary educational institutions. The aim of the NBT is not to reproduce the same information as that derived from the matriculation examination.

According to Griesel (2006), the chief purpose of the NBT is to measure students' verbal reasoning, quantitative literacy and mathematical proficiency. Two tests – academic and quantitative literacy and mathematics – are designed to facilitate the placement of first-year

[109] See the University of Cape Town's Alternative Admissions Research Project website, http://www.aarp.ac.za/uct/tests.htm (accessed 30 November, 2011).
[110] See http://nbt.ac.za/ and http://www.ched.uct.ac.za/departments/adp/interfac_proj/aarp/nbtp (accessed 15 December, 2011).

students into AD, augmented or mainstream programmes. These tests were first offered in 2009 and it is as yet too early to determine their predictive capacity as regards students' graduation performance. That said, it is important that research is conducted to determine the predictive power of the NBTs as regards AD students' academic performance at the first- and second-year levels.

Improving students' mathematical skills

There is a strong correlation between AD and mainstream students' academic performance in the first- and second-year courses and through to graduation, and their mathematical ability as measured by their performance in the school-leaving mathematics examination.

This strong and unsurprising finding for commerce, engineering and science students means that every effort should be made to improve and support the successful delivery of the mathematics curriculum at the primary and secondary levels.

9.5 Avenues for future research

Do the results hold for the three UCT AD programmes for other time periods?

Tertiary institutions and their AD programmes change over time. It is important to know whether the graduation rates of AD students changed over time relative to the rates achieved by mainstream students, and to identify the possible causes of any observed changes. It would also be useful to know whether the same determinants of academic performance for commerce, engineering and science AD and mainstream students hold for students from the Faculties of Humanities, Health Sciences and Law.

Do the results hold for AD programmes at other universities?

The results reported in this thesis are consistent across each of the first-year, second-year and graduation case studies. Few such studies have been conducted in South Africa as was described in Chapter 4. It is important that research is done to determine whether these results are repeated for similar studies conducted for other time periods and at other institutions,

where the student body, faculty, and the types of AD programme might differ from those at UCT for the period 1999–2005. The results of such research would enable tertiary institutions to gain a clearer understanding of the necessary ingredients for a successful AD programme.

In 2006 the DOE issued a call for proposals to establish Extended Curriculum Programmes (ECP), and at the same time announced the allocation of R367m of earmarked funds towards such programmes for the 2007/8–2009/10 triennium (DOE 2006). Since then about 200 programmes in all faculties were funded at South Africa's tertiary institutions, with two-thirds of these programmes at universities of technology (Kloot 2011). It would be very useful to conduct a series of investigations to determine whether these programmes have been effective in improving the graduation rates of AD students.

How important are epistemological access, language and learning, and the non-cognitive factors?

UCT's Education Development Unit (EDU) in the Commerce Faculty was established in 2008, when it replaced the CADP. One of its main aims is to develop a model of an AD programme with which students can positively identify and come to prefer to comparable mainstream programmes (Pym 2009, Pym and Kapp 2011). The EDU offers a range of academic and other interventions in addition to the usual set of first-year courses designed to enable AD students to gain epistemological access and to experience personal growth. In particular, the EDU programme provides students with a variety of engagements designed to develop a supportive community and a culture of learning. The purpose of the interventions is to promote social cohesion and personal agency. Space is created for students to engage with a range of issues that enable them to configure new identities that hold meaning, and to give them impetus to negotiate the complexity that surrounds their experience of tertiary education. In short, the EDU programme includes a comprehensive range of interventions in the areas of education (courses, workshops and tutorials at the first-, second and third-year levels), life skills, leadership, and mentoring, in addition to the standard first-year AD courses. These interventions were not available to the CADP cohorts of the years 1999–2004, which are subject of this thesis.

It follows that it is important to estimate the effect of the EDU programme on students' academic performance. In particular, it is important to estimate the effect of the EDU

programme on the graduation rates achieved by AD students. Unfortunately, it will not be possible to conduct a rigorous study until at least 2017; only then will most 2008 –2012 cohorts have completed their university careers.

Who are the potential AD graduates?

Given the high exclusion rate (43.2%) for AD students, it is important to establish the predictive powers of the NBT test scores in the determination of graduation rates.

Scott et al. (2005) report, using survival analysis, that the AARP test scores are a better predictor of academic performance of DET students than are their school-leaving results. Also, an above-average performance on the PTEEP is related to better progression through degree programmes, relative to poor performance on the PTEEP, or relative to matriculation results.

That said, Scott et al. (2005) do not refer to graduation performance. MVA can be undertaken for the 2009 and 2010 cohorts to identify the predictive power of the NBT scores in selected first-year courses. From 2015 on, MVA can be undertaken for the 2009 and subsequent cohorts to identify the predictive power of the NBT scores in determining whether students graduate or not.

What is the relationship between English and first-year academic achievement?

First-year CADP, ASPECT and GEPS students who declare their home language English and who take English first language (HG) underperform their peers who are also on these three AD programmes. This finding is not repeated for mainstream students. It is important to identify the causes of this phenomenon, and it would be useful to establish whether this phenomenon is repeated for AD students at other South African universities.

Why do females outperform males?

In general, females outperform males in engineering and science at graduation, and the difference is statistically significant for science students ($p<0.01$). In particular, females on each of the three AD programmes investigated in this thesis outperform their male

counterparts through to graduation, and the difference is statistically significant for the ASPECT and GEPS students. Surprisingly, these results for AD students are not repeated in the first- and second-year courses. In fact there is an opposite effect in the multiple-choice questions in first-year microeconomics, where males outperform females, and the result is statistically significant ($p<0.01$), conditional on the control variables.

As was noted previously, the difference in the graduation rates of males and females may be the result of self-selection. It is important to determine whether these findings are repeated in other faculties at UCT, for example law and humanities, for AD students at other South African tertiary institutions, and to identify the characteristics of males who are most likely to underperform females, the causes of their relatively poor graduation performance, and to identify what can be done to improve the relative poor graduation performance of males across the three AD programmes.

Research methods

The main methodological problem of this thesis lies in the use of non-experimental data, which leads to the sample-selection problem and omitted variable bias. Research of a rigorous nature is required to determine the nature of the educational interventions that are most effective in improving the academic performance of AD students. There are, however, a number of caveats attached to using randomised control trials (RCT) in the field of education research, as was mentioned in Chapter 3. These include ethical issues and the complexity of the dynamics underlying the educational process, which makes it difficult to control for all the independent variables that might influence the dependent variable, and to identify the precise nature of the relationships between any single individual independent variable and the dependent variable.

Nevertheless, RCT can be used to estimate the effectiveness of a variety of educational interventions, for example different sized AD and mainstream classes (lectures), different AD and mainstream lecturers, and different AD and mainstream tutorials, in order to develop a further understanding of the nature of the processes underlying the effect of AD courses on students' academic performance.

That said, the central research issue is to determine whether AD programmes are successful in improving AD students' graduation rates relative to mainstream students. Given the difficulties associated with RCT, it is preferable to use quasi- or natural experiments to test the effectiveness of AD programmes. Identifying the conditions suitable for such studies, however, presents a considerable challenge, given the great differences between the AD programmes offered by the different tertiary institutions across South Africa.

In conclusion, this thesis has provided some answers to the questions that have been raised regarding AD courses and programmes. There is, however, much research that must be done to clarify the role that AD programmes can play in improving course pass rates and graduation rates for socioeconomically and educationally disadvantaged students. Furthermore, action should be taken by South African universities to ensure that the many students from disadvantaged backgrounds experience equity of access and outcomes. Any delay in this urgent task will result in several generations of able students being denied the opportunity to contribute to the building of a more prosperous and inclusive South Africa, for the benefit of its people.

Appendices

Appendix A

Interaction estimation results for selected first-year courses and control variables for second-year microeconomics

Table A1 Interaction estimation for first-year microeconomics

Dependent variable Examination mark	Number	Coefficient	Std Err.	t-stat	P>|t|
Independent variables					
D 1010H (H)	1	2.91	9.51	0.31	0.760
Adjmatpt	2	-0.14	0.62	-0.23	0.819
Adjmatpt^2	3	0.02	0.01	1.79	0.074
Age	4	1.54	1.56	0.98	0.326
Age^2	5	-0.03	0.04	-0.93	0.351
H*Adjmatpt	6	-0.10	0.17	-0.58	0.562
H*Age	7	0.27	0.45	0.59	0.552
H*D White	8	0.91	1.98	0.46	0.648
H*D Finaid	9	1.27	1.48	0.86	0.390
H*D Commerce	10	4.69	1.50	**3.11	0.002
H*D HRD	11	-1.81	1.78	-1.01	0.311
H*D DET	12	4.44	1.79	*2.47	0.014
H*D 2002	13	-0.26	1.93	-0.13	0.894
H*D 2003	14	-7.27	2.20	**-3.29	0.001
H*D 2004	15	-7.84	2.03	**-3.86	0.000
H*D 2005	16	-4.19	2.21	-1.90	0.058
Adjmatpt*D 2002	17	0.22	0.31	0.69	0.489
D Eng FL HG ABC*D 2002	18	-1.42	2.15	-0.66	0.512
D Eng FL HG DEF*D 2002	19	-3.16	2.85	-1.11	0.268
D Math HG ABC*D 2002	20	2.17	2.66	0.81	0.416
D Math HG D*D 2002	21	0.50	2.38	0.21	0.833
D Math HG EF*D 2002	22	-5.76	2.61	*-2.20	0.028
D PS HG* D 2002	23	-1.52	2.12	-0.72	0.474
Adjmatpt*D 2003	24	-0.43	0.31	-1.35	0.177
D Eng FL HG ABC*D 2003	25	-2.61	2.37	-1.10	0.271
D Eng FL HG DEF*D 2003	26	-0.88	3.30	-0.27	0.789
D Math HG ABC*D 2003	27	4.29	2.70	1.59	0.113
D Math HG D*D 2003	28	3.88	2.75	1.41	0.160
D Math HG GEF*D 2003	29	-0.86	3.13	-0.27	0.785
D PS HG*D 2003	30	0.02	2.08	0.01	0.992
Adjmatpt*D 2004	31	-0.14	0.32	-0.43	0.664
D Eng FL HG ABC*D 2004	32	-3.88	2.19	-1.77	0.077
D Eng FL HG DEF*D 2004	33	-8.41	2.76	**-3.05	0.002
D Math HG ABC*D 2004	34	3.23	2.68	1.20	0.230
D Math HG D*D 2004	35	2.13	2.73	0.78	0.435
D Math HG EF*D 2004	36	-4.17	3.17	-1.31	0.189
D PS HG*D 2004	37	0.41	2.20	0.19	0.852
Adjmatpt* D 2005	38	0.04	0.30	0.13	0.894
D Eng FL HG ABC*D 2005	39	-2.72	2.16	-1.26	0.209
D Eng FL HG DEF*D 2005	40	0.27	3.04	0.09	0.929
D Math HG ABC*D 2005	41	7.47	2.58	2.90	0.004
D Math HG D*D 2005	42	3.54	2.66	1.33	0.184
D Math HG EF*D 2005	43	2.14	2.96	0.72	0.470
D PS HG*D 2005	44	1.72	2.12	0.81	0.417
D Eng FL HG ABC	45	1.66	1.73	0.95	0.340
D Eng FL HG DEF	46	2.03	2.00	1.01	0.312
D Math HG ABC	47	3.02	1.82	1.65	0.099
D Math HG D	48	2.76	1.65	1.67	0.095
D Math HG EF	49	6.22	1.90	**3.27	0.001
D PS HG	50	2.91	1.46	*1.98	0.048
D Economics	51	-1.50	0.94	-1.59	0.111
D White	52	3.67	0.88	**4.15	0.000
D Finaid	54	-0.28	1.09	-0.26	0.797
D Enghome	55	-2.80	0.81	**-3.41	0.001
D Male	56	0.75	0.61	1.22	0.222
D WC	57	-0.45	0.64	-0.70	0.484
D HRD	58	2.51	1.30	1.92	0.055
D DET	59	-3.14	1.52	*-2.06	0.040
D First time	60	0.86	1.08	0.80	0.426

D Commerce	61	0.76	0.87	0.87	0.383
D 2002	62	0.56	7.75	0.07	0.942
D 2003	63	11.1	8.93	1.24	0.214
D 2004	64	12.2	9.02	1.35	0.178
D 2005	65	-0.32	8.54	-0.04	0.970
Constant	66	12.50	18.8	0.66	0.508
R^2		0.196			
F-stat				**6.77	
Number of observations		1838			

** and * statistically significant at the 1% and 5% levels, respectively

Table A2 Interaction estimation for first-year mathematics

Dependent variable	**Number**	**Coefficient**	**Std Err.**	**t**	**P>|t|**
Course mark					
Independent variables					
D ASPECT	1	36.8	13.5	**2.71	0.007
D ASPECT (mainstream)	2	0.38	2.57	0.15	0.881
D Mainstream (transfer to ASPECT)	3	2.14	2.79	0.77	0.444
Adjmatpt	4	-4.84	1.00	**-4.80	0.000
$Adjmatpt^2$	5	0.13	0.01	**6.44	0.000
Age	6	1.04	1.48	0.70	0.483
Age^2	7	-0.01	0.03	-0.07	0.944
Adjmatpt*D ASPECT	8	-0.65	0.28	*-2.23	0.026
Age*D ASPECT	9	-0.75	0.52	-1.43	0.152
D Finaid*D ASPECT	10	-1.82	1.83	-0.99	0.321
D HRD*D ASPECT	11	-5.54	2.86	-1.93	0.054
D DET*DASPECT	12	-3.35	1.96	-1.70	0.089
D 2000*D ASPECT	13	6.84	4.05	1.69	0.091
D 2001*D ASPECT	14	2.03	3.80	0.53	0.594
D 2002*D ASPECT	15	6.37	3.76	1.69	0.091
D 2003*D ASPECT	16	5.36	3.96	1.35	0.177
D 2004*D ASPECT	17	11.9	3.81	**3.12	0.002
D 2005*D ASPECT	18	10.5	3.89	**2.70	0.007
Adjmatpt*D 2000	19	0.07	0.51	0.13	0.893
D Eng FL HG*D 2000	20	8.86	3.52	*2.51	0.012
D Math HG A*D 2000	21	-3.31	5.01	-0.66	0.509
D Math HG B*D 2000	22	-5.04	4.66	-1.08	0.280
D Math HG C*D 2000	23	-6.64	4.53	-1.46	0.144
D PS HG AB*D 2000	24	3.65	5.28	0.69	0.490
D PS HG C*D 2000	25	-1.02	4.43	-0.23	0.819
Adjmatpt*D 2001	26	0.27	0.49	0.55	0.581
D Eng FL HG*D 2001	27	4.67	3.22	1.45	0.148
D Math HG A*D 2001	28	-6.35	4.84	-1.31	0.190
D Math HG B*D 2001	29	-3.63	4.54	-0.80	0.425
D Math HG C*D 2001	30	-3.72	4.31	-0.86	0.389
D PS HG AB*D 2001	31	-2.10	4.87	-0.43	0.667
D PS HG C*D 2001	32	-2.63	4.19	-0.63	0.530
Adjmatpt*D 2002	33	-0.27	0.49	-0.55	0.584
D Eng FL HG*D 2002	34	4.00	3.08	1.30	0.194
D Math HG A*D 2002	35	-5.09	4.66	-1.09	0.275
D Math HG B*D 2002	36	-1.53	4.25	-0.36	0.719
D Math HG C*D 2002	37	-2.46	3.92	-0.63	0.532
D PS HG AB*D 2002	38	2.25	4.85	0.46	0.643
D PS HG C*D 2002	39	-5.16	3.92	-1.31	0.189
Adjmatpt*D 2003	40	-0.61	0.46	-1.30	0.195
D Eng FL HG*D 2003	41	6.20	3.16	*1.96	0.050
D Math HG A*D 2003	42	-4.65	4.88	-0.95	0.342
D Math HG B*D 2003	43	-2.66	4.78	-0.56	0.578
D Math HG C*D 2003	44	-3.43	4.52	-0.76	0.449
D PS HG AB*D 2003	45	7.15	4.96	1.44	0.150
D PS HG C*D 2003	46	0.30	4.26	0.07	0.945
Adjmatpt*D 2004	47	-0.17	0.43	-0.39	0.697
D Eng FL HG*D 2004	48	5.81	2.93	*1.98	0.048
D Math HG A*D 2004	49	2.67	4.83	0.55	0.581
D Math HG B*D 2004	50	0.97	4.65	0.21	0.834
D Math HG C*D 2004	51	3.39	4.49	0.75	0.450
D PS HG AB*D 2004	52	0.47	4.69	0.10	0.920
D PS HG C*D 2004	53	-5.65	3.96	-1.43	0.154
Adjmatpt*D 2005	54	0.36	0.42	0.85	0.394
D Eng FL HG*D 2005	55	5.39	2.89	1.86	0.063
D Math HG A*D 2005	56	4.26	4.82	0.88	0.377
D Math HG B*D 2005	57	4.87	4.61	1.06	0.291
D Math HG C*D 2005	58	2.20	4.43	0.50	0.620
D PS HG AB*D 2005	59	8.97	5.21	1.72	0.086

D PS HG C*D 2005	60	4.54	4.56	0.99	0.320
D Eng FL HG	61	-4.21	2.60	-1.61	0.107
D Math HG A	62	18.3	3.41	**5.36	0.000
D Math HG B	63	9.34	3.16	**2.96	0.003
D Math HG C	64	4.42	3.08	1.43	0.153
D PS HG A	65	0.86	3.60	0.24	0.810
D PS HG C	66	2.82	2.87	0.98	0.327
D White	67	4.23	0.86	**4.94	0.000
D Male	68	0.65	0.74	0.88	0.379
D Enghome	69	-1.20	0.94	-1.28	0.202
D Finaid	70	0.20	1.08	0.19	0.851
D WC	71	-1.71	0.69	*-2.44	0.015
D HRD	72	1.92	1.29	1.48	0.138
D DET	73	3.87	1.62	*2.38	0.017
D 2000	74	-7.40	11.1	-0.66	0.506
D 2001	75	-5.76	10.3	-0.55	0.579
D 2002	76	1.22	11.1	0.11	0.913
D 2003	77	-1.48	11.3	-0.13	0.896
D 2004	78	-14.5	10.7	-1.35	0.178
D 2005	79	-31.9	10.8	**-2.95	0.003
Constant	80	73.9	22.2	**3.32	0.001
R^2		0.418			
F-stat				**16.10	
Number of observations		1854			

** and * statistically significant at the 1% and 5% levels, respectively

Table A3 Control variables for second-year microeconomics (AD and mainstream (ECO1010F includes ECO1010S))

	PERIOD 1 2000−2002			PERIOD 2 2003−2005		
	AD ECO1010H	**Mainstream ECO1010F**	**Tests**	**AD ECO1010H**	**Mainstream ECO1010F**	**Tests**
Personal characteristics	**% share**	**% share**	**z-test**	**% share**	**% share**	**z-test**
Black	55.6	16.7	**15.6	62.0	18.8	**16.2
Indian	5.9	8.6	1.6	7.5	12.6	*2.5
Coloured	22.2	11.8	**5.1	30.5	12.8	**7.9
White	16.3	62.9	**15.4	0.0	55.8	**19.3
English home language (Enghome)	46.1	81.6	**13.9	35.8	79.1	**15.8
Male	52.3	56.0	1.2	44.4	56.2	**3.8
Financial Aid	42.8	9.7	**15.8	41.9	8.4	**8.6
	Mean	**Mean**	**t-test**	**Mean**	**Mean**	**t-test**
Age at entry (Age)	18.3	18.6	**4.6	18.3	18.9	**10.7
School attended	**% share**	**% share**	**z-test**	**% share**	**% share**	**z-test**
HRD (HRD)	17.0	7.7	**5.4	20.1	9.0	**5.9
DET (DET)	18.3	3.8	**10.3	25.4	4.3	**13.7
Matriculation points	**Mean**	**Mean**	**t-test**	**Mean**	**Mean**	**t-test**
Mean matriculation points score (Matpt)	32.4	40.9	**34.6	36.2	43.2	**30.6
Mean adjusted matriculation points score (Adjmatpt)	21.5	27.5	**32.4	25.3	28.5	**16.5
Matriculation subjects	**% share**	**% share**	**z-test**	**% share**	**% share**	**z-test**
English first language (HG) (Eng FL HG)	71.6	94.9	**13.6	65.6	94.2	**16.1
Xhosa first language (HG) (Xhosa FL HG)	14.7	1.0	**13.9	16.5	1.2	**15.0
Zulu first language (HG) (Zulu FL HG)	2.6	0.9	*2.5	6.8	1.4	**6.2
Mathematics (HG) (Math HG)	46.1	88.9	**19.0	67.4	92.8	**13.6
Physical Science (HG) (PS HG)	37.6	77.3	**14.6	41.6	76.9	**12.7
Province						
Western Cape (WC)	45.8	48.3	0.8	52.0	45.7	*2.0
Other						
Commerce Faculty (Commerce)	53.6	96.2	**24.4	94.6	95.8	0.9
Year						
D 2000	26.5	30.8	1.54			
D 2001	39.5	34.8	1.61			
D 2002	34.0	34.4	0.01			
D 2003				19.0	34.8	**5.4
D 2004				45.9	31.8	**4.7
D 2005				35.1	33.4	0.6
Observations	306	2217		279	2513	

The column titled "Tests" provides the t- and z-statistics for the tests of equality of means and proportions between ECO1010H and ECO1010F students.

** and * statistically significant at the 1% and 5% levels, respectively

Appendix B

1. Case study estimations

Table B1 Codes for the variables included in the estimations

Estimation code	Thesis table code	Description
1010h	D 1010H	AD first-year course (ECO1010H) in microeconomics (CADP)
adjmatpt	Adjmatpt	
age	Age	
asp08	D ASPECT	AD first-year course (END1007W) in mathematics (ASPECT)
asp08mstream	D ASPECT (mainstream)	ASPECT students who did the mainstream course in first-year mathematics (MAM1003W)
asp08transmstream	D Mainstream (transfer to ASPECT)	Mainstream students who transferred to END1007W during the first semester
attcont	Course repeated	
chemmark	Final course mark in first-year chemistry	
commerce	D Commerce	Commerce Faculty
det	D DET	Department of Education and Training
economics	D Economics	
enghome	D Enghome	English home language
engflhg	D Eng FL HG	
engflhgabc	D Eng FL HG ABC	
engflhgdef	D Eng FL HG DEF	
f	D 1010F	Mainstream first-year course (ECO1010F) in microeconomics
finaid	D Finaid	Financial aid
five	D 2005	2005 cohort
four	D 2004	2004 cohort
geps	D GEPS	AD first-year course (CEM1009H and CEM1010F) in chemistry (GEPS)
gepsmstream	D GEPS (mainstream)	GEPS students who did the mainstream course in first-year chemistry (CEM1000W)
h	D 1010H	AD first-year course (ECO1010H) in microeconomics (CADP)
heckman	Heckman two-step estimation	
hrd	D HRD	Education Departments Houses of Representatives and Delegates
logit	Regression with a dichotomous dependent variable	
male	D Male	
markexam	Exam mark	Mark for the final economics examination
markmcq	MCQ mark	Mark for the multiple-choice questions in the final economics examination
marksq	SQ mark	Mark for the structured/essay questions in the final economics examination
mathhga	D Math HG A	
mathhgb	D Math HG B	
mathhgabc	D Math HG ABC	
mathhgd	D Math HG D	
mathhgef	D Math HG EF	
mathhgdef	D Math HG DEF	
mathmark		Final course mark for first-year mathematics

one	D 2001	2001 cohort
pshg	D PS HG	
pshgab	D PS HG AB	
pshgabc	D PS HG ABC	
pshgc	D PS HG C	
pshgd	D PS HG D	
pshgef	D PS HG EF	
probit	Regression with a dichotomous dependent variable	
psmatch2	Propensity score matching estimation	
s	D 1010S	Mainstream first-year course (ECO1010S) in microeconomics
s1	D First time	
two	D 2002	2002 cohort
three	D 2003	2003 cohort
w	D White	
wc	D Western Cape Province	
wshopall	Workshops	
zero	D 2000	2000 cohort

2. Estimations

Chapter 5

Equation (1)

OUTPUT = F(D ADP, STUDENT, MATRCULATION PERFORMANCE, SCHOOL, COURSE, OTHER)

Chapter 6

First-year courses

Microeconomics

Dependent variable: MCQ mark
reg markmcq 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five

heckman markmcq1010 h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five, select(age enghome economics hrd det test1) twostep

psmatch2 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det commerce two three four five, kernel outcome(markmcq)

Dependent variable: SQ mark
reg marksq 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five

heckman marksq 1010hh adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five, select(age enghome economics hrd det test1) twostep

psmatch2 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det commerce two three four five, kernel outcome(marksq)

Dependent variable: Examination mark
reg markexam 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five

heckman markexam 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det s1 commerce two three four five, select(age enghome economics hrd det test1) twostep

psmatch2 1010h adjmatpt engflhgabc engflhgdef mathhgabc mathhgd mathhgef pshg economics w finaid age enghome male wc hrd det commerce two three four five, kernel outcome(markexam)

Mathematics

Dependent variable: Course mark
reg mathmark asp08 asp08mstream asp08transmstream adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc w age male enghome finaid wc hrd det zero one two three four five

heckman mathmark asp08 asp08mstream asp08transmstream adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc w age male enghome finaid wc hrd det zero one two three four five, select(age enghome hrd det w test1) twostep

psmatch2 asp08 asp08mstream asp08transmstream adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc age male enghome finaid wc hrd det zero one two three four five, kernel outcome(mathmark)

Chemistry

Dependent variable: Course mark

reg chemmark geps gepsmstream adjmatpt engflhg mathhgabc mathhgd mathhgef pshgabc pshgd pshgef w age male enghome finaid wc hrd det zero one two three four five

psmatch2 geps gepsmstream adjmatpt engflhg mathhgabc mathhgd mathhgef pshgabc pshgd pshgef age male enghome finaid wc hrd det zero one two three four five, kernel outcome(chemmark)

Chapter 7

Second-year courses

Microeconomics

Dependent variable: Course mark

Period 1

ECO1010H and ECO1010S v ECO1010F
reg mark h s adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont one two

heckman mark h s adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont one two, select(age enghome hrd det w passt1) twostep

psmatch2 geps mstream adjmatpt engflhg mathhgabc mathhgd mathhgef pshgabc pshgd pshgef age male enghome finaid wc hrd det zero one two three four five, kernel outcome(chemmark)

Period 2

ECO1010H and ECO1010S v ECO1010F
reg mark h s adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont four five

heckman mark h s adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont four five, select(age enghome hrd det w passt1) twostep

reg mark h s wshopall adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont four five

heckman mark h s wshopall adjmatpt engflhg mathhgabc mathhgdef pshg finaid age enghome male w commerce wc hrd det attcont four five, select(age enghome hrd det w passt1) twostep

Mathematics

Dependent variable: Course mark

reg mark asp08only asp08mstream asp08trans adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc w age male enghome finaid wc hrd det attcont zero one two three four five

heckman mark asp08only asp08mstream asp08trans adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc w age male enghome finaid wc hrd det attcont zero one two three four five, select(age enghome hrd det w test1) twostep

psmatch2 asp08only adjmatpt engflhg mathhga mathhgb mathhgc pshgab pshgc w age male enghome finaid wc hrd det attcont zero one two three four five, kernel outcome(mark)

Chemistry

Dependent variable: Course mark

CEM2007F
reg mark geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five

logit pass geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five

psmatch2 geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five, kernel outcome(mark)

psmatch2 geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five, kernel outcome(pass)

CEM2008S
reg mark geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five

logit pass geps adjmatpt engflhg mathhgabc mathhgdef pshgabc pshgdef w age male enghome finaid wc hrd det attcont zero one two three four five

psmatch2 geps adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det, kernel outcome(mark)

psmatch2 geps adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det, kernel outcome(pass)

Chapter 8

Graduation

Dependent variable: Graduation

CADP

psmatch2 cadp adjmatpt engflhg mathhg pshg w age male enghome finaid wc hrd det comb01 comb03 comb04 comb07/17 comb08 comb12 comb13 comb16 zero one two three four, kernel outcome(grad)

logit grad cadp adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det comb01 comb03 comb04 comb07/17 comb08 comb12 comb13 comb16 zero one two three four

ASPECT

psmatch2 aspect adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det zero one two three, kernel outcome(grad)

logit grad aspect adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det one two three

GEPS

psmatch2 geps adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det zero one two three four, kernel outcome(grad)

logit grad adjmatpt engflhg mathhgabc pshgabc w age male enghome finaid wc hrd det zero one two three four

Appendix C

Case study parameters

		CADP	ASPECT	GEPS
First-year courses	ADP courses	ECO1010H Whole-year first-year course in microeconomics	END1007W Whole-year first-year course in mathematics	CEM1009H Whole-year first-year half-course in chemistry CEM1010F First-semester first-year half-course in chemistry
	Mainstream course control group	ECO1010S Second-semester first-year course in microeconomics	MAM1003W	CEM1000W
	Statistical analysis	Heckman MVA (OLS) PSM	Heckman MVA (OLS) PSM	Heckman MVA (OLS) PSM
Second-year courses	ADP courses	Workshops ECO2003F	None	Tutorials CEM2008S
	Mainstream courses	ECO2003F	MAM2028W	CEM2007F CEM2008S
	Statistical analysis	Heckman MVA (OLS) PSM	Heckman MVA (OLS) PSM	Heckman MVA (OLS) PSM
Graduation	ADP cohorts	CADP	ASPECT	GEPS
	Mainstream cohorts	Commerce	Engineering	Science
	Statistical analysis	MVA (Logit) PSM	MVA (logit) PSM	MVA (Logit) PSM

Figure C1 Outline of the parameters of the case studies

Appendix D

PSM "common support" results

If most of the regions of the propensity score values (0 to 1), defined as the conditional probability of being treated given the selected independent variables, have observations from both the treated and untreated groups then the condition for "common support" is met.

The condition for "common support" is met if there is some chance that a student with a given propensity score could fall into either of the treated and untreated groups.

Turning to figure D1, the condition for "common support" is partly met as all the regions of the propensity score values have observations from the treated and untreated groups. That said, the propensity score values are not spread evenly across the regions for the treated and untreated groups. Most of the untreated group have low propensity score values and many of the treated group have relatively high propensity score values.

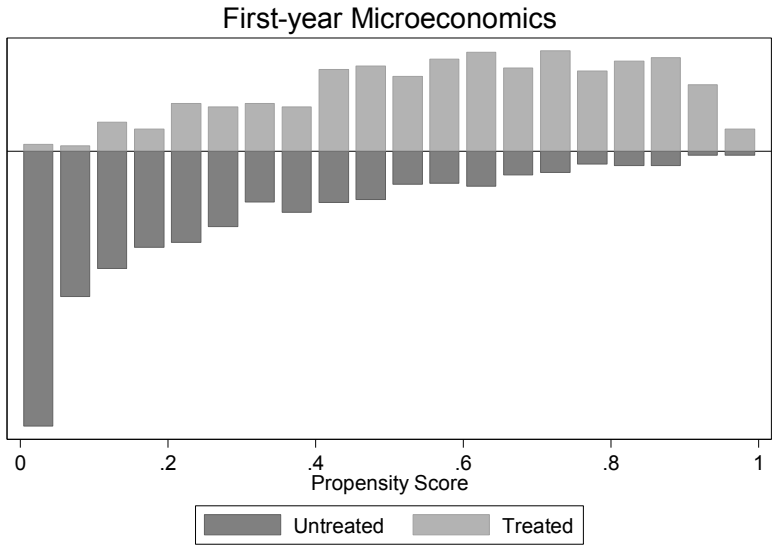

Figure D1 Common support first-year microeconomics

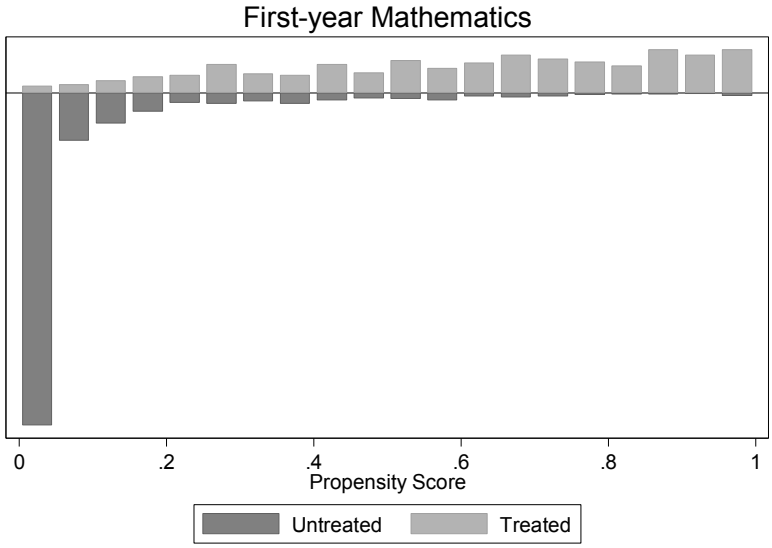

Figure D2 Common support first-year mathematics

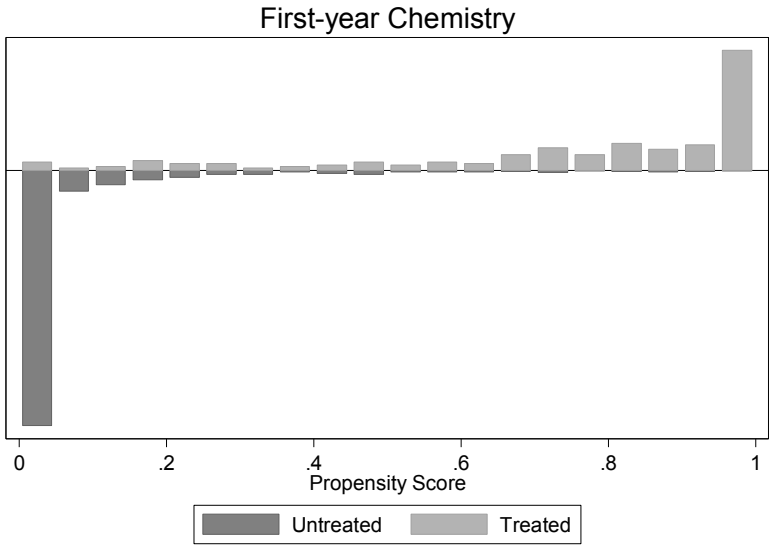

Figure D3 Common support first-year chemistry

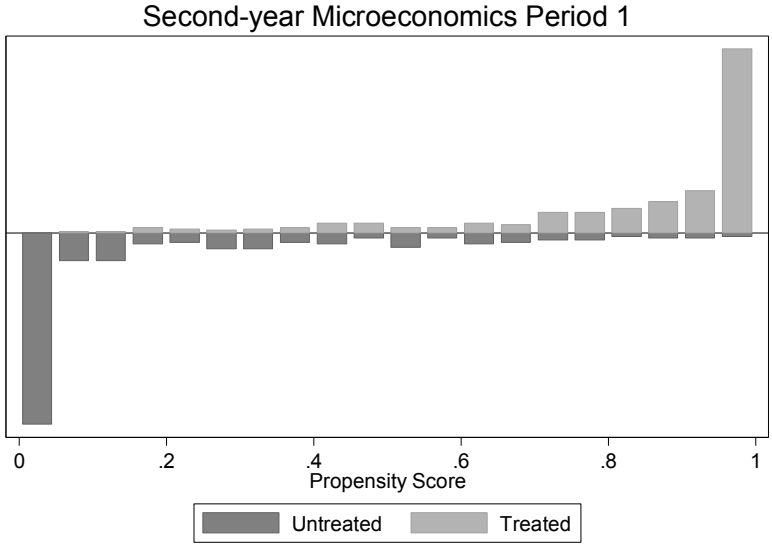

Figure D4 Common support second-year microeconomics period 1

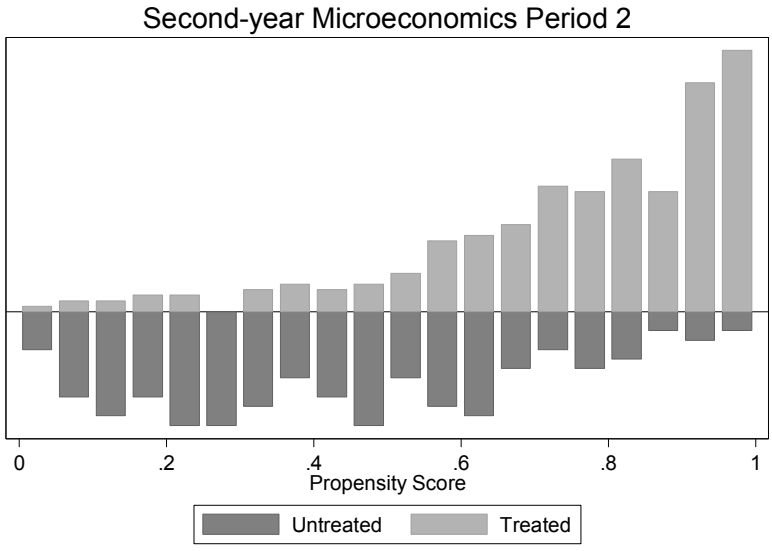

Figure D5 Common support second-year microeconomics period 2

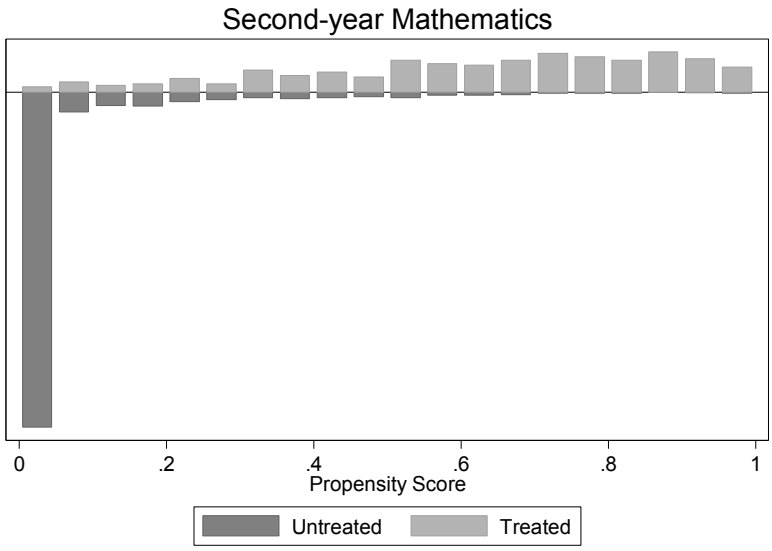

Figure D6 Common support second-year mathematics

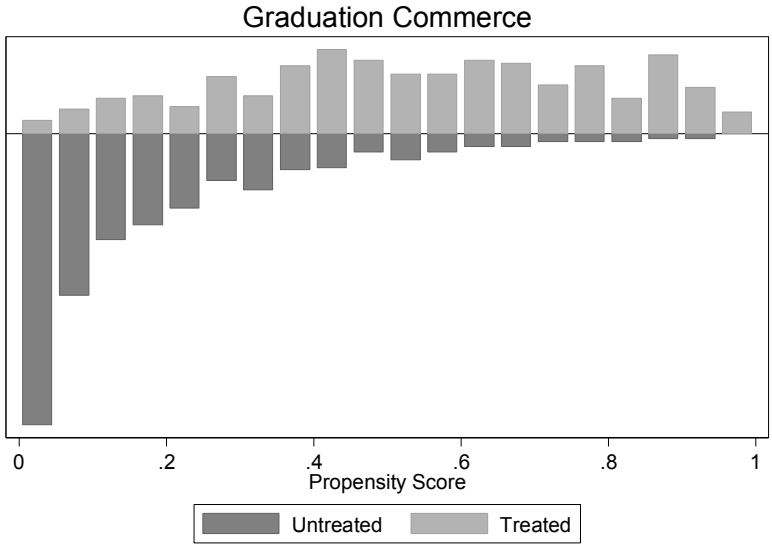

Figure D7 Common support graduation commerce

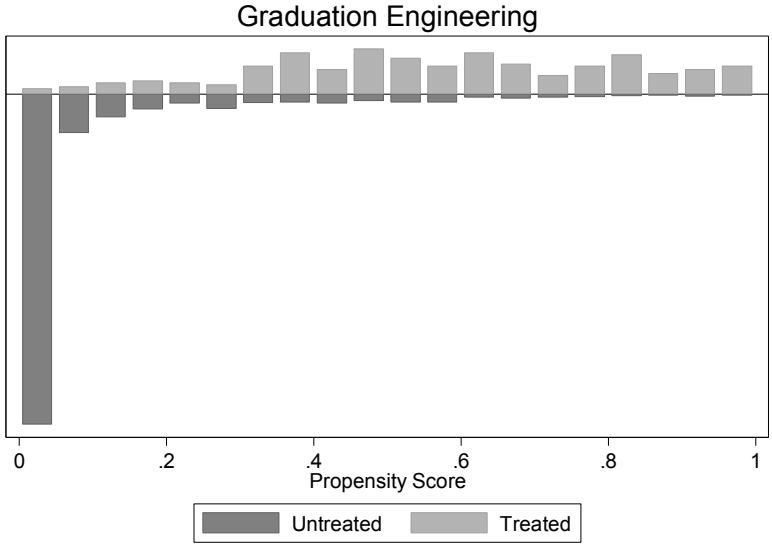

Figure D8 Common support graduation engineering

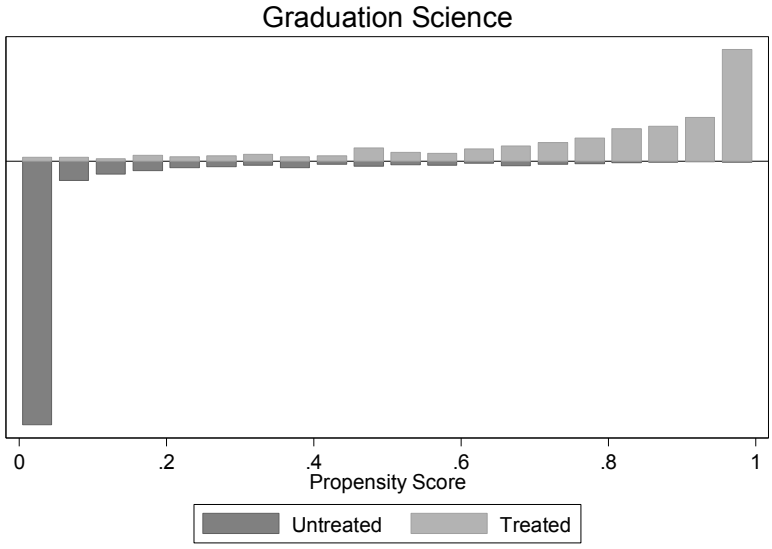

Figure D9 Common support graduation science

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